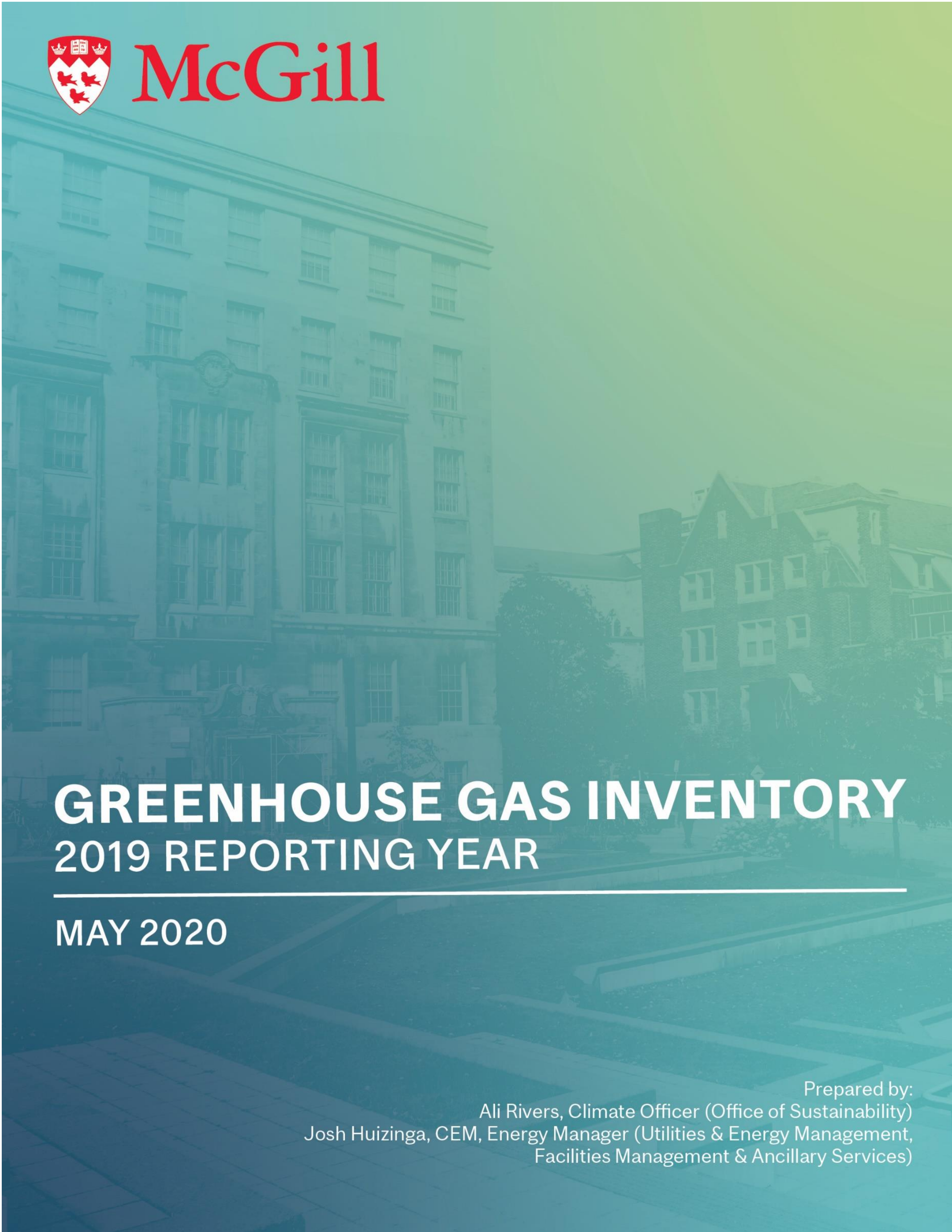

McGill

GREENHOUSE GAS INVENTORY
2019 REPORTING YEAR

MAY 2020

Prepared by:
Ali Rivers, Climate Officer (Office of Sustainability)
Josh Huizinga, CEM, Energy Manager (Utilities & Energy Management, Facilities Management & Ancillary Services)

Executive Summary

Scope

- **Reporting period:** January 1 – December 31, 2019
- **Consolidation approach:** operational control
- **Operational scope:** Scope 1 and 2 emissions; select Scope 3 emissions; select carbon sequestration
- **Protocol:** compiled following the guidance of the WBCSD/WRI GHG Protocol

Key Results

- **Gross emissions for reporting year 2019 are 58,091 tonnes of CO_2 equivalent (tCO_2e)**. An additional 25 tCO_2e was generated from biogenic (biodiesel) sources. This is a decrease of 1,118 tCO_2e (1.9%) compared to the updated 2015 inventory, but an increase of 1,832 tCO_2e compared to 2018. Scope 1 emissions – particularly natural gas consumption (57% of total emissions) – continue to contribute the majority of emissions (64%) and the majority of reductions achieved since 1990.

- **Net emissions for reporting year 2019 are 55,462 tCO_2e.** Forests at the Gault Nature Reserve and Morgan Arboretum sequester carbon and act as carbon sinks. Net carbon sequestration on these lands is equal to 717 tC/year, or 2,629 tCO_2e/year (4.5% total emissions). Afforestation efforts at the Arboretum and Macdonald Campus Farm could increase annual sequestration by 231 tCO_2e.

- **Several emission sources were responsible for the increase seen in 2019**. A colder average annual temperature in 2019 compared to 2018 caused a material increase in Scope 1 natural gas consumption and associated emissions, and the introduction of new heat recovery-capable chillers downtown – linked to Smart Grid Energy projects – increased emissions from refrigerants. We acquired significant amounts of new, leased space at properties including 2001 McGill College, UQAM, Campus1 MTL and 1980 Sherbrooke, leading to increases in energy consumption and emissions at these locations. And our commuting emissions increased as a result of an increased student, faculty and staff population.

- **Emission reductions were achieved across multiple areas in 2019 as well.** While these reductions were not large enough to offset the increases described above, progress continues on reducing emissions tied to heating oil consumption, fleet vehicle consumption, and overall steam & electricity consumption (and resulting transmission & distribution losses). We increased the share of biodiesel used by our inter-campus shuttle and decreased related non-biogenic emissions, while fluctuations in air travel contributed to reductions as well.

- **Relevant intensity-based key performance indicators (KPIs) were calculated for 2018/2019.** McGill's emissions per student enrolment were 1.02 tCO_2e/FTE student and emissions per gross area were 0.041 tCO_2e/m^2, both of which have decreased since the 2015 inventory but increased since 2018. We have included a detailed comparison of McGill's performance against select Canadian and American universities across several KPIs critical to research-intensive institutions.

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1. Introduction

A greenhouse gas (GHG) assessment, also known as a GHG inventory or a carbon footprint assessment, is a quantified list of an organization's GHG emissions and sources within a chosen scope. It is a valuable and strategic tool for understanding, managing and communicating climate change impacts resulting from an organization's activities – specifically, greenhouse gas emissions.

A. Greenhouse Gas Reporting at McGill

Since 2014, McGill has conducted annual GHG assessments to inform and achieve a number of internal and external targets related to sustainability efforts, emissions reductions initiatives, monitoring & reporting, and compliance.

In 2017, McGill launched the Vision 2020: Climate & Sustainability Action Plan, which – among other ambitious goals – committed the University to achieving institutional carbon neutrality by 2040. Later this year, we are launching the next iteration of our university-wide strategy, which will outline short-term actions up to 2025 as well as preserve our long-term goals. Results from annual GHG assessments allow us to track and communicate progress against our short and long-term emissions targets, gauge the impact of reduction initiatives, and identify potential reduction opportunities for future action. We report McGill's GHG emissions to the Board of Governors annually as one of three strategic key performance indicators linked to sustainability progress. Externally, data and emissions from our inventory are reported to a number of mandatory and voluntary reporting programs. These include:

- **Greenhouse Gas Reporting Program for GHGs:** Run by ECCC at the federal level, we report emissions from the Downtown campus and voluntarily report emissions for Macdonald campus.

- **National Pollutant Inventory Report for airborne contaminants excluding GHGs:** Run by Environment Canada and complementary to the above program. We report CO and NO_x for the downtown campus as required and report voluntarily on all other Part 4 substances (e.g. sulphur dioxide, particulate matter, VOCs) for the downtown and Macdonald campuses.

- **Inventaire québécois des émissions atmosphériques:** This program includes both airborne contaminants and GHGs, and is effectively the same as Environment Canada's program but at the provincial level. We report GHGs and Part 4 contaminants (see above) for downtown as required, and voluntarily report these for Macdonald campus.

- **Inventaire des sources fixes d'émissions atmosphériques:** This municipal program is managed by the Ville de Montreal and includes our downtown and Macdonald campuses. Reporting is therefore mandatory and includes the volume of fossil fuels consumed at each campus.

- **Relevé énergétique du réseau universitaire:** This program, managed by the Ministère de l'Enseignement supérieur du Québec is mandatory for all university-owned buildings and includes all sources of energy used in those buildings.

- **STARS:** The Association for the Advancement of Sustainability in Higher Education's Sustainability Tracking, Assessment & Rating System is a voluntary self-reporting framework for colleges and universities. McGill has a Gold rating currently, and committed to achieving Platinum by 2030.

B. Compliance with the Greenhouse Gas Protocol

This GHG inventory follows the guidelines of the World Business Council for Sustainable Development (WBCSD) and World Resources Institute's (WRI) Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (2004). This standard, considered international best practice for organizational GHG accounting, is articulated around the following principles:

- **Relevance:** McGill's GHG inventory appropriately reflects the emissions of the University and was compiled in the spirit of serving decision-makers, both internal and external to McGill.

- **Completeness:** All material emission sources and activities within the chosen boundary are accounted for and reported, and any exclusions are disclosed and justified.

- **Consistency:** Consistent methodologies are used for meaningful comparison over time. Changes to data, inventory boundary, methods, or any relevant factors is transparently documented, and base year and other years are updated when materially significant.

- **Transparency:** All relevant issues are addressed in a coherent manner based on a clear audit trail. Any relevant assumptions are disclosed and appropriate references to the accounting and calculation methodologies and data sources used are made.

- **Accuracy:** Quantification of GHG emissions is systematically neither over nor under actual emissions and uncertainties have been reduced as far as practicable. The achieved level of accuracy should enable decision-making with reasonable assurance as to the integrity of the reported information.

McGill's 2019 GHG inventory was conducted using the location-based Scope 2 methodology detailed within the GHG Protocol Scope 2 Guidance: An amendment to the GHG Protocol Corporate Standard.

C. Description of the Organization

McGill, located in Montréal, Québec, is one of Canada's leading-edge research universities. The University was founded in 1821 and has grown into a world-class research institution. McGill offers more than 300 academic programs through 11 faculties and schools. Student enrollment for FY2019 was over 32,000 full-time equivalents and the University employed more than 13,000 faculty and staff, part time and full time. As of April 30 2019, the University's endowment was $1.679 billion[1] and the budget for the financial year ending April 30, 2018 was $1.348 billion[2]; reports for the more recent period were not yet finalized.

McGill owns and operates over 200 buildings located on three main campuses on the island of Montréal in Québec: the Downtown Campus in downtown Montréal, the Macdonald Campus in Sainte-Anne-de-Bellevue, and Gault Nature Reserve in Mont-Saint-Hilaire. In the 2018 inventory, carbon sequestered by the Gault Nature Reserve and Morgan Arboretum was included for the first time, sourced from McGill-specific research into this potential on our properties, and we now include both gross and net emissions totals.

The University also owns and operates several research stations both in Canada and abroad. The Bellairs Research Institute in Barbados is the largest such research station, but others include the McGill Arctic Research Station (MARS) and the McGill Sub-Arctic Research Station (M-SARS).

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[1] https://mcgill.ca/investments/files/investments/report_on_endowment_performance_-_eng_-_finalv2.pdf, p. 4 (market value)
[2] https://www.mcgill.ca/vpadmin/files/vpadmin/audited_financial_statements_year_ended_april_2019_0.pdf p 2

2. Scope of the Inventory

A. Reporting Period

This assessment report details the scope, data and results from McGill University's GHG inventory for calendar year 2019, from January 1 – December 31, 2019.

Reasonable effort was made to include data specific to this period. In some cases, due to the impacts of COVID-19 measures, consumption and billing periods, data delays, or timeframes for existing data tracking systems, data has been included for a slightly offset annual period or estimated using previous data. Over consecutive assessments, we ensure that all activity data is captured and included. Importantly, if facilities or other assets are sold or relinquished, all activity data up to the date of transfer of ownership or retirement is included in the inventory for which data is available.

B. Greenhouse Gases and Global Warming Potentials

As required by best practice in organizational GHG accounting and the chosen WBCSD/WRI GHG Protocol, all seven Kyoto Protocol greenhouse gases have been included where applicable and material. This includes biogenic carbon dioxide, which is created from the combustion, harvesting, decomposition or processing of biological sources rather than fossil sources.

Global warming potentials (GWPs) are factors describing the radiative forcing impact of one unit of a specific greenhouse gas (e.g. methane) relative to one unit of carbon dioxide. They are used in GHG accounting to convert individual greenhouse gas emissions totals to a single standardized unit useful for comparison – carbon dioxide equivalent, or CO_2e.

McGill applied 100-year GWPs without climate-carbon feedbacks to all emissions data in this inventory in order to calculate total emissions in tonnes carbon dioxide equivalent (tCO_2e). Global warming potential values were sourced from the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5 2013), the most recent IPCC report available at the time of assessment. The sixth assessment cycle is currently underway, with reports expected by 2021. The Kyoto Protocol GHGs (or categories of GHGs) and their respective GWPs are listed in the table below.

Greenhouse Gas	Chemical Formula	100-Year GWP
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
Hydrofluorocarbons (HFCs)	Various	Various
Perfluorocarbons (PFCs)	Various	Various
Nitrogen trifluoride	NF_3	16,100
Sulphur hexafluoride	SF_6	23,500

Table 1. Kyoto Protocol GHGs and GWPs, IPCC 2013

C. Change in Scope and Methodology

The scope of the inventory remained the same as for the 2015 – 2018 inventories. As in 2018, we have included two inventory components reported outside total emissions: carbon sequestration from two of our properties – the Gault Nature Reserve and Morgan Arboretum – and biogenic carbon emissions from biodiesel consumption in our shuttle bus.

Organizational Boundary

McGill University goes beyond best practice requirement by including energy consumption from a number of buildings over which we do not have operational control in our Scope 3 emissions. We have also estimated data for a few smaller research stations and facilities whose emissions are relatively immaterial compared to our main campus emissions. Examples of research facilities within our inventory scope are the McGill Sub-Arctic Research Station (M-SARS) and energy consumption from the CLUMEQ super-computer shared with the École de technologie supérieure (ETS). We have included office space at 1010 Sherbrooke and 680 Sherbrooke, the Dentistry Clinic at 2001 McGill College, and a number of cottages and small residences rented out to non-student individuals at the Macdonald and Downtown campuses. For some shared buildings where we perceive full operational control, we include energy consumption and resulting emissions to take full account of these spaces. To ensure consistency, all of McGill's past and future inventories have been updated to reflect these same scoping and methodological decisions.

Operational Boundary

The same set of emission sources that was included in the base year 2015 inventory and subsequent inventories is included for 2019 as well. Beginning in 2018, we have additionally included annual carbon sequestration from the Gault Nature Reserve and Morgan Arboretum. We also included biogenic emissions from the biodiesel used in the Macdonald shuttle buses during non-winter months. Per best practice, sequestered carbon and biogenic carbon are reported separately from total emissions.

Methodology

Global warming potentials (GWPs) were sourced from the IPCC's 5th Assessment Report, aligned with updates inventories for all past years. Emission factors remain generally consistent between inventories, with annual updates integrated as necessary and available from chosen third party organizations. Emission factors for vehicle use are now sourced from Environment Canada, where relevant, to allow for more specific factors by fuel and vehicle type.

D. Organizational Boundary

This inventory follows the "operational control" consolidation approach of the GHG Protocol. Under this approach, McGill is required to account for 100% of the emissions from operations, facilities and sources over which it has operational control and is not required to account for GHG emissions from operations in which it owns an interest but over which it has no operational control.

We have chosen to include emissions from energy consumption in some buildings over which we do not have operational control within our Scope 3 emissions, going beyond the requirements of the chosen Protocol. Guidance from "Categorizing GHG Emissions Associated with Leased Assets: *Appendix F to the GHG Protocol Corporate Accounting and Reporting Standard*" (2006) was used for decision-making on the scope of energy emissions in these cases. The below section provides a summary of unique cases; for all owned or leased buildings with operational control, we have included relevant emissions as Scope 1 and 2.

- **Buildings that were never or are no longer under McGill ownership or control:** Any such building is not included in the scope of the inventory.
  - Examples include hospitals affiliated with McGill research or researchers, but that we do not own or have operational control over, such as the MUHC-GLEN, Douglas Hospital, Jewish General Hospital, and Montreal General Hospital, and the Presbyterian College

- **Buildings owned by McGill with emphyteutic leases:** Where McGill is a lessor and the lease is emphyteutic, McGill does not have operational control and we have not included these emissions in the inventory. For all other buildings not listed below where McGill is the lessor, we perceive that we do have operational control and have included their energy emissions as Scope 1 or 2.
  - Emissions not included in inventory scope: McCord Museum, University 3605 – 3621, and the Moxley Building

- **Buildings co-owned or jointly managed:** We share, or previously shared, ownership or administration of a couple buildings with other organizations.
  - The Neuro: McGill owns the building and shares administration with the MUHC. We perceive operational control due to our current responsibility for the operations, maintenance and upgrades to the building's HVAC systems. All energy consumption is therefore categorized Scope 1 or 2 as relevant.
  - Sherbrooke 688: McGill took over full ownership (and operational control) on August 1, 2017. Since that date, energy emissions are categorized as Scope 1 and 2 as relevant.
  - Stewart Athletic Complex: McGill co-owns the building with John Abbott College. We perceive operational control since we are responsible for the operation and maintenance of the energy systems, so energy consumption is categorized as Scope 1 or 2 as relevant.

- **Buildings where McGill is a lessee without operational control:** For a number of locations, McGill leases or shares space but does not have operational control. Specifically, in these instances, we are unable to make any modifications to the building or energy systems and are not responsible for the operations or maintenance of these systems. Per Appendix F, a perceived lack of operational control exists and relevant emissions are not Scope 1 or 2. We have categorized the relevant energy emissions as Scope 3 and chosen to include these within the scope of our inventory.
  - Aima Inc., Cote de Neiges 5858, 4920 de Maisonneuve West, the ETS-CLUMEQ computer, McGill College 2001, Le James @ 3544 ave de Parc, Peel 1555, Sherbrooke 550, Sherbrooke 1010, Sherbrooke 1980 (new in CY2019), UQAM Pavillion des Sciences, Villa Burland @ the Douglas Hospital and Campus1 MTL (new in CY2019)

- **Buildings where McGill is a lessee with operational control:** Per Appendix F, we perceive full operational control and have categorized energy consumption as Scope 1 or 2, as relevant.
  - Parc Avenue 3575

E. Operational Boundary

Greenhouse gas emissions are broken down into three categories known as "scopes" that help delineate direct and indirect emission sources and avoid double counting between organizations, particularly at the level of national reporting. The WBCSD/WRI GHG Protocol requires the inclusion of all material Scope 1 and Scope 2 emissions because an organization has the most ownership and control over these activities. Scope 3 emission sources are optional under this Protocol, though best practice encourages organizations to include Scope 3 emissions sources that are critical to their business activities and strategic decisions.

- **Scope 1 emissions:** direct emissions from sources owned or controlled by McGill
- **Scope 2 emissions:** energy indirect emissions from the consumption of purchased grid electricity and other similarly distributed energy types such as steam, hot water and chilled water
- **Scope 3 emissions:** other indirect emissions

Typically, the decision to include Scope 3 emission sources is based on a value chain analysis to determine their relevance and materiality. Relevant emissions are defined by McGill as: large, or believed to be so, relative to Scope 1 and 2 emissions; contributing to McGill's emissions and climate risk exposure; deemed critical by key stakeholders; and showing potential for reduction through measures that could be undertaken by McGill. As such, McGill's GHG inventory includes:

Scope 1 Emissions

All Scope 1 emissions within the organizational boundaries defined above are included, with the exception of process gases generated by chemicals used for, and by-products generated by, research experiments. The reason for this exclusion is threefold:

- Though McGill has a central chemical inventory management system, it isn’t consistently used by the research community and data is therefore incomplete
- Due to the extremely diverse nature of research happening on campus, it is virtually impossible to account for all the types of by-products generated during these experiments
- Greenhouse gas emissions generated by experiments are deemed minimal with respect to total institutional Scope 1 and Scope 2 emissions

Scope 2 Emissions

All Scope 2 emissions within the defined organizational boundaries are included.

Scope 3 Emissions

Scope 3 emissions deemed to be relevant as defined above. For the moment, the inclusion of relevant Scope 3 emission sources has been decided in conjunction with key stakeholders based on activities that are believed to have significant greenhouse gas impact are most relevant to the University's mission; access to accurate data has also been considered.

- As such, the following activities and resulting Scope 3 emissions are included in the CY2019 inventory:
  - Electricity and natural gas consumption for the Scope 3 cases outlined in section D above
  - Student, faculty and staff commuting
  - Directly-financed University-related air travel
  - Travel by the University’s sports teams
  - Travel by the Macdonald Shuttle bus
  - Water supply & treatment
  - Power transmission & distribution (T&D) losses occurring between production sites and McGill facilities

- In CY2019, the University worked with over 10,000 suppliers from around the world, and purchased over $450 million worth of goods and services. Just under 6,000 faculty and staff members can make purchases through the McGill MarketPlace (MMP). Despite the fact that most emissions from procured goods & services are excluded from the inventory, McGill University's Procurement Services is actively involved in mitigation efforts. They are seeking to reduce the negative impacts of the University's purchases and contributing to the emergence of a more circular economy in the supply chain by developing a framework for asset lifecycle management.

Other Emission Sources and Sinks Reported Separately

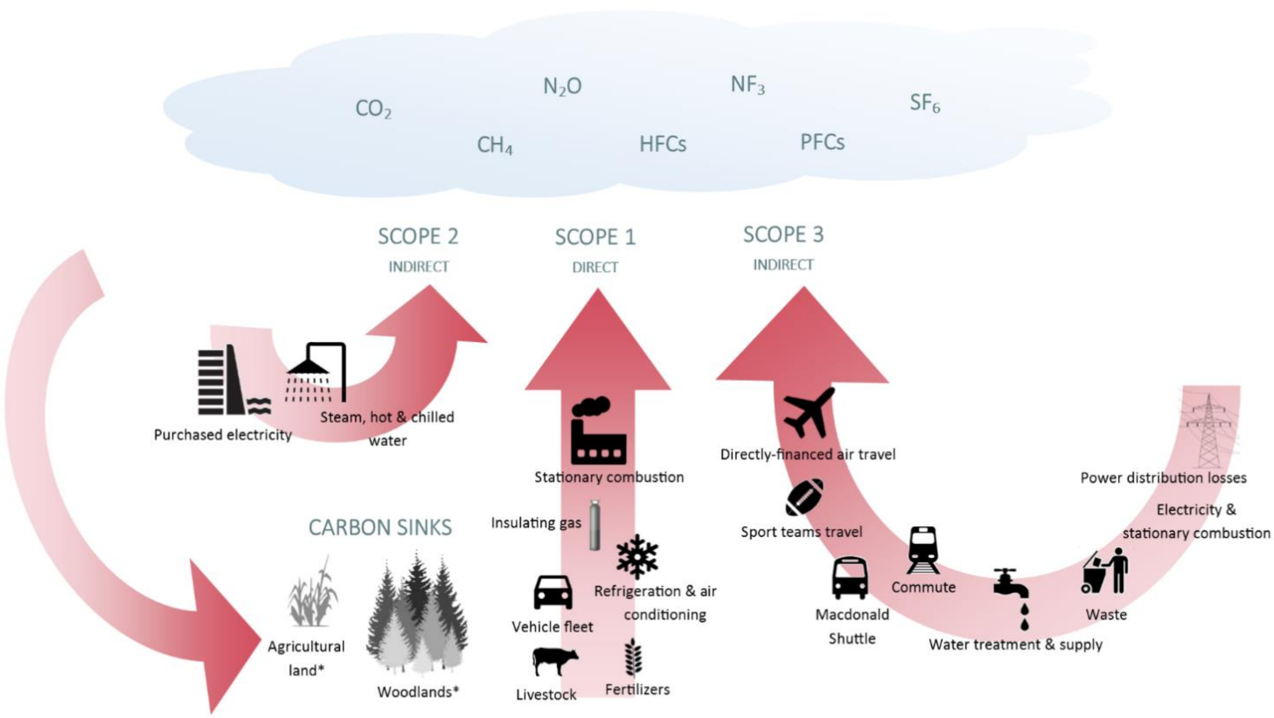
Emissions from refrigerants not covered by the Kyoto Protocol and avoided emissions from solid waste disposal are reported separately per best-practice accounting standards, as are biogenic emissions.

Estimations of greenhouse gas reductions achieved by McGill through its waste management and diversion program are reported separately.

While negotiating the new contract for the Macdonald shuttle bus, we included a strategic requirement to use 20% non-animal derived biodiesel during non-winter months. Carbon dioxide emissions from biofuel are biogenic in nature, and thus reported separately from McGill's total footprint, per best practice.

Carbon sequestration is reported separately and integrated into the net emissions total. So far, sequestration from the Gault Nature Reserve and Morgan Arboretum has been estimated.

** Note: Depending on land management practices, agricultural land and woodlands can be emission sources or sinks.*



Adapted from GHG Protocol, 2004

Figure 1. Overview of Emissions Included in McGill's 2019 Inventory by Scope

Detailed List of Activities Included in the Inventory

The below table details the activities included in the inventory. The "Exclusions" column here focuses on specific exclusions within the identified activity; activities fully excluded from the inventory are detailed further below.

Activity	Scope	Fuel or Gas	Exclusions	Rationale for Exclusion
On-site stationary combustion – large boilers	1	Natural gas, heating oil	None	N/A
On-site stationary combustion – small boilers	1	Natural gas, heating oil, propane	None	N/A
On-site stationary combustion – emergency power generators	1	Diesel, natural gas	Small research stations	No data available and emissions deemed minimal
Uncontrolled leaks of refrigerants	1	Various refrigerants	1) Stand-alone systems from some buildings 2) A/C window units 3) Refrigerants not covered by Kyoto Protocol	1) Data unavailable 2) No inventory of A/C window units 3) Reported separately
Uncontrolled leaks of electrical insulating gas	1	SF_6	None	N/A
On-site combustion – mobile equipment (grounds & landscaping)	1	Diesel	None	N/A
McGill-owned fleet of vehicles	1	Gasoline, diesel	None	N/A
Fertilizers	1	N/A	None	N/A
Livestock	1	N/A	None	N/A
Purchased electricity	2	Electricity	Small research stations	No data available and emissions deemed minimal
Purchased steam	2	Steam	None	N/A
Purchased hot and chilled water	2	Water	None	N/A
Directly-financed air travel	3	N/A	None	N/A
Commuting	3	N/A	Commute to and from smaller campuses and research stations	No data available and emissions deemed minimal
Sport teams travel	3	N/A	Varsity teams only; clubs are not included	Emissions are deemed minimal
Water supply & treatment	3	N/A	None	N/A
Macdonald Shuttle	3	Diesel, biodiesel	None	N/A
Power distribution losses	3	Electricity	Small research stations	No data available and emissions deemed minimal

Table 2. List of Activities Included in Inventory

List of Activities Reported Separately

Activity	Rationale for Separate Reporting	Exclusions	Rationale for Exclusion
Solid waste (domestic waste, hazardous waste, and construction waste)	This report evaluates reductions in GHG emissions achieved through McGill's waste management.	Waste from small research stations	No data available
Refrigerants not regulated by the Kyoto Protocol	As per the GHG Protocol's "Corporate Accounting and Reporting Standard".	1) Stand-alone systems from some buildings 2) A/C window units	1) Data unavailable 2) No inventory of campus A/C units
Emissions data for biologically sourced fuels (e.g. from burning biomass/biofuels)	As per the GHG Protocol's "Corporate Accounting and Reporting Standard".	N/A	N/A
Carbon sequestration from the Morgan Arboretum & Gault Nature Reserve	As per the GHG Protocol's "Corporate Accounting and Reporting Standard".	Molson Reserve, Penfield property, Macdonald Farm	Initial research focused on the Arboretum and Gault Nature Reserve

Table 3. List of Activities Reported Separately

List of Activities Excluded from the Inventory

Activity	Rationale for Exclusion from Inventory Reporting
Research experiments	1) Incomplete data re: types and amounts of chemicals purchased 2) Calculating and/or monitoring types and amounts of experiment products and by-products is currently unfeasible
Research animals	1) Data on types of animals and headcount is classified and unavailable 2) Given the types of research animals, direct emissions presumed negligible compared to already-quantified Scope 1 and 2 emissions
Directly-financed travel other than air travel (e.g. train, bus, car rentals and taxis, and trips by personal vehicle)	Information currently unavailable; working to obtain and/or model
Refrigerants, commuting, waste, water supply & water treatment for Gault Nature Reserve and the Bellairs Research Institute	Amounts are negligible and data isn't readily available; working to obtain and/or model
Data for smaller offsite research stations	Information unavailable and/or hard to collect; energy for larger research stations has been included, such as Bellairs
Carbon sequestration rate from the Macdonald Farm, Molson Reserve and Penfield Property	No data. Research conducted to date focused on our largest forested properties. Sequestration rate & potential for these lands may be estimated or investigated in future.

Table 4. List of Activities Excluded from Inventory

3. Calculation Methodology

A. Process Flow

The figure below outlines the process flow of the different steps of the greenhouse gas reporting process.

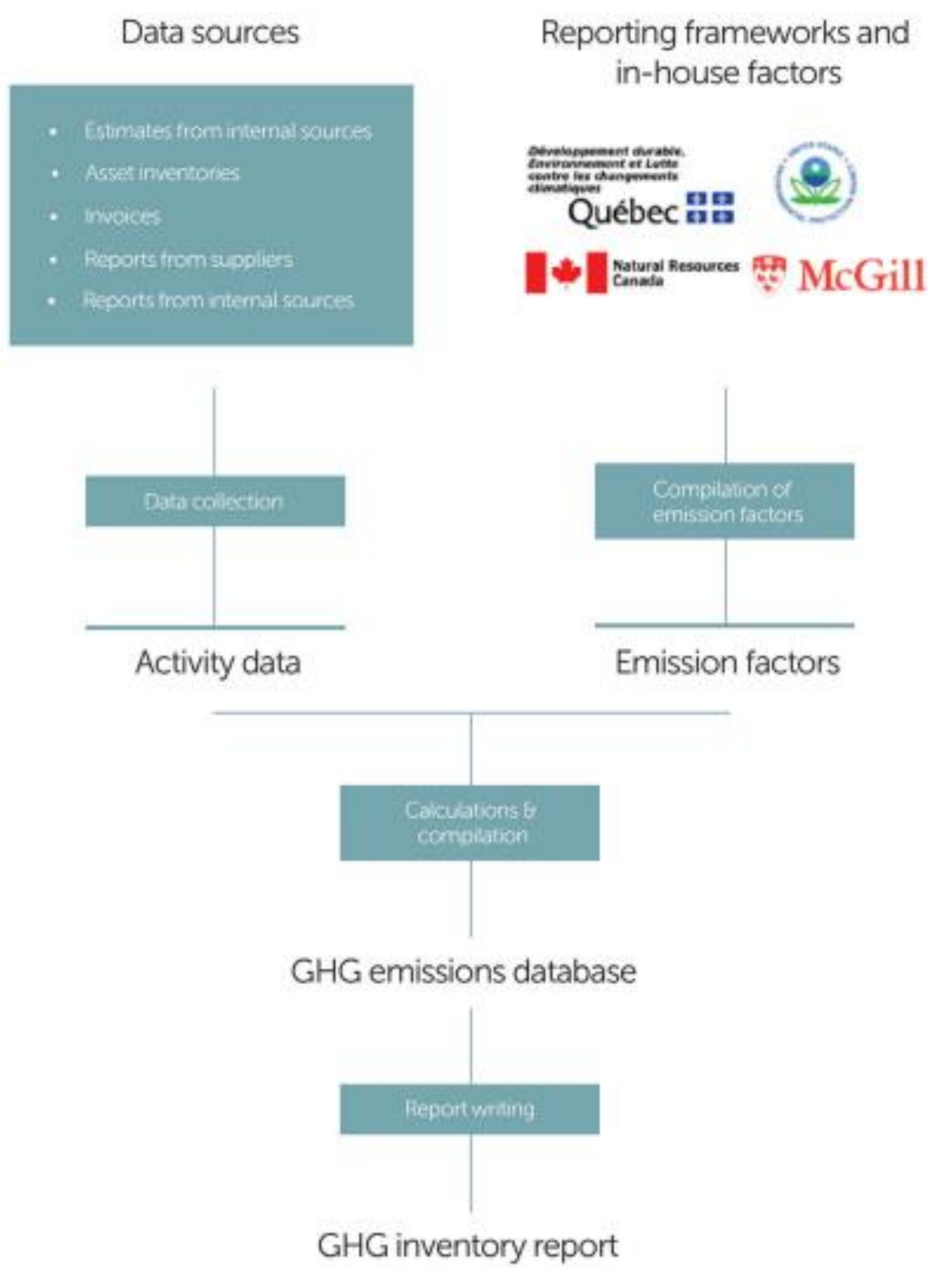


Figure 2. McGill's Greenhouse Gas Reporting Process

B. Data Sources and Calculation Methods

The following table briefly outlines the calculation methods used. Detailed calculation methodologies are included in the appendices to this report. There are several acronyms used in the below table:

- **FAMIS:** McGill University's Facilities Management and Space System
- **MDDELCC:** Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques du Québec
- **EC:** Environment Canada
- **NRCan:** Natural Resources Canada
- **UK BEIS:** United Kingdom Department for Business, Energy and Industrial Strategy
- **US EPA:** United States Environmental Protection Agency

Scope 1			
Activity	**Data source**	**Calculation Method**	**Source of Emission Factor**
Generators, Downtown	Invoices collected by Facilities Accounting; financial database	Emission factor	MDDELCC
Generators, Macdonald	Invoices collected by Macdonald Operations; financial database	Emission factor	MDDELCC
Grounds, Downtown	Invoices collected by Facilities Accounting; financial database	Emission factor	EC
Heating oil, Downtown	Invoices collected by Facilities Accounting; financial database	Emission factor	MDDELCC
Heating oil, Macdonald	Invoices collected by Macdonald Operations; financial database	Emission factor	MDDELCC
Natural gas, Large boilers	Invoices collected by Utilities & Energy Management	Emission factor	EC
Natural gas, Small boilers	Invoices collected by Utilities & Energy Management	Emission factor	EC
Purchased steam	Meter data read by Utilities & Energy Management & MUHC invoices	Estimate of production + generation efficiency Emission factor method	EC
Vehicles & Grounds, Macdonald	Report from Supervisor of Property and Maintenance based on vehicle logs	Emission factor	MDDELCC, EC, NRCan
Vehicles, Downtown	Report from fleet management software from Parking and Transportation Services	Emission factor	MDDELCC, EC, NRCan
Vehicles, Research	List of assets from Risk Management & Insurance unit	Emission factor	MDDELCC, EC, NRCan
Fertilizers, Macdonald, Lods and Horticulture Centre	Volumes and types spread according to Chief Agronomy Technicians	Emission factor	US EPA

Livestock	Estimate of headcount and manure management by Farm Manager	Emission factor	NRCan
Refrigerants, Downtown	List of assets from Downtown Operations	Estimate of leak rate Emission factor method	MDDELCC, IPCC
Refrigerants, Macdonald	List of assets from Macdonald Operations	Estimate of leak rate Emission factor method	MDDELCC, IPCC
Insulating gas	List of assets from FAMIS	Emission factor	MDDELCC, IPCC
Scope 2			
Activity	**Data source**	**Calculation Method**	**Source of Emission Factor**
Electricity	Annual report to the Ministry of Higher Education compiled by Facilities Accounting & invoices from Hydro-Québec	Emission factor	EC, UNEP/DTU
Electricity, other SHHS buildings	Invoices compiled by SHHS Facilities	Emission factor	EC
Scope 3			
Activity	**Data source**	**Calculation method**	**Source of emission factor**
Air travel, directly funded	Report from McGill's Travel Helpdesk based on reimbursement requests Financial services	Emission factors	UK BEIS
Commuting	2011 McGill Transportation Survey report (TRAM)	Survey results corrected to student and employee populations	In-house (McGill)
Solid waste: Composting, Downtown	Reports from service supplier	Calculate reductions from reference scenario	US EPA Warm Model
Solid waste: Composting, Macdonald	Estimates from the Supervisor of Property Maintenance	Calculate reductions from reference scenario	US EPA Warm Model
Solid waste: Construction, renovation and demolition waste	Estimates from the Senior Manager of Design Services	Calculate reductions from reference scenario	US EPA Warm Model
Solid waste: Domestic waste, recycling & compost, Downtown	Report from service suppliers	Calculate reductions from reference scenario	US EPA Warm Model
Solid waste: Domestic waste, recycling & compost, Macdonald	Estimates using previous years' data	Calculate reductions from reference scenario	US EPA Warm Model
Hazardous waste	Annual report from Hazardous Waste Management	Calculate reductions from reference scenario	US EPA Warm Model
Macdonald Shuttle	Fuel reports from supplier	Emission factor	EC, US EPA
Sport teams travel	Athletics travel records	Emission factor	UK BEIS; EC; STM
Water supply and treatment	Water audits from Utilities & Energy Management	Emission factor	In-house (McGill)

Table 5. Data Sources and Calculation Methods

C. Emission Factors

Applied emission factors were sourced from reputable third-party organizations, typically government reports, or have been developed in-house specific to McGill's own systems or transit behaviour.

Fuel or Activity	Organization	Source
Air travel – short, medium and long haul (average class)	UK BEIS	2019 Government GHG Conversion Factors for Company Reporting, Air Travel
Electricity (Québec)	EC	National Inventory Report 1990 - 2018: Greenhouse Gas Sources and Sinks in Canada. Part 3, Table A13-6
Electricity (Barbados)	UNEP/DTU	Analysis of Grid Emission Factors for the Electricity Sector in Caribbean Countries, Annex 4
Fertilizers (various)	US EPA	Emissions Factors & AP 42, Compilation of Air Pollutant Emission Factors, Ch. 14.1
Diesel – stationary combustion	MDDELCC	LRQ Q-2, r. 15, Table 1-3, Diesel
Diesel – mobile equipment, on-road	MDDELCC	LRQ Q-2, r. 15, Table 27-1, Diesel vehicle
Diesel – mobile equipment, off-road	NRCan	National Inventory Report 1990 – 2018: Greenhouse Gas Sources and Sinks in Canada, Part 2.
Gasoline – mobile equipment, on-road	MDDELCC	LRQ Q-2, r. 15, Table 27-1, Gasoline vehicle
Gasoline – mobile equipment, off-road	NRCan	National Inventory Report 1990 – 2018: Greenhouse Gas Sources and Sinks in Canada, Part 2
Propane – mobile equipment	MDDELCC	LRQ Q-2, r. 15, Table 27-1, Propane vehicle
Heating oil	MDDELCC	LRQ Q-2, r. 15, Table 1-3, Light fuel oil, Institutional
Sulphur hexafluoride (SF_6)	IPCC	Climate Change 2013: The Physical Science Basis, WGI, Fifth Assessment Report. Ch 8: Anthropogenic and Natural Radiative Forcing. Table 8.A.1.
Livestock (various)	NRCan	National Inventory Report 1990 - 2010, Annex 3
Natural gas – stationary combustion	NRCan	National Inventory Report 1990 – 2018: Greenhouse Gas Sources and Sinks in Canada, Part 2.
Propane	MDDELCC	LRQ Q-2, r. 15, Table 1-3, Propane – All other uses
Refrigerants (various)	IPCC	Climate Change 2013: The Physical Science Basis, WGI, Fifth Assessment Report. Ch 8: Anthropogenic and Natural Radiative Forcing. Table 8.A.1.
Diesel – coach bus	NRCan	National Inventory Report 1990 – 2018: Greenhouse Gas Sources and Sinks in Canada, Part 2.
Biodiesel – bus	US EPA	Emission Factors for GHG Inventories. EPA Centre for Corporate Climate Leadership. Table 2.
Diesel – bus	MDDELCC	LRQ Q-2, r. 15, Table 27-1, Diesel vehicle
Taxi	NRCan	National Inventory Report 1990 – 2018: Greenhouse Gas Sources and Sinks in Canada, Part 2
Public transit	US EPA	Emission Factors for GHG Inventories. EPA Centre for Corporate Climate Leadership. Table 10.
Water supply	McGill	Fall 2015 ENV-401 student project. Emission factors were calculated from information collected from the City of Montréal, City of Sainte-Anne-de-Bellevue, and Montréal Wastewater Treatment Plant.
Water treatment	McGill	

Table 6. Emission Factors

D. Key Assumptions

Complete, primary data was used wherever possible. For certain emissions sources, data was either unavailable or incomplete, and assumptions and modelling were necessary to conservatively estimate associated emissions. COVID-19 measures increased the need for some estimation of 2019 energy data.

Stationary Energy Consumption

- For all buildings with missing energy data (typically smaller buildings or buildings where McGill is the lessee or lessor to a non-student individual), electricity consumption was estimated using an annual energy intensity factor (GJ/m^2) for base load electricity, specific to the Commercial and Institutional sector in Québec (Natural Resources Canada).
- For all buildings with missing energy data, heating and hot water energy consumption was similarly estimated, using an annual energy intensity factor (GJ/m^2) for space heating and domestic hot water in the same sector and location as noted above (Natural Resources Canada). In buildings where the energy source of heating was unknown, natural gas was assumed as a conservative measure. In order to convert annual energy intensity to fuel combustion, estimated average system efficiencies were applied per energy source (100% for electricity, 80% for natural gas, 75% for propane and 75% for heating oil).
- Actual consumption data for petroleum fuels (#2 fuel oil, diesel, etc.) was taken directly from invoices wherever possible. However due to limited campus access from COVID-19, obtaining hard copy invoices for all oil deliveries was not possible. Missing delivery data was estimated using information from McGill's financial database for invoices from oil suppliers. This database only included cost data (not volume of consumption). This required estimation of consumption from cost data using average fuel rates from hard copy invoices on hand for 2019 for similar delivery types. Heating oil and generator fuel deliveries for Macdonald campus share the same purchase order number, which makes it impossible to determine delivery type without having hard copy invoices. Generator fuel usage at Macdonald Campus was estimated using average of the past 3 years of consumption data, and subtracted from total estimated fuel consumption.
- Steam consumption data for the RVH was obtained through steam meter data and meter readings from 2019 MUHC invoices. Total steam consumption was converted into natural gas equivalent by assuming the same distribution efficiency (90%) and combustion efficiency (29 lb/m^3) as for McGill's downtown steam distribution.
- Heating hot water and domestic hot water consumption for the Neuro was obtained from meter readings for 2019 taken from invoices from the MUHC and converted into the natural gas equivalent assuming a distribution efficiency of 95% and combustion efficiency of 90%.
- Chilled water consumption from Second Investment was calculated using a coefficient of performance of 4.0 to determine the electricity consumption corresponding to monthly chilled water invoices.
- Hot water consumption from Second Investment was calculated using an overall efficiency of 90% to determine the volume of natural gas corresponding to monthly hot water invoices. Hot

water data for 2019 was estimated using a regression analysis based on actual historical data from Jan 2015 through March 2017 and extrapolated using HDD 18°C data for 2019.

- Electricity consumption from JAC was estimated using total cost amount invoiced for electric in 2019 and assuming it has a same blended electrical rate as Macdonald Campus ($0.0560/kWh).
- Heating-related natural gas consumption from JAC was estimated for months with missing data using a regression analysis from actual consumption data from Jan 2018 to April 2019. Data was extrapolated for months with missing data using HDD 18°C data for 2019.
- Domestic hot water-related natural gas usage was estimated similar to electricity at JAC, using the known total cost invoiced for hot water and applying an estimated natural gas rate based on JAC heating data.

Vehicle Fleet

- Fuel consumption data for vehicles and mobile equipment at Macdonald Campus was available per vehicle (for Farm and Facilities vehicles), while fuel consumption data for the majority of vehicles and mobile equipment at the Downtown Campus was available aggregated by fuel type (gasoline vs. diesel) in ARI reports. ARI reports aggregate all non-diesel fuels (e.g. ethanol, methanol) into the gasoline total.
- Actual fuel consumption data for a couple vans and light duty vehicles as well as a number of specialized vehicles downtown – including ATVs, boats, snowmobiles, tractors, forklifts and seadoos – was not available from either of the above data sources. Fuel consumption for the van and light duty vehicles were estimated using average fuel efficiency values per fuel type sourced from the ARI report. Fuel consumption for each category of specialized vehicle was estimated using researched fuel efficiency and usage metrics specific to vehicle type.
- All vehicles and mobile equipment were categorized as either “on-road” (e.g. cars, pickup trucks, vans, SUVs and maintenance vehicles) or “off-road” (e.g. tractors, ATVs, forklifts, boats, seadoos and small machinery) to allow the application of emission factors specific to off-road and on-road vehicles. All vehicles included in the ARI fuel reports were considered “on-road”.

Process Gases

- The amount of refrigerant used and lost per system is not directly available. Refrigerant gas loss for various buildings and systems was estimated following the calculation of the total cooling capacity per system (in BTU/hour or tons of refrigeration) using LEED’s methodology and the below assumptions and default values:
    - 2% leakage rate (LEED default value)
    - 10 years equipment lifetime (LEED default value)
    - 10% end-of-life refrigerant loss (LEED default value)
    - Refrigerant charge of 5.0 lbm per ton of cooling

- Using the above data and methodology, the lifetime emissions of the system were calculated and divided by the expected equipment lifetime to estimate annual leakage.
- For refrigeration equipment where the refrigerant gas used was unknown, the most commonly used refrigerant was assumed (R-134a). If no cooling capacity data was available for a piece of equipment, it was not included.

Agriculture and Livestock

- Headcount data and manure management details (e.g. % liquid systems vs. % solid storage & dry lot vs. % pasture, range & paddock vs. % other) was provided for the Macdonald farm per species of livestock.
- Fertilizer data was provided as quantity spread per fertilizer type for the Macdonald farm, Lods Research Centre and Horticultural Centre.
- The EPA's methodology[3] for calculating nitrous oxide emissions from commercial fertilizer was applied to calculate nitrogen content per fertilizer type and resulting emissions.

Commuting

- In their "Transportation Survey Report" (2011), the researchers for Transportation Research at McGill (TRAM) conducted a survey of our community's mobility and commuting habits and calculated average emission factors for annual commuting emissions per student and per staff.
- These emission factors were applied to FY2019 headcount data for students and staff. Note that the 2013 TRAM survey did not include the objective to calculate environmental impacts from commuting, so TRAM 2011 results were applied. A new commuting survey to update emission intensity data for McGill commuters will occur in 2020 and 2021.

Air Travel

- Air travel data was sourced from McGill's expense reporting system, which does not currently request details related to flight origin (only a destination field is included), route, multiple legs or class of travel. The below assumptions were made to account for these gaps in data.
- Flight class was assumed "average" for all flights in absence of information.
- All flights were assumed direct, unless otherwise stated in provided information, in absence of transparency into flight route.
- All flights were assumed to originate from Montreal's Pierre Elliot Trudeau airport (YUL) and return to this airport unless otherwise stated in the "Destination City" data.

[3] https://www3.epa.gov/ttnchie1/ap42/ch14/final/c14s01.pdf

- For “Destination City” entries with multiple destinations listed, flight route was assumed to proceed in the order entered on the expense report.
- For “Destination City” entries that were stated as a whole country or province/state/region (e.g. “France” or “Florida”) and not a specific city, either the capital city or the largest nearby city with an international airport was used, as appropriate.
- Unless stated in the “Destination City” information (e.g. JFK, LHR), airports were determined using the city in the “Destination City” entry and the “TravelMath – nearest major airport” function. The closest international airport was selected as a default unless the closest international airport was a) >400km away or b) located in another country. In these cases, the closest regional airport may have been used.
- A number of flights in the Canada data set were labelled with a “Destination City” of Montreal (various spellings) or MTL. Per the note in the Minerva expense reporting system, which indicates that entries of Destination City - Montreal and Country - Canada are not travel, these entries have been assumed not to be air travel.
- There were also several flights in all three data sets (Canada, USA and International) had non-usable “Destination City” entries (e.g. “Various cities”, “Aug 26”). In absence of usable flight data, a median $/mile was calculated from all usable data per data set and applied to estimate total distance (and haul category) from the cost data for these rows.

Macdonald Shuttle

- Total distance travelled in passenger-km was calculated using ridership data from seasonal reports and the route-specific distance between the downtown and Macdonald campuses.
- Due to strategic contract requirements, the Macdonald shuttle bus now runs on at least 20% biodiesel, aside from during the coldest winter months. The emission factor for 100% biodiesel (EPA) was applied to the biofuel share and the emission factor for diesel buses (EC) was applied to the remaining consumption.

Sports Team Travel

- Varsity team travel data was collected and calculated during summer 2019 from Athletics travel records for 2018. Due to considerations related to COVID-19, 2018 data has been used again for 2019.
- This data included the team, origin and destination of trips, travel mode, number of travelers (for public transit and air) or number of vehicles, and travel date. Total return distance was calculated using Google Maps.
- For taxi travel, an assumption of three people per vehicle was made. It was assumed that all athletes traveled to and from airports by taxi, and that this distance was on average 50km. All taxis and personal vehicles were assumed equivalent to average gasoline cars (EC).

- A new data collection process for varsity team travel has been established with the Athletics department to facilitate accurate team travel data tracking for future inventories.

Water Supply and Treatment

- Annual water input data was available for approximately 54% of Downtown campus buildings and 61% of Macdonald campus buildings (by area). Consumption for the remaining buildings was estimated using average water use intensity factors ($m^3/year/m^2$) specific to each campus. In order to account for water savings achieved since 2016, consumption associated with estimated savings was removed from the Downtown campus' consumption total.
- Water volume attributed to process losses was aggregated with estimated water volume lost to leakage for each campus. Both these values were sourced from an ENV-401 student group's applied research, conducted specifically for this purpose. Total water output volume was then calculated for each campus and assumed equivalent to wastewater treated.

Transmission & Distribution (T&D) Losses

- Electricity lost to transmission & distribution was estimated using average T&D loss factors sourced from the most recent data available (2018) from Statistics Canada for Québec. Metrics for power production, exports, imports, and consumption were used to estimate Québec's T&D loss factor and applied to Downtown, Macdonald and Gault campus consumption. A T&D loss factor from Barbados Light & Power was applied to Bellairs campus consumption.

4. Results

A. Emission Sources: Greenhouse Gas Emissions

Total gross emissions for calendar year 2019 were 58,091 tCO_2e. An additional 25 tCO_2e was generated from biogenic (biodiesel) sources. It is useful to show a breakdown of our emissions by gas, scope and activity because the identification of large emission sources allows us to target these areas for emission reduction initiatives and enables us to track our progress for each emission source over time.

Greenhouse Gas	Emissions (tGHG)	Emissions (tCO_2e)
Carbon dioxide (CO_2)	55,461	55,461
Methane (CH_4)	20	560
Nitrous oxide (N_2O)	1.5	401
Refrigerant R134a	1.1	1,457
Refrigerant R125	0.04	137
Refrigerant R32	0.04	29
Sulphur hexafluoride (SF_6)	0.002	45
Total	**N/A**	**58,091**

Note: For emission factors only available in units of CO_2e, emissions have been wholly attributed to CO_2 in the tGHG column

Table 7. Emissions Breakdown by Greenhouse Gas

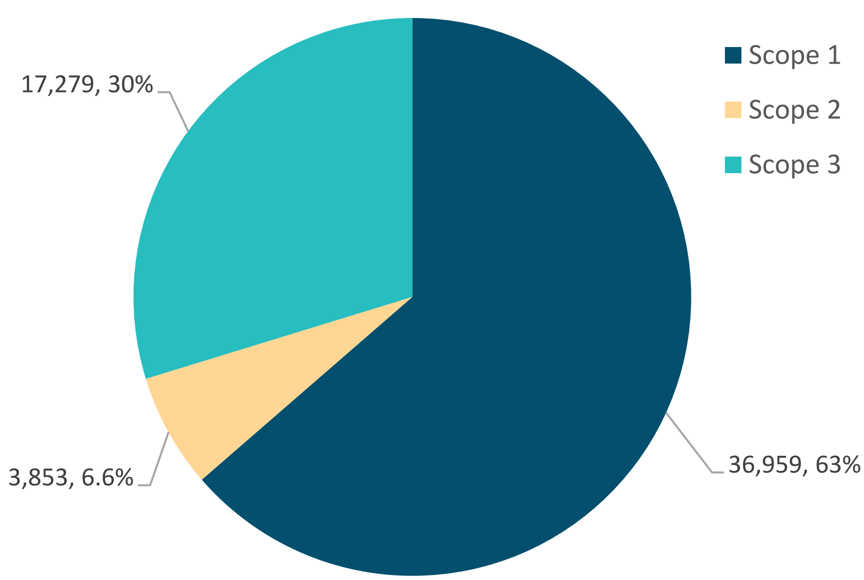


Figure 3. Emissions Breakdown by Scope

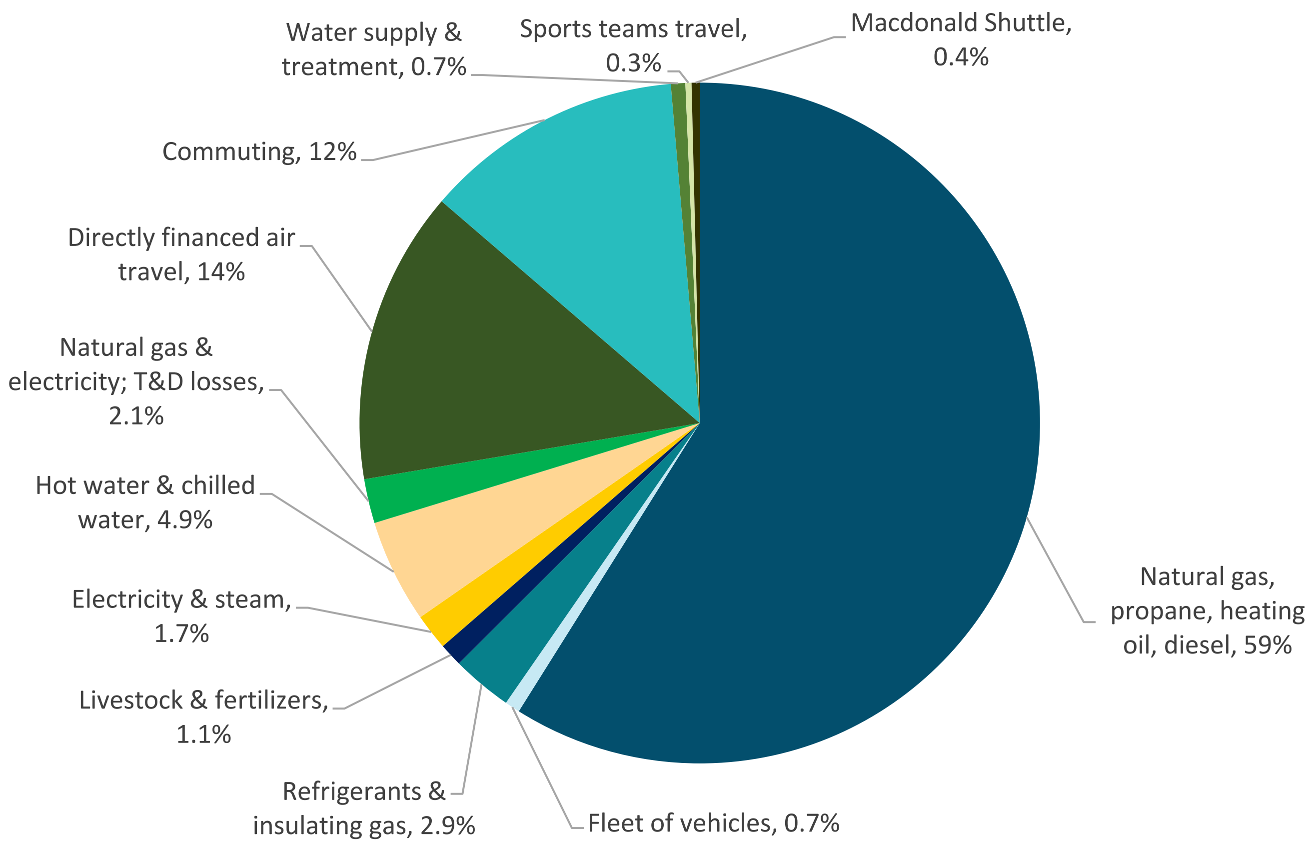


Figure 4. Emissions Breakdown by Activity

Scope 1 sources contributed a significant share – 36,959 tCO_2e (64%) – of McGill's emissions. Building natural gas use - for heating, cooling, and research activities - contributed 33,193 tCO_2e and accounted for the majority (90%) of Scope 1 emissions. Energy efficiency and reduction efforts across our campuses over the past decade have contributed to significant reductions already; to date, absolute emissions from building energy use have decreased over 30% since 1990. Continuing this trend will be critical to achieving carbon neutrality, which is one of the reasons that McGill's 2016 – 2020 Energy Management Plan (EMP)[4] includes a 64% energy GHG reduction target below 1990 by 2021, and an energy use intensity target of 22% reductions below 2012/2013 by 2020/2021. A new EMP will be released in 2020.

An overview of the electricity generation mix of each Canadian province is provided below. Renewable energy dominates the mix in Québec, with 94% of generated electricity produced from hydropower and a further 4.9% derived from other renewable sources such as wind, tidal and solar. This creates the lowest electricity generation intensity in Canada at only 1.2 gCO_2e/kWh. For context, the average Canadian generation intensity is 130 gCO_2e/kWh and in Alberta, the most carbon intensive province, it is 750 gCO_2e/kWh. Due to both the low carbon intensity of Québec's electricity grid and ongoing electricity efficiency initiatives on our campuses, our Scope 2 sources – comprised of electricity consumption and other grid-distributed energy such as steam, hot water and chilled water – accounted for 3,853 tCO2e – only 6.6% of the University's emissions – in 2019.

[4] https://www.mcgill.ca/facilities/utilities/energymanagement

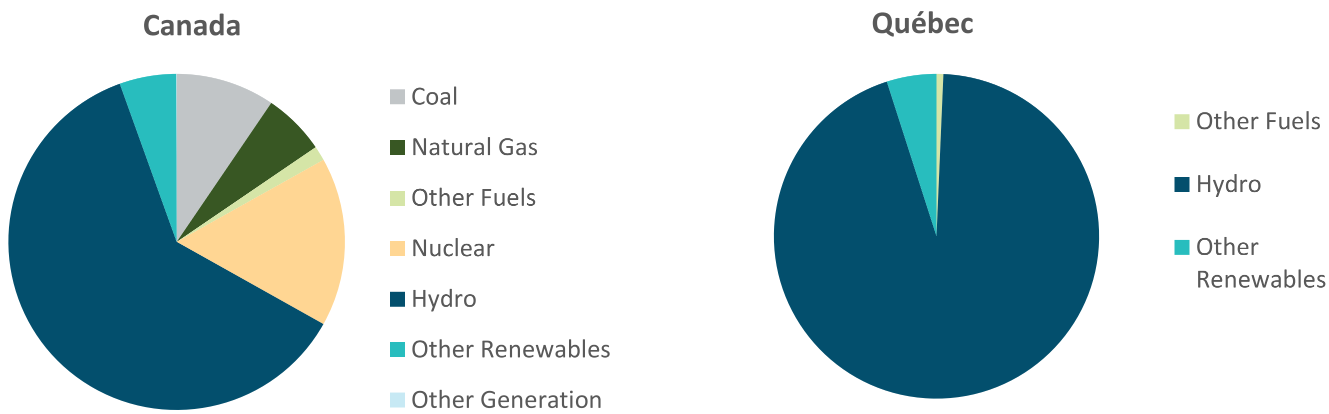


Figure 5. Energy Source Used for Electricity Generation: Canada vs. Québec (GWh)

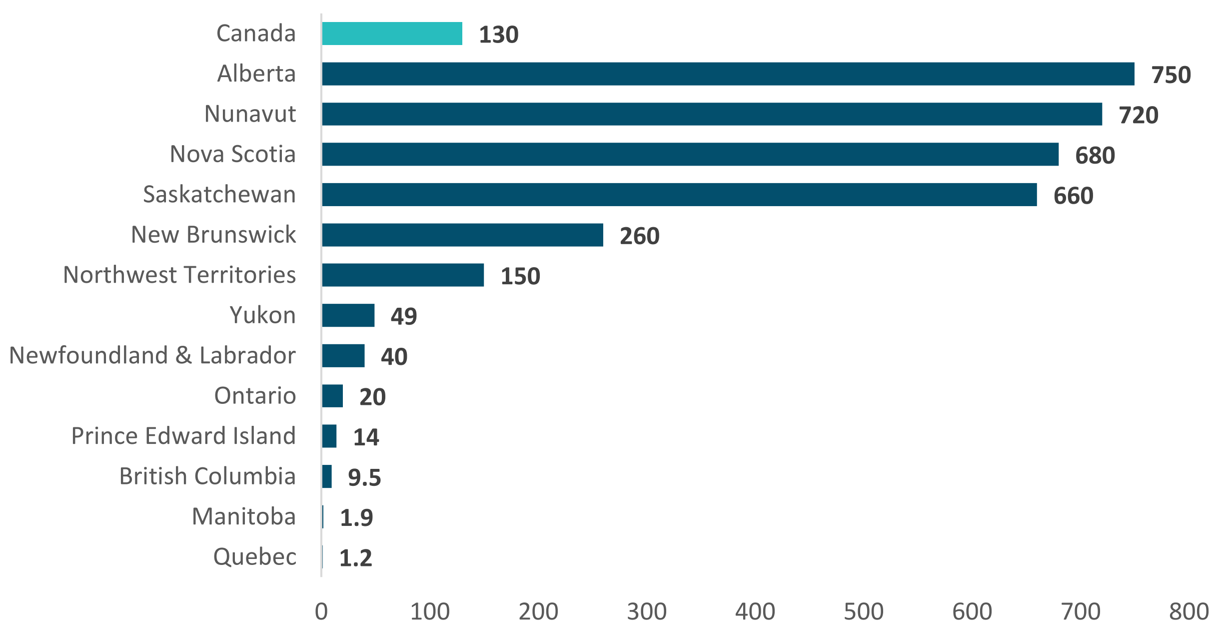


Figure 6. Electricity Generation Intensity by Province (gCO_2e/kWh)

McGill's Scope 3 sources made up the remaining 30% of our footprint, and the majority result from travel. Directly financed air travel accounted for 14% of emissions, while daily commuting by students, faculty and staff contributed over 12%. Together, they account for 88% of Scope 3 emissions.

The table below provides a detailed overview of McGill's emissions in 2019, broken down by scope and activity. In addition, the table displays the information outlined in Table 3 of this report – that is, information that needs to be presented separately from our GHG inventory according to best practice. Specifically, we show emissions that we avoided due to the diversion of our recycled and composted waste from landfill and emissions arising from the loss of refrigerants that are governed by the Montreal Protocol and not the Kyoto Protocol.

Inventory Category	Activity	Activity Level	Unit	Emissions (tCO_2e)	% of Total Emissions
Scope 1 (direct emissions)					
Stationary combustion	Natural gas	17,494,526	m³	33,193	57%
	Propane	0	L	0	0%
	Heating oil	300,340	L	821	1.4%
	Diesel	79,065	L	217	0.4%
McGill-owned fleet of vehicles	Diesel vehicles	86,142	L	235	0.4%
	Gasoline vehicles	76,858	L	183	0.3%
	Propane vehicles	0	L	0	0%
Refrigerants & chemicals	Refrigerants	1,207	kg	1,623	2.8%
	Insulating gas	1.9	kg	45	0.08%
Agriculture	Livestock	6,604	heads	574	1.0%
	Fertilizers	49,067	kg	68	0.1%
Scope 1 - Total				**36,959**	**64%**
Scope 2 (energy indirect emissions)					
Purchased energy	Electricity	174,482,219	kWh	258	0.4%
	Steam	389,439	m³	739	1.3%
	Hot water	1,505,256	m³	2,856	4.9%
	Chilled water	109,031	kWh	0.1	0.0002%
Scope 2 - Total				**3,853**	**6.6%**
Scope 3 (indirect emissions)					
Stationary combustion	Natural gas	629,351	m³	1,194	2.1%
	Electricity	9,964,447	kWh	12	0.02%
Commuting	Faculty & staff	13,112	staff	4,822	8.3%
	Students	32,439	students	2,351	4.0%
Third-party fleet	Macdonald shuttle	75,392	L	223	0.4%
Air travel	Directly-financed air travel	81,316,582	pass-km	8,095	14%
Sports team travel	Air	689,113	pass-km	57	0.1%
	Bus	111,969	pass-km	98	0.2%
	Public transit	144,948	pass-km	10	0.02%
	Taxi & car	23,302	km	4.3	0.007%
Water	Supply	1,862,713	m³	137	0.2%
	Treatment	1,129,156	m³	261	0.4%
Energy losses	Transmission & distribution	10,692,512	kWh	16	0.03%
Scope 3 – Total				**17,279**	**30%**
Total Emissions				**58,091**	**100%**

Non-Inventory Category	Activity	Activity Level	Unit	Emissions (tCO_2e)	% of Total Emissions
Avoided emissions from waste management					
	Solid waste - recycling	540	tonnes	-1,836	-
	Solid waste - composting	340	tonnes	-188	-
Total				**-2,024**	
Refrigerants governed by Montreal Protocol					
	Refrigerants (e.g. R22)	214	kg	286	-
Total				**286**	**-**
Biogenic emissions					
	Macdonald shuttle, biodiesel	10,209	L	25	-
Total				**25**	**-**

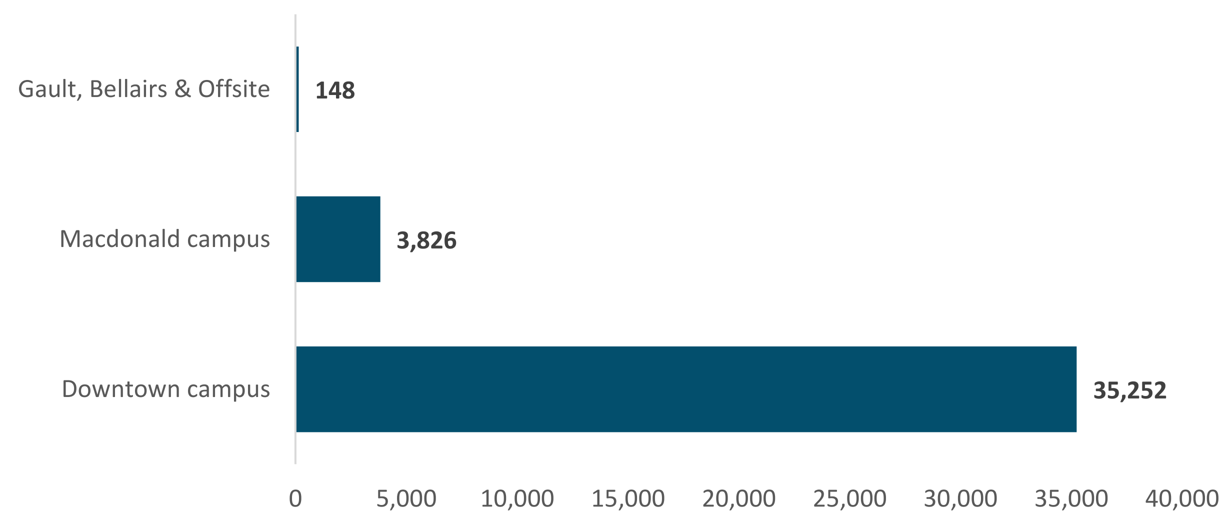
Table 8. 2019 Greenhouse Gas Inventory

Our GHG inventory includes activities from all of our campuses – Downtown, Macdonald, Gault and Bellairs. In addition to geographic location, our campuses also differ in number & type of facilities, predominant energy sources & generation efficiencies, campus activities, and population. It is therefore worthwhile to split emissions arising from energy consumption for each campus. While data is available for other emission sources by campus – such as refrigerant gas loss, vehicle fleet & waste – we've highlighted energy because it comprises such a significant portion of the footprint at each campus.

Location	Electricity (kWh)	Chilled water (kWh-e)	Steam (m^3 NG equivalent)	Hot water (m^3 NG equivalent)	Natural gas (m^3)	Heating oil (L)	Propane (L)	Diesel (L)
McGill								
Scope 1	0	0	0	0	17,494,526	300,340	0	55,153
Scope 2	174,482,219	109,031	389,439	1,505,256	0	0	0	0
Scope 3	9,964,447	0	0	0	629,351	0	0	0
Total	**184,446,666**	**109,031**	**389,439**	**1,505,256**	**18,123,877**	**300,340**	**0**	**55,153**
Per Campus								
Downtown	159,976,156	109,031	389,439	1,485,570	16,527,559	0	0	51,944
Macdonald	17,801,084	0	0	19,685	1,574,959	281,582	0	3,209
Gault Reserve	541,920	0	0	0	0	18,757	0	0
Bellairs	61,123	0	0	0	0	0	0	0
Offsite	6,066,383	0	0	0	21,359	0	0	0
Total	**184,446,666**	**109,031**	**389,439**	**1,505,256**	**18,123,877**	**300,340**	**0**	**55,153**

Table 9. Energy Consumption by Energy Type by McGill Campus

Unsurprisingly, given the number of buildings, campus population, and higher proportion of energy-intensive research labs, energy consumption at the downtown campus is highest and accounts for 90% of McGill's total energy emissions. The Macdonald campus accounts for 9.8% of the remaining energy emissions, while the Bellairs and Gault campuses represent 0.12% and 0.13%, respectively.



Note: "Offsite" refers to the MSARS research station, the ETS-CLUMEQ supercomputer and two properties on de Maisonneuve

Figure 7. Energy Emissions (tCO_2e) by McGill Campus

B. Emission Sinks: Carbon Sequestration

Carbon sequestration refers to long-term removal or capture of carbon dioxide from the atmosphere as a result of biological, chemical or physical processes. McGill owns and stewards a number of different properties and lands, including the Macdonald Campus Farm, Gault Nature Reserve, Morgan Arboretum, Wilder & Helen Penfield Nature Conservancy, Molson Reserve, and Downtown, Macdonald and Bellairs campuses. One of the many benefits and ecosystem services provided by these lands is that they can act as natural carbon sinks due to their ability to store carbon in trees and soils. They are a vitally important solution to climate change and form part of McGill's strategy to mitigate, and adapt to, climate impacts.

McGill's carbon neutrality strategy prioritizes emission reductions, followed by carbon sequestration on our own properties, and lastly offsetting for unavoidable emissions. To understand opportunities to increase carbon sequestration, the first step was to determine the current rate of sequestration. From 2017 to 2019, we supported a thesis project[5] carried out in McGill's Department of Agricultural and Environmental Sciences & Department of Natural Resource Sciences. The goals of this research were to:

- **Evaluate current rate of aboveground forest carbon sequestration** at two forested properties: the Gault Nature Reserve and the Morgan Arboretum
- **Explore potential for increased carbon sequestration** at two managed properties: the Morgan Arboretum and the Macdonald farm

Key results related to the first research goal are presented in the table below. Currently, the Morgan Arboretum and Gault Nature Reserve sequester 2,629 tCO_2e per year, equal to 4.5% of our footprint.

Results	Gault Nature Reserve	Morgan Arboretum	Total
Location	Mont Saint-Hilaire	Sainte-Anne-de-Bellevue	-
Property Type	Unmanaged forest	Managed forest	-
Dominant Tree Species	Maple, beech	Maple, beech	-
Total Area (ha)	1,000	240	**1,240**
# Sample Plots Used	37	34	**71**
Mean Gross Seq. Rate (tC/ha/yr.)	1.96	3.19	**2.58**
Gross Seq. (tC/yr.)	1,877	513	**2,390**
Gross Seq (tCO_2/yr.)	6,882	1,881	**8,763**
Mean Decomposition Rate (tC/ha/yr)	1.77	0.0175	-
Mean Net Seq. Rate (tC/ha/yr.)	0.016	3.17	**1.68**
Net Seq. (tC/yr.)	25	690	**717**
Net. Seq. (tCO_2/yr.)	**95**	**2,533**	**2,629**

Note: Net carbon sequestration accounts for carbon emissions from biomass decomposition

Table 10. Gross and Net Carbon Sequestration on Two of McGill's Forested Properties

It is worthwhile to highlight that while Gault Nature Reserve has a larger forest area with higher annual gross carbon sequestration, the carbon sequestration rate per hectare (net & gross) and annual net

[5] Boushey, I. 2019. "Evaluation of Aboveground Forest Carbon Sequestration for Climate Change Mitigation Targets: A Case Study on McGill University Properties".

carbon sequestration are significantly higher at the Morgan Arboretum. One reason for this is that older growth forests are limited in their capacity to sequester carbon over time as their growth rate decrease with age, compared to managed forests with plantations – such as the Morgan Arboretum – which have younger, fast-growing trees with the capacity to sequester carbon at a greater rate. As such, factors including management, forest age, tree mortality and stand density are contributing to the difference in carbon sequestration. Of course, the Gault Nature Reserve, which is a biosphere reserve and migratory bird sanctuary, is an iconic and critical ecosystem as one of the last stands of primeval forest in the Saint-Lawrence valley. Each of these lands is ecologically significant and contributes to climate mitigation & resilience, biodiversity, and ecosystem services in different ways. The results of this research help us to identify and develop opportunities related to afforestation & carbon sequestration.

Potential to increase carbon sequestration at the Morgan Arboretum and Macdonald Campus Farm was estimated using average net carbon sequestration per hectare calculated specifically for the "Hardwood Plantation" and "Softwood Plantation" forest types at the Arboretum and the area of non-forested, but potentially afforestable, land on these properties under two scenarios. Scenario 1 focuses on areas identified by land managers as potential areas for afforestation: two clearings at the Morgan Arboretum (~10 ha) and three zones at the Macdonald Campus Farm (~8 ha) with limited or non-essential agricultural production or that are relatively inaccessible. Scenario 2 was a thought experiment involving the afforestation of all agricultural areas; this will not be pursued due to the educational, research and operational significance of the Macdonald Campus Farm.

Under Scenario 1, annual sequestration at these two properties could increase from 717 tC/year (2,629 tCO_2e) to 780 tC/year (2,860 tCO_2e) – an increase of 231 tCO_2e/year. At 2019 emission levels, this would offset 4.9% of total GHG emissions. We will use this valuable research, and associated projections, to set a target for increasing sequestration on our lands. We have yet to explore the sequestration status or potential of our forest or agricultural soils – which can be sources or sinks depending on management practices – or the sequestration impacts of urban trees on our Downtown and Macdonald campuses.

C. Sources vs. Sinks: Gross vs. Net Emissions

With the addition of a carbon sink – carbon sequestration of forested properties – into our inventory scope this year, we must now present both gross and net GHG emissions. We will also present these totals with and without biogenic emissions, to allow a full picture of these various areas.

Gross Emissions
58,091 tCO_2e

Net Emissions
55,462 tCO_2e

Figure 8a. Gross vs. Net Emissions
(without biogenic emissions)

Gross Emissions
58,116 tCO_2e

Net Emissions
55,487 tCO_2e

Figure 8b. Gross vs. Net Emissions
(with biogenic emissions)

In future years, we anticipate using offsets to help neutralize certain unavoidable emission sources such as research-related air travel, low intensity emissions from Québec's electricity grid, and a portion of commuting. Offsets will be included in the above analysis as well, factored into the net emissions total.

D. Comparison of Base Year and Current GHG Emissions

As required by the GHG Protocol, McGill must select an inventory base year for which verifiable data is available in order to track emissions over time. McGill's base year is 2015 because the 2015 inventory was the first to comply with the GHG Protocol, relatively complete data sets were available for all material emission sources, and McGill's internal audit team audited the 2015 inventory. Total emissions for the updated 2015 inventory were 59,209 tCO_2e. We have achieved near continuous gross emission reductions since 1990 and our more recent 2015 baseline, the exception being an increase in 2019.

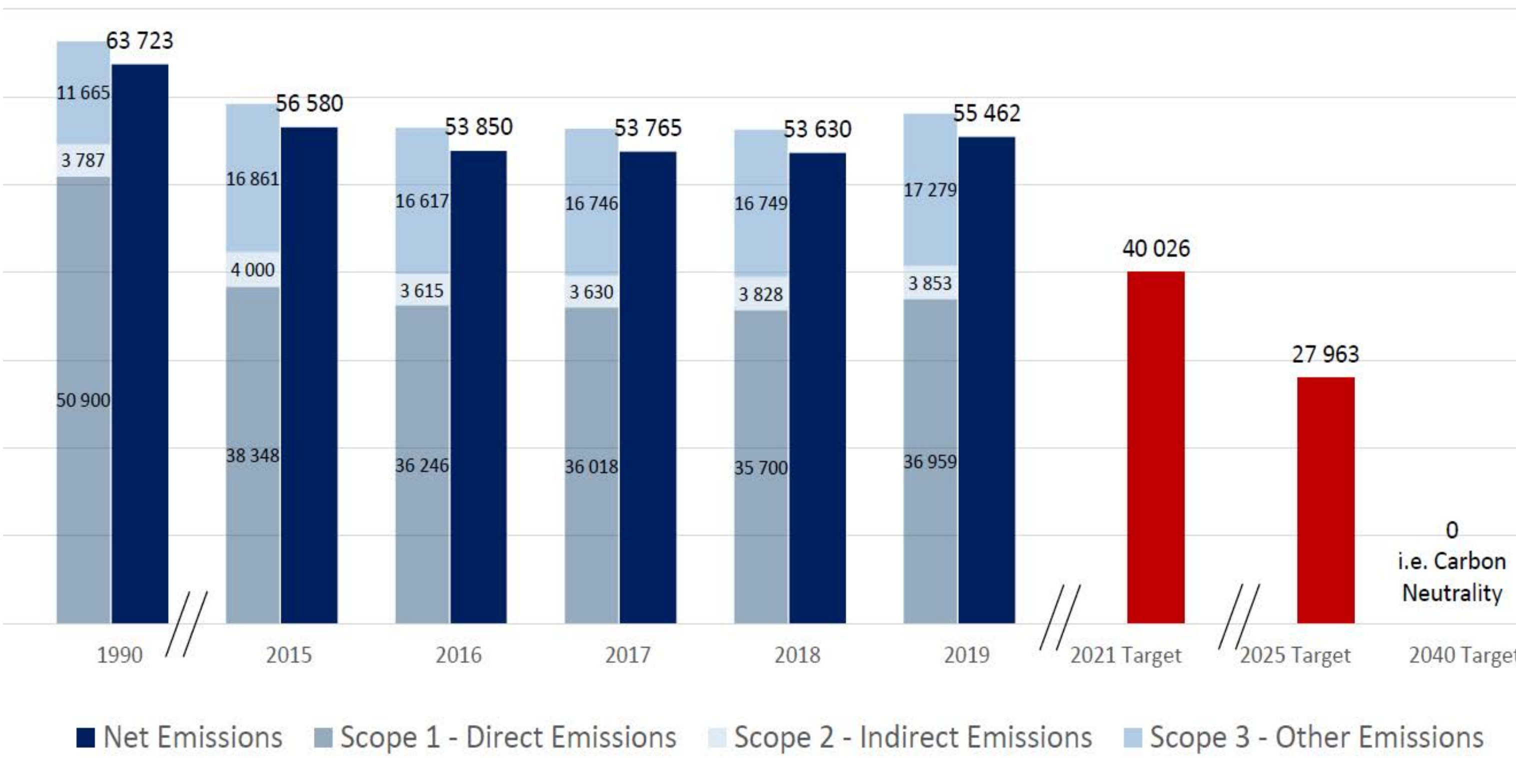


Figure 9. Emissions from 1990 to Present, and Intermediate and Final Reduction Targets

As noted previously, McGill has committed to achieving carbon neutrality by 2040, a commitment that includes the Scope 1, 2 and select Scope 3 emissions shown above. Of course, we should and will also strive to monitor and reduce emissions from other important sources such as procurement and resulting deliveries, our endowment and investments, and construction & other renovation projects. McGill's carbon neutrality target date will be re-assessed every three years to take into account potential changes in regulations, available technologies, carbon markets, and climate conditions that could accelerate our timeline. As noted in the "Vision 2020: Climate & Sustainability Action Plan 2017 – 2020", carbon neutrality initiatives are prioritized in the following order: GHG reductions, carbon sequestration on our own managed lands, and third party carbon offsetting. The below table provides a comparison of data and emissions between the updated 2015 baseline inventory and the 2019 inventory.

Inventory Category	Activity	Emissions (tCO_2e) 2015	2019	Change (tCO_2e)	Change (%)
Scope 1 (direct emissions)					
Stationary combustion	Natural gas	34,334	33,193	-1,142	-3.3%
	Propane	26	0	-26	-100%
	Heating oil	1,184	821	-362	-31%
McGill-owned fleet of vehicles	Diesel	98	217	119	122%
	Diesel vehicles	414	235	-180	-43%
	Gasoline vehicles	207	183	-25	-12%
	Propane vehicles	8.8	0	-8.8	-100%
Refrigerants & chemicals	Refrigerants	1,436	1,623	187	13%
	Insulating gas	47	45	-1.7	-3.6%
Agriculture	Livestock	520	574	55	11%
	Fertilizers	73	68	-5.1	-7.0%
Scope 1 - Total		**38,348**	**36,959**	**-1,389**	**-6.9%**
Scope 2 (energy indirect emissions)					
Purchased energy	Electricity	261	258	-3.0	-1.2%
	Steam	952	739	-213	-22%
	Hot water	2,787	2,856	69	2.5%
	Chilled water	0.2	0.1	-0.06	-30%
Scope 2 - Total		**4,000**	**3,853**	**-147**	**-3.7%**
Scope 3 (indirect emissions)					
Stationary combustion	Natural gas	1,000	1,194	194	19%
	Electricity	14	12	-2.2	-16%
Commuting	Faculty & staff	4,428	4,822	394	9%
	Students	2,277	2,351	74	3.2%
Third-party fleet	Macdonald shuttle	176	223	47	27%
Air travel	Directly-financed air travel	8,223	8,095	-128	-1.6%
Sports team travel	Air	153	57	-97	-63%
	Bus	78	98	19	25%
	Public transit	1.7	10	8.5	493%
	Taxi	0.002	4.3	4.3	199592%
Water	Supply	167	137	-30	-18%
	Treatment	322	261	-62	-19%
Energy losses	Transmission & distribution	20	16	-4.1	-21%
Scope 3 - Total		**16,861**	**17,279**	**-130**	**418**
Total Emissions		**59,209**	**58,091**	**-1,118**	**-1.9%**

Non-Inventory Category	Activity	Emissions (tCO_2e) 2015	2019	Change (tCO_2e)	Change (%)
Avoided emissions from waste management					
	Solid waste - recycling	-1,006	-1,836	830	82.5%
	Solid waste - composting	-114	-188	74	65%
Total		**-1,120**	**-2,024**	**904**	**80.7%**
Refrigerants governed by Montreal Protocol					
	Refrigerants (e.g. R22)	242	286	44	18%
Total		**242**	**286**	**44**	**18%**
Biogenic emissions					
	Macdonald shuttle, biodiesel	N/A	25	25	-
Total		**N/A**	**25**	**25**	**-**

Table 11. 2015 vs. 2019 Greenhouse Gas Inventory

As shown in the table on the previous page, we realized emission reductions of 1,118 tCO_2e in 2019 compared to 2015. However, our emissions increased by 1,832 tCO_2e (3.3%) compared to 2018 and we saw increases across all three scopes. The average temperature in 2019 was 0.9°C colder than in 2018, creating 5.6% more heating degree-days and increasing Scope 1 natural gas consumption and emissions accordingly. We also introduced several heat recovery-capable chillers related to our Smart Energy Grid projects downtown, which increased emissions from refrigerants by 142 tCO_2e. These increases were higher than emissions reductions from heating oil consumption and livestock (due to fewer dairy cows). For Scope 2 emissions, combined decreases in emissions from electricity (-21 tCO_2e), steam (-55 tCO_2e) and chilled water (-0.09 tCO_2e) consumption were less than the increase in emissions from hot water consumption (101 tCO_2e). Importantly, our Scope 3 natural gas & electricity consumption increased significantly due to a large increase in leased space at 2001 McGill and UQAM and the acquisition of significant new leased spaces at 1980 Sherbrooke and Campus1 MTL, creating an additional 573 tCO_2e emissions from natural gas and 3.8 tCO_2e from electricity. Our commuting emissions increased due to an increase in population, and together these increases were larger than the decreases realized in air travel, T&D losses, and from a larger share of biodiesel usage in our inter-campus shuttle.

Progress towards the 2040 carbon neutrality target will display characteristics of a step function, rather than a purely linear function. In other words, there may be minimal progress between some years (e.g. 2016 to 2019) followed by substantial reductions as key reduction measures – such as large-scale energy transformations, fleet conversion measures, sustainable commuting programs, offset programs, and other initiatives – come online. For example, McGill secured $1.8 million in funding from the ECCC's Low Carbon Economy Fund (LCEF) "Champions Stream" in January 2019 in an application process led by Utilities & Energy Management & the Office of Sustainability. Two proposals were successful:

1. **Downtown & Gault Energy Conversion Portfolio:** Features the conversion of one of the natural gas-fired boilers at the Downtown Powerhouse to an electric boiler to be used during off-peak hours and the conversion of the entire Gault Nature Reserve campus from heating oil to electricity using heat pumps and electric boilers.
2. **Downtown District Steam Optimization Portfolio:** Efficiency improvements to the Downtown distribution network involving the installation of heat exchangers to recover heat from combustion flue gases at the Powerhouse.

Taken together, these projects will generate significant and long-lasting emissions reductions of roughly 8,700 tCO_2e per year by 2022. This will reduce our total institutional footprint by around 15%.

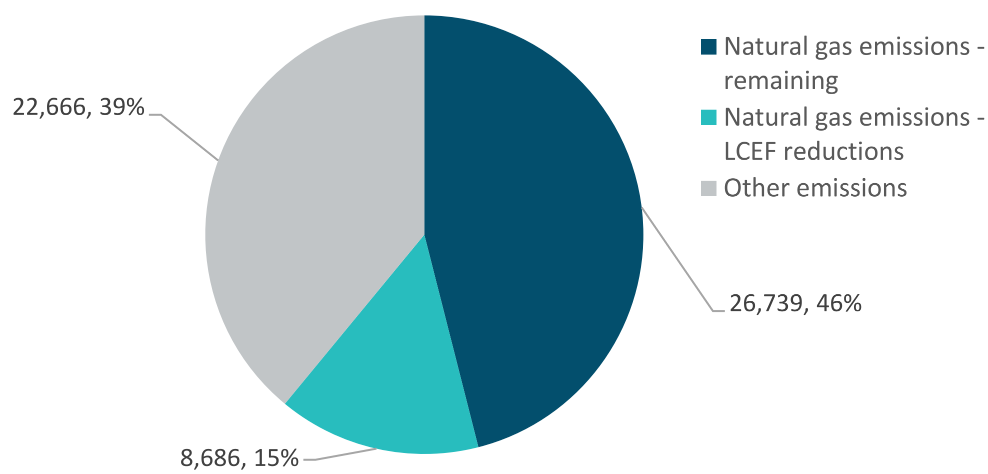


Figure 10. Projected Energy Emission Reductions from Approved LCEF Projects

Reductions projected between 2019 and 2021 are primarily due to emission reductions achieved by the implementation of the Energy Management Plan, including the completion of heat recovery networks, and the two project portfolios funded by the LCEF. Other short to mid-term measures include major projects planned across multiple buildings at Macdonald campus with construction phases tentatively planned to be completed in 2021 and 2022. These will include substantial HVAC and energy efficiency upgrades such as implementation of heat recovery networks and lighting improvements which will have an impact on electricity and natural gas consumption at Macdonald Campus.

Other initiatives include fleet decarbonization efforts such as those supported by the Sustainable Alternatives for Vehicle Replacement (SAVR) initiative. In 2019, the SAVR was instrumental in supporting Buildings & Grounds in the acquisition of several electric vehicles, and a few other replacements are under investigation for 2020. The launch of offsetting initiatives for air travel, beginning in 2020, will help to neutralize unavoidable emissions associated with research and other critical travel and contribute to lower net emissions, and will be tied to actions to reduce institutional air travel mileage and emissions at the source. As a community of conscientious travelers, we need to take action through strategic foresight in planning trips, switching to rail and carpooling for short-haul trips, and opting for videoconferencing. Consult our Sustainable Travel & Mobility Guide for tips, and get involved through the #BecauseIDidntFly campaign.

E. Benchmarking GHG Emissions

Benchmarking emissions is an important exercise to allow comparison between years, against national averages, and amongst peers. This exercise is challenging given the variety of applied methodologies, GWPs, and Scope 3 sources included, and the difference in energy requirements between research-intensive and non-research focused institutions.

In addition to absolute emission reductions, McGill is committed to improving our performance for each of the below key performance indicators (KPIs). This table highlights performance from 2015 to 2019. Note that these calculations (based on what we report to the Ministry of Education) include only building-related Scope 1 and 2 energy emissions. The below metrics are important because they have a significant impact on emissions at research-intensive universities such as McGill. Metrics for the most recent inventory year are in the 2018/2019 column, and these metrics are compared against our 2015 base year in the far right column.

	2015/ 2016	2016/ 2017	% Change (15/16 to 16/17)	2017/ 2018	% Change (16/17 to 17/18)	2018/ 2019	% Change (17/18 to 18/19)	% Change (15/16 to 18/19)
Emissions/student enrolment *tCO_2e/FTE student*	1.12	1.02	-8.9%	1.00	-2.0%	1.02	2.0%	-8.9%
Emissions/gross area *tCO_2e/m^2*	0.045	0.038	-16%	0.040	5.3%	0.041	2.5%	-8.9%
Emissions/endowment *tCO_2e/M$*	24.96	22.18	-11%	23.79	7.3%	20.51	-14%	-18%

Table 12. 2015 vs. 2019 Emission KPIs for McGill

In addition to benchmarking internally, we are also interested in learning from initiatives in place at other institutions, and monitoring KPI performance at institutions similar to McGill. Below is a comparison of McGill's performance across a number of key performance indicators (KPIs) to other peer research universities in Québec, Canada and the northeastern United States. As above, it is important to note that these calculations include only building-related Scope 1 and Scope 2 energy and resulting emissions for each institution, in an effort to standardize the comparison; non-building and Scope 3 sources are not included[6].

	McGill	Rank (out of 9)	U de M	Laval*	Sherbrooke	UBC	U of T	Harvard	MIT	Stanford
	2018/19		*2016/17*	*2016/17*	*2016/17*	*2019*	*2017*	*2018*	*2019*	*2018*
Geographic Region			**Québec**			**Canada**		**United States**		
Emission-Related KPIs										
Emissions/student enrolment *tCO_2e/FTE student*	1.02	5	0.59	0.69	0.36	0.69	1.31	9.70	15.00	3.46
Emissions/gross area *tCO_2e/m^2*	0.041	5	0.035	0.032	0.017	0.023	0.085	0.084	0.143	0.041
Emissions/endowment *tCO_2e/M$*	20.51	4**	67.61	668.30	N/A	23.31	43.69	3.82	7.38	1.68
Energy-Related KPIs										
Energy/student enrolment *GJ/FTE student*	39	6	24	29	26	31	39	181	129	87
Energy/gross area *GJ/m^2*	1.56	7	1.44	1.37	1.24	1.02	1.73	1.56	1.23	1.05
Energy/endowment *GJ/M$*	788	4**	2,776	28,123	N/A	1,042	1,285	71	64	43

** Université Laval endowment numbers for 2017*
*** 4th out of 8, as Université de Sherbrooke endowment metrics were unavailable*

Table 13. Comparison of KPIs for Select Canadian and American Research Institutions

McGill has set a long-term target of achieving STARS Platinum by 2030. Per the STARS accreditation program, McGill's Gold rating (and related STARS data) remained valid for three years and is being updated presently, throughout spring and summer 2020. Once we receive our rating from AASHE, we will include an updated STARS benchmarking analysis in the next GHG inventory, likely for CY2020, which will be completed in spring 2021.

[6] Scope included in KPI calculations is based on what is reported to the Ministry of Education

5. International, National and Regional Context

A. International Context

At the time of writing this report, the world is in the midst of the COVID-19 pandemic. It is truly an unprecedented global health challenge. International and national responses – by governments, the private sector and the plural sector – have proven both how dangerous it is to ignore science and scientists and what is possible when all levels of society rise to meet a crisis head-on. There are innumerable parallels to the climate crisis and to the scope of action needed to confront it.

The ongoing recovery process – and the introspection and reflection associated with it – provide us with an opportunity to change our systems & behaviours in fundamental ways in order to create a future that is healthier, more sustainable and more resilient. Recently, António Guterres, Secretary-General of the United Nations, proposed six actions linked to climate change that will help support this goal[7].

1. Deliver new jobs and businesses through a clean, green transition during recovery spending.
2. Where taxpayer money is used to rescue businesses, require green job and sustainable growth.
3. Drive a shift from the grey to the green economy, and make societies and people more resilient.
4. Invest public funds in the future, not the past, through investment into sustainable sectors and projects that help the environment & the climate. This includes ending fossil fuel subsidies.
5. Incorporate climate risks and opportunities into the financial system as well as all aspects of public policy-making and infrastructure.
6. Work together as an international community.

This is not the first time that lofty statements have been made following a global crisis. During the 2008 financial crisis, there were also plans to "build back better". By and large, these initiatives did not deliver on the promise of a systemic transformation. This time must be different. We must admit that climate change not only increases the likelihood of future global health, economic, biodiversity & humanitarian crises but also exacerbates their impacts. We must seize this moment to take aggressive action on the climate crisis, at every level of society and in all regions. We simply don't have any more time left not to.

The Intergovernmental Panel on Climate Change (IPCC)'s 5th Assessment Report details the emissions reductions needed to achieve each of the potential warming scenarios we face as a global population. Importantly, the IPCC's "Special report on the impacts of global warming of 1.5°C…" (2018) urgently communicates that an unprecedented scale of global action is required immediately – with the next decade being the most critical – if we have a reasonable chance at limiting temperature increase to 1.5°C and averting some of the worst impacts of the deepening climate crisis.

	By 2050	By 2100
Change in CO_2e emissions required to maintain temperature increase below 2°C relative to 1990	*avg. ↓87.5%*	*avg. ↓129%*

Table 14. Average Global Emission Reduction Timelines Corresponding to the 2-Degree Scenario

[7] https://www.un.org/en/observances/earth-day/message

As shown in the below figure[8], climate science indicates that anticipated risks and impacts under the 2°C scenario are too high for vulnerable populations including least developed countries, small-island developing states, and communities dependent on coastal or agricultural livelihoods, and for ecosystems such as coral reefs and the Arctic. The risks highlighted in the report include those to human health, livelihoods, food security, water supply, human security and economic growth.

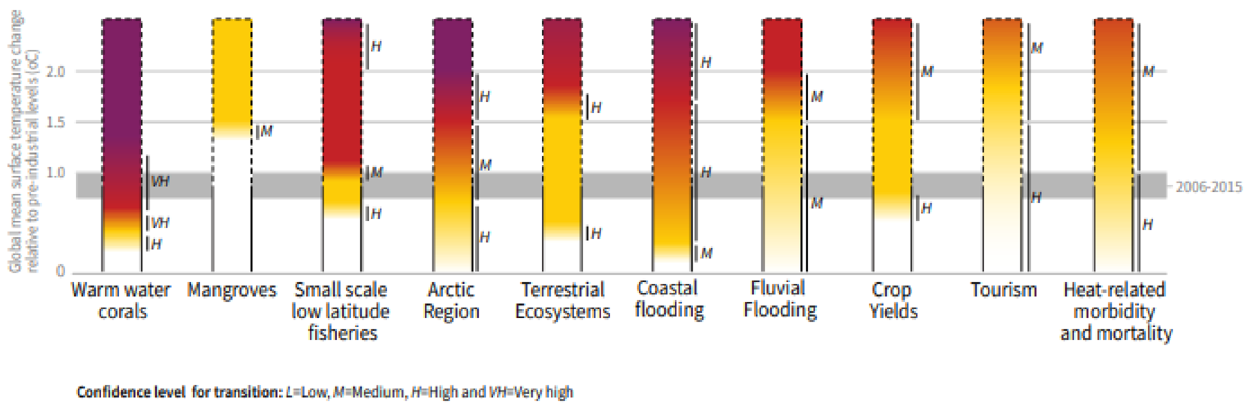


Figure 11. Impacts and Risks for Selected Natural, Managed and Human Systems

McGill's own target of achieving carbon neutrality by 2040 ensures that we remain aligned with the targets of the global scientific community. As seen in the below table, global emissions need to be reduced by almost 90% by 2050 (relative to 1990 levels) to have a likely chance of limiting temperature increase below 2°C. The IPCC special report emphasizes the need to accelerate this timeline, requiring emissions reductions of 45% below 2010 levels by 2030, and achieving net zero emissions by mid-century. As shown in Figure 9 above, McGill has set intermediate targets of 40% below 1990 levels by 2021 and 58% below 1990 levels by 2025. Our long-term target is to achieve carbon neutrality by 2040, with the majority of reductions planned at the source by transforming our energy systems, allowing our travel and consumption habits to evolve, and elevating our waste systems.

B. Canadian Context

Canada emitted 729 MT CO_2e in 2018[9], a 20.9% increase (126 MT CO_2e) since 1990 and almost equivalent to our 2005 levels (difference of only 0.4 MT CO_2e). Emissions increases since 1990 are primarily the result of increased emissions from mining and upstream oil & gas production, as well as transportation. Our current emission levels represent around 1.6% of total global emissions. Importantly, our per capita emissions in Canada are among the highest in the world, alongside Australia and the United States, at between 19.7 and 20.6 tCO_2e/person (depending on source data). Oil & gas and transportation are Canada's two largest sectors in terms of GHG emissions, together contributing 52% of total emissions in 2018.

[8] http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf SPM-13
[9] Canada's "National Inventory Report 1990 – 2018: Greenhouse Gas Sources and Sinks in Canada" (April 2020)

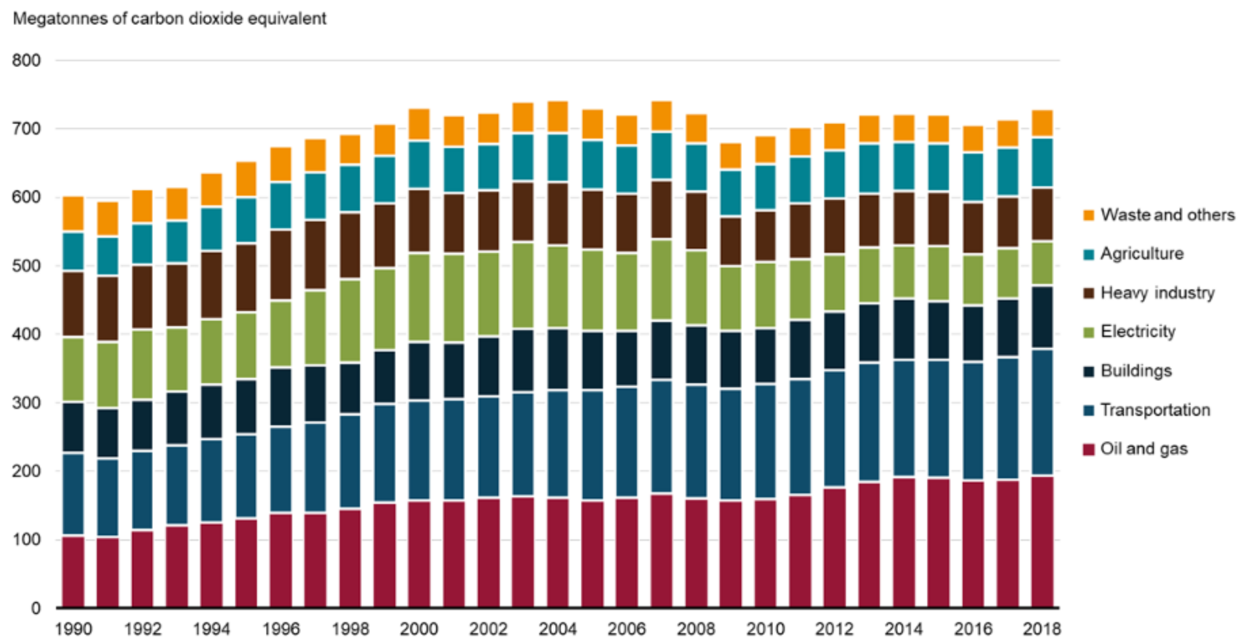


Figure 12. GHG emissions by economic sector, 1990 to 2017[10]

Canada ratified the Paris Agreement in 2016 and committed to an economy-wide target of reducing emissions by 30% below 2005 levels by 2030[11], and 80% below 2005 levels by 2050. As part of our Nationally Determined Contribution (NDC), we also pledged to reduce annual emissions to 12.8 tCO_2e/person by 2030. However, the Deep Decarbonization Pathways Project has determined that to limit warming to 2C above pre-industrial levels, global average per capita emissions need to decrease from 6.2 tCO_2e/person (2012 level) to 1.7 tCO_2e/person by 2050[12]. It is clear that Canadians have a long way to go in terms of decarbonizing our infrastructure, industry, and travel & consumption habits.

Carbon pricing is central to achieving Canada's targets. The federal government's Pan-Canadian Framework on Clean Growth and Climate Change from 2016 states that the benchmark carbon price would start at a minimum of \$10 per tonne CO_2e in 2018, and rise by \$10 each year to \$50/tonne CO_2e in 2022[13]. Since Québec already has a legislated cap-and-trade system in place, it is required under this framework to establish a reduction target equal to or greater than Canada's target of 30% below 2005 levels by 2030 and ensure that annual caps decline to at least 2022. Presently, Québec's target of 37.5% below the 1990 level by 2030 exceeds the federal mandate[14]. Legislation is likely to progress over time. Several provinces have challenged the federal government regarding the constitutionality of the Greenhouse Gas Pollution Pricing Act (GHGPPA), including Saskatchewan and Ontario. Provincial courts have so far sided with the federal government, concluding that the GHGPPA is a legitimate exercise of legislation related to matters of national concern under the "Peace, Order and Good Government" clause of the constitution.

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[10] https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html
[11] http://www4.unfccc.int/ndcregistry/PublishedDocuments/Canada%20First/Canada%20First%20NDC-Revised%20submission%202017-05-11.pdf
[12] https://www.ivey.uwo.ca/cmsmedia/2112500/4462-ghg-emissions-report-v03f.pdf
[13] https://www.canada.ca/content/dam/themes/environment/documents/weather1/20170125-en.pdf
[14] http://www.mddelcc.gouv.qc.ca/changementsclimatiques/engagement-quebec-en.asp

C. Provincial Context

In 2018, Québec contributed 83 MT CO_2e to Canada's emissions and was the third largest emitting province in Canada behind Alberta (273 MT CO_2e) and Ontario (165 MT CO_2e).

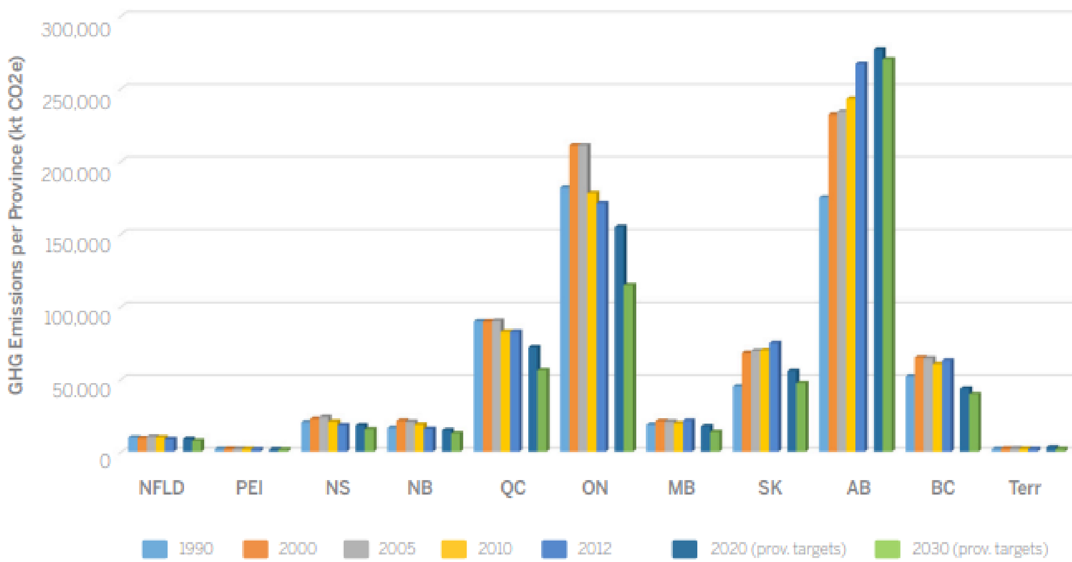

Figure 13. GHG Emissions per Province, 1990 – 2013 and Projected Levels for 2020 and 2030 Targets[15]

However, Québec ranks among the best-performing provinces in terms of per capita emissions at 10 tCO_2e/person. This is largely due to the presence of hydroelectric power generation and fewer large industrial emitters. Québec has set targets of 8.9 tCO_2e/person by 2020 and 6.2 tCO_2e/person by 2030.

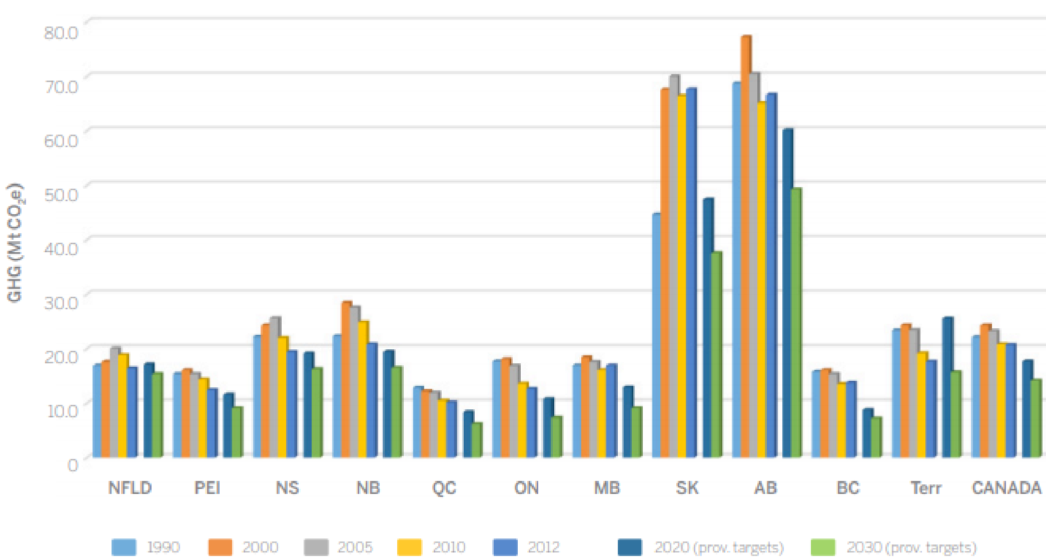

Figure 14. Per Capita Emissions per Province, 1990 – 2013, and Projected Levels for 2020 and 2030 Targets[16]

[15] https://www.ivey.uwo.ca/cmsmedia/2112500/4462-ghg-emissions-report-v03f.pdf
[16] https://www.ivey.uwo.ca/cmsmedia/2112500/4462-ghg-emissions-report-v03f.pdf

D. Municipal Context

Currently, at the time of this report writing in May 2020, Montreal is the epi-centre of the COVID-19 crisis in Canada, has been under a state of emergency as a result since late March, and is in the midst of a historic spring heat wave. The heat wave in particular creates a huge challenge between balancing the risks of the coronavirus – which requires social distancing and self-isolation – against the need for vulnerable individuals to access air-conditioned buildings and splash pads and water access in public parks. Climate forecasting for the island of Montreal shows that events such as heat waves are likely to occur more frequently and for longer durations in future. Clearly, climate adaptation planning for the city must find ways to integrate complex risk interactions such as those presented by public health events in order to successfully increase our resilience against future climate impacts.

At a municipal level, Montreal's targets are to reduce the city's GHG emissions by 30% below 1990 levels by 2020 and by 80% by 2050. The former commitment was made during the 4th Municipal Leaders Summit on Climate Change held in Montreal in December 2005, while the latter came into effect when Montreal ratified the Paris City Hall Declaration[17] in December 2015.

	2009	2020	2050
Montreal's GHG reduction targets, expressed as reductions below 1990 levels	14,090 kt CO_2e	10,509 kt CO_2e *(-30%)*	3,003 kt CO_2e *(-80%)*

Table 15. Montreal's GHG Reduction Targets

The "Sustainable Montreal 2016 – 2020" plan[18] identifies three sustainable development challenges for the city, and the first is "Low-Carbon Montreal". Specific actions to achieve this goal include reducing automobile dependency and encouraging the use of active and public transit; investing in electric vehicle infrastructure; and building and renovating buildings sustainably. The city plans to work with municipal partners to implement these actions effectively and efficiently.

While renewable energy technologies are an important lever to transform energy systems and reduce emissions, they often have a visual impact – solar collectors, photovoltaic panels and even air-source heat pumps are outdoor installations. This poses a challenge in McGill's downtown context where a large portion of the campus falls into historic or environmental heritage areas with municipal by-laws influencing the feasibility of such installations; the Macdonald campus and the Bellairs Research Institute are under fewer constraints in this regard.

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[17] https://www.uclg.org/sites/default/files/climate_summit_final_declaration.pdf
[18] http://ville.montreal.qc.ca/pls/portal/docs/page/d_durable_en/media/documents/plan_de_dd_en_lr.pdf

E. Comparison of Emission Scales

Climate change is a global issue, requiring ambitious international commitment, action and cooperation. Reduction initiatives are required from all areas – governments, businesses, institutions, cities and regions, and individuals – in order to achieve the dramatic changes required within this timeframe. Commitments made by the federal government of Canada, the provincial government of Québec and the city of Montreal will impact McGill's own reduction efforts, since policies implemented at these levels will affect energy generation, building and renovation codes, vehicle market share and efficiency standards, and investment in renewable energy and public transit. It is therefore interesting to visualize the total emissions at each of these levels, to remind us that our efforts at McGill are contributing to widespread efforts across the province and country.

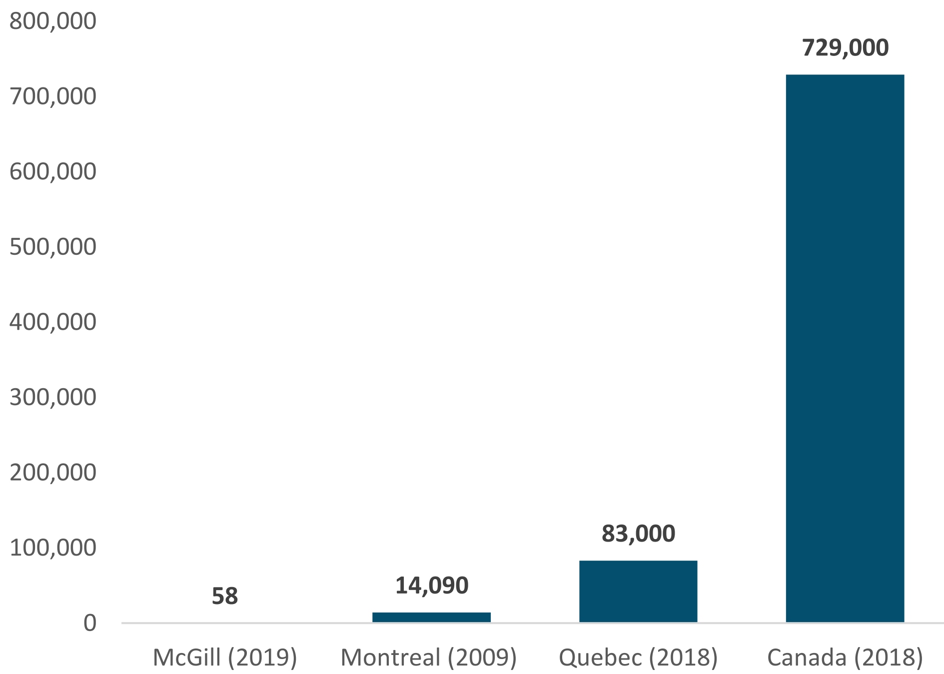

Figure 15. Comparison of Total Emissions for Different Entities ($ktCO_2e$)[19]

[19] Sourced from McGill's 2019 GHG inventory, Sustainable Montreal 2016 – 2020, and Canada's NIR 1990 – 2018

Appendix – Detailed Methodology

1. ON-SITE STATIONARY COMBUSTION

Fuels: natural gas, heating oil, propane, diesel

Activity levels collected from invoices

Equation 1: Calculation of GHG emissions from stationary combustion

$$CO2e = \sum_{i=1}^{n} Fuel_{\ i} \times \left(EF_{CO2,i} \times GWP_{CO2} + EF_{CH4,i} \times GWP_{CH4} + EF_{N2O,i} \times GWP_{N2O}\right)$$

Where:

CO_2e = total 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 (mass or volume) consumed during the reporting period

$EF_{CO2,i}$ is the CO_2 emission factor for activity *i* (same thing for CH_4 and N_2O)

GWP_{CO2} is the global warming potential of CO_2 (same thing for CH_4 and N_2O)

2. PURCHASED STEAM

Fuel: steam supplied by a third party (the MUHC).

Activity level: meter readings

Equation 2: Estimating the natural gas equivalent of purchased steam

$$Natural\ gas\ equivalent = \frac{Steam\ consumption}{Production\ eff. \times Distribution\ eff.}$$

Where:

Natural gas equivalent: natural gas consumption at the MUHC powerhouse to deliver steam to McGill

Steam consumption: as read by McGill's steam meter

Production efficiency: assumed to be 29 lb/m³ of natural gas, i.e. similar to McGill's own powerhouse

Distribution efficiency: assumed to be 90%, i.e. similar to McGill's own steam distribution

The volume thus calculated is then used in ***Equation 1*** to calculate the equivalent CO_2 emissions.

3. PURCHASED HOT WATER

Fuel: hot water supplied by a third party (the MUHC).

Activity level: meter readings

Equation 3: Estimating the natural gas equivalent of purchased hot water

$$Natural\ gas\ equivalent = \frac{Hot\ water\ consumption}{Production\ eff. \times Distribution\ eff.} \times Conversion\ Factor$$

Where:

Natural gas equivalent: natural gas consumption to deliver hot water to McGill

Hot water consumption: as read from energy meters

Production efficiency: assumed to be 90%

Distribution efficiency: assumed to be 95%

Conversion factor: British Thermal Units to cubic meters of natural gas

The volume thus calculated is then used in ***Equation 1*** to calculate the equivalent CO_2 emissions.

4. ON-SITE MOBILE EQUIPMENT

Fuels: diesel, gasoline

For centrally managed vehicles, including Macdonald Farm and FMAS vehicles:

Activity level: from fleet management solution

Equation 4: Calculation of the GHG emissions from mobile combustion

$$CO2e = \sum_{i=1}^{n} Fuel_{\ i} \times \left(EF_{CO2,i} \times GWP_{CO2} + EF_{CH4,i} \times GWP_{CH4} + EF_{N2O,i} \times GWP_{N2O}\right)$$

Where:

CO_2e = total 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 (volume) consumed during the reporting period

$EF_{CO2,i}$ is the CO_2 emission factor for activity *i* (same thing for CH_4 and N_2O)

GWP_{CO2} is the global warming potential of CO_2 (same thing for CH4 and N_2O)

For remaining research and other vehicles:

Activity level: the following assumptions were made:

- Passenger cars: same fuel efficiency as calculated for the centrally-managed fleet of vehicles
- Snowmobiles, seadoos, and ATVs: annual distance travelled was estimated

5. UNCONTROLLED LEAKS OF REFRIGERANTS

Chemicals: different types of refrigerants

Activity level: calculated using the equations below

Equation 5: Calculation of the amount of refrigerant leaked by mechanical systems

$$Ref_{i,j} = RC_{i,j} \times \left(LR_j + \frac{EOL_j}{EL_j}\right)$$

Where:

$Ref_{i,j}$ is the amount of refrigerant *i* leaked by system *j* annually

$RC_{i,j}$ is the charge of refrigerant *i* of system *j*, $RC_{i,j} = CC_j \times UC$

CC_j is the total cooling capacity of system *j*

UC is the unitary charge of refrigerant, assuming 5 lbm of refrigerant per ton of cooling

LR_j is the annual leakage rate of system *j*, assumed to be 2% for all systems

EOL_j is the end of life refrigerant loss of system *j*, assumed to be 10%

EL_j is the equipment life of system *j*, set to 10 years by default

Equation 6: Calculation of GHG emissions from uncontrolled leaks of refrigerants

$$CO2e = \sum_{j=1}^{m} \sum_{i=1}^{n} Ref_{\ i,j} \times \ GWP_i$$

$CO2e$ is the total greenhouse gas emissions from uncontrolled leaks of refrigerant in CO_2 equivalent

Index *i* refers to each type of refrigerant; *n* is the total number of types of refrigerants

Index *j* refers to each mechanical system with refrigerants; *m* is the total number of systems

$Ref_{\ i,j}$ is the amount of refrigerant *i* leaked by system *j* annually as calculated in ***Equation 5***

GWP_i is the global warming potential of refrigerant *i*

6. UNCONTROLLED LEAKS OF ELECTRICAL INSULATING GAS

Chemical: SF_6

Activity level: calculated using an annual leakage rate of 0.5%

Equation 7: Calculation of GHG emissions from uncontrolled leaks of SF_6

$$CO2e = \sum_{j=1}^{m} Mass\ SF6_j \times\ LR \times GWP_{SF6}$$

Where:

$CO2e$ is the total greenhouse gas emissions from uncontrolled leaks of SF_6 in CO_2 equivalent

Index *j* refers to each electrical system which contains SF_6; *m* is the total number of systems

$Mass\ SF6_j$ is the total mass of SF_6 contained in system *j*

LR is the annual leakage rate of SF_6, assumed to be 0.5%

GWP_{SF6} is the global warming potential of SF6

7. FERTILIZERS

Chemicals: different types of fertilizers

Activity level: annual report from Macdonald Campus (Farm, Horticultural Centre, LODS Research Centre)

Equation 8: Calculations of GHG emissions from fertilizers

$$CO2e = \left(\sum_{i=1}^{n} FC_i \times \%N_i \times EC \times \frac{44}{28}\right) \times GWP_{N2O}$$

Where:

Index *i* refers to each type of fertilizer used; *n* is the total number of types of fertilizers used

FC_i is the is the mass of fertilizer spread

$\%N_i$ is the nitrogen content of fertilizer *i*

EC is the emission coefficient and equals 0.0117 tons N_2O-N per ton of N applied

$\frac{44}{28}$ is the molecular weight ratio of N_2O to N_2O as N (i.e., $N_2O \div N_2O$-N)

GWP_{N2O} is the global warming potential of N_2O

8. LIVESTOCK

Activity: different types of farm animals

Activity level: average headcounts estimated for each type of livestock by the manager of the Macdonald Farm

Emissions come from two main sources: enteric fermentation and manure management.

Equation 9: Calculation of GHG emissions from farm animals

$$CO2e = (CH4_{EF} + CH4_{MM}) \times GWP_{CH4} + N2O_{MM} \times GWP_{N2O}$$

Where:

$CO2e$ is the total greenhouse gas emissions in CO_2 equivalent from farm animals

$CH4_{EF}$ is the total CH_4 emissions from enteric fermentation for all animal categories

$CH4_{MM}$ is the total CH_4 emissions from manure management for all animal categories

$N2O_{MM}$ is the total N_2O emissions from manure management for animal categories

GWP_{CH4} and GWP_{N2O} are the global warming potentials of CH_4 and N_2O respectively

Equation 10: Calculation of CH_4 emissions from enteric fermentation

$$CH4_{EF} = \sum_i N_i \times EF_{EF_i}$$

Where:

$CH4_{EF}$ is the total CH_4 emissions from enteric fermentation for all animal categories

Index *i* refers to each animal category

N_i is the total population of each animal category

EF_{EF_i} is the CH_4 emission factor from enteric fermentation for each animal category

Equation 11: Calculation of CH_4 emissions from manure management

$$CH4_{MM} = \sum_i N_i \times EF_{MM_i}$$

$CH4_{MM}$ is the total CH_4 emissions from manure management for all animal categories

Index *i* refers to each animal category

N_i is the total population of each animal category

EF_{MM_i} is the CH_4 emission factor from manure management for each animal category

Equation 12: Calculation of N_2O emissions from manure management

$$N2O_{MM} = \sum_j \sum_i N_i \times N_j \times N_{EX,i} \times EF_j \times \frac{44}{28}$$

$N2O_{MM}$ is the total N_2O emissions from manure management for all animal categories

Index *j* refers to each type of waste management system

Index *i* refers to each animal category

N_i is the total population of each animal category

N_j is the percentage of nitrogen handled by each animal waste management system

$N_{EX,i}$ is the nitrogen excretion rate for each animal category

EF_j is the N_2O emission factor from manure management for each animal waste management system

9. PURCHASED ELECTRICITY

Fuel: electricity generated by Hydro Québec for facilities in Québec and BLPC for facilities in Barbados

Activity level: energy consumption from invoices

Equation 13: Calculation of greenhouse gas emissions from electricity consumption

$$CO2e = \sum_{i=1}^{n} Fuel_{\,i} \times EF_i$$

$CO2e$ is the total greenhouse gas emissions from electricity consumption in CO_2 equivalent

Index *i* refers to each supplier

$Fuel_{\,i}$ is the total electricity purchased from supplier *i*

EF_i is the emission factor for each utility company in g CO_2 equivalent per kWh consumed

10. PURCHASED CHILLED WATER

Fuel: Chilled water supplied by a third party.

Activity level: meter readings

Equation 14: Estimating the electrical equivalent of purchased chilled water

$$Electrical\ equivalent = \frac{Chilled\ water\ consumption}{COP} \times Conversion\ Factor$$

Where:

Electrical equivalent: natural gas consumption to deliver hot water to McGill

Chilled water consumption: as read from energy meters

COP: coefficient of performance, assumed 4.0

Conversion factor: British thermal units to kWh

The volume thus calculated is then used in ***Equation 13*** to calculate the equivalent CO_2 emissions.

11. DIRECTLY-FINANCED AIR TRAVEL

Activity: air travels financed by McGill (faculty, students, and staff)

Activity level: annual compilation of reimbursement claims submitted by all travellers

Equation 15: Calculation of greenhouse gas emissions from directly-financed air travel

$$CO2e = \sum_{i=1}^{n} Distance_{\ i} \times \left(EF_{CO2,i} \times GWP_{CO2} + EF_{CH4,i} \times GWP_{CH4} + EF_{N2O,i} \times GWP_{N2O}\right)$$

Where:

CO2e = total greenhouse gas emissions in CO_2 equivalent

Index *i* refers to each journey

n is the total number of journeys, which excludes entries of “Montreal” in the Canada set, per Minerva expense reporting indications that these entries are not travel-related

$Distance_i$ is the total distance travelled in passenger-km for each journey

$EF_{CO2,i}$ is the CO_2 emission factor for journey *i* (same thing for CH_4 and N_2O)

$EF_{CO2,i}$ has different values depending on the length of the journey leg (short haul <300 miles, medium haul ≥300 miles and <2,300 miles, and long haul ≥2,300 miles) (same applies to CH_4 and N_2O)

GWP_{CO2} is the global warming potential of CO_2 (same thing for CH_4 and N_2O)

12. COMMUTING

Activity: commuting of McGill students, faculty, and staff to and from the two main campuses

Method: emissions calculated in survey from McGill’s School of Urban Planning “Transportation Research at McGill” (TRAM) team and re-adjusted to enrollment and staff headcount, which are updated annually

13. SPORT TEAMS TRAVEL

Activity: sport teams travelling to sports games and competitions

Activity level: total distance travelled by mode per team

Equation 16: Calculation of the greenhouse gas emissions from sport teams travels

$$CO2e = \sum_{i=1}^{n} Distance_{\,i} \times \left(EF_{CO2,i} \times GWP_{CO2} + EF_{CH4,i} \times GWP_{CH4} + EF_{N2O,i} \times GWP_{N2O}\right)$$

Where:

CO2e = total greenhouse gas emissions in CO_2 equivalent

Index i refers to each journey

n is the total number of journey

$Distance_i$ is the total distance travelled in passenger-km for each journey

$EF_{CO2,i}$ is the CO_2 emission factor for journey *i* (same thing for CH_4 and N_2O)

$EF_{CO2,i}$ has different values depending on transportation mode and on the length of the journey leg for air travel

GWP_{CO2} is the global warming potential of CO_2 (same thing for CH_4 and N_2O)

14. WATER SUPPLY

Activity: greenhouse gas emissions related to the treatment and distribution of fresh water by the City of Montréal and the City of Sainte-Anne-de-Bellevue

Activity level: total consumption estimated in water audits of the Downtown and Macdonald campuses

Equation 17: Calculation of greenhouse gas emissions from water supply

$$CO2e = \sum_{i=1}^{n} Water\ Consumption_i \times EF_i$$

Where:

$CO2e$ is the total greenhouse gas emissions from water consumption in CO_2 equivalent

Index *i* refers to each campus

$Water\ Consumption_i$ is the total water consumed on campus *i* in m^3

EF_i is the emission factor applicable to each campus in g CO_2 equivalent per m^3 consumed. These factors were computed by McGill students in an ENV-401 research project.

15. WASTEWATER TREATMENT

Activity: greenhouse gas emissions related to the collection and treatment of wastewater at Montréal's wastewater treatment plant

Activity level: total effluents estimated by ENV-401 student research project

Equation 18: Calculation of greenhouse gas emissions from water supply

$$CO2e = \sum_{i=1}^{n} Wastewater_i \times EF_i$$

Where:

$CO2e$ is the total greenhouse gas emissions from water consumption in CO_2 equivalent

Index *i* refers to each campus

$Wastewater_i$ is the total wastewater from campus i in m^3

EF_i is the emission factor applicable to each campus in g CO_2 equivalent per m^3 consumed. These factors were computed by McGill students

16. POWER TRANSMISSION & DISTRIBUTION (T&D) LOSSES

Activity: electricity transmission and distribution losses

Activity level: calculated from utility invoices (Hydro Québec and BLPC)

Equation 19: Calculation of greenhouse gas emissions from power transmission and distribution losses

$$CO2e = \sum_{i=1}^{n} Fuel_{\ i} \times TDLF_i \times EF_i$$

Where:

$CO2e$ is the total greenhouse gas emissions from electricity transmission and distribution losses in CO_2 equivalent

Index *i* refers to each supplier

$Fuel_{\ i}$ is the total electricity purchased from supplier i

$TDLF_i$ is the average transmission and distribution loss factor for supplier i

EF_i is the emission factor for each utility company in g CO_2 equivalent per kWh consumed

17. SOLID WASTE

Activity: reduction in greenhouse gas emissions from the management of waste generated on the Downtown and Macdonald campuses

Activity level: monthly reports from contracted landfilled waste, recycling and compost suppliers (downtown campus) + estimates for landfilled waste, recycling and compost at Macdonald Campus and landfilled and recycled waste at SHHS.

The difference between the baseline (100% of waste to landfill) and actual (a mix of recycling, composting, and landfilling) disposal streams was calculated using the US EPA’s WARM model. The different categories considered are yard trimmings, mixed paper, mixed recyclables, food waste, and mixed municipal solid waste (MSW).