CONCORDIA UNIVERSITY

2014-2015 GREENHOUSE GAS INVENTORY

DOMINIQUE CROTEAU, SUSTAINABILITY ANALYST
ENVIRONMENTAL HEALTH AND SAFETY
APRIL 2016

DATA AND METHODOLOGY UPDATED BY NOELLE RACINE, SUSTAINABILITY ANALYST
OFFICE OF SUSTAINABILITY
APRIL 2020

REPORT UPDATED BY CASSANDRA LAMONTAGNE, SUSTAINABILITY COORDINATOR
OFFICE OF SUSTAINABILITY
NOVEMBER 2020

TABLE OF CONTENT

Objectives 2
Introduction 2
Summary 3
Highlights 3
Recommendations 4
Methodology 5
Boundaries of the Inventory 5
Global Warming Potential (GWP) and Emission Factor (EF) 7
Calculations 7
Results 12
SCOPE 1 and SCOPE 2 12
SCOPE 3 17
Qualitative Assessment 18
Latent sources 18
Unavailability of data 18
Appendix 1 – List of Buildings and Space Type (SGW & Loyola Campuses) 19
Appendix 2 – Global Warming Potentials (GWPs) and Emission Factors (EFs) 20
Appendix 3 – Internal References for Data 24

CONCORDIA UNIVERSITY – 2015 GREENHOUSE GAS INVENTORY

Objectives

1. Creating a baseline for a Climate Action Plan

In order to decide on actions to take regarding climate mitigation and adaptation, it is important to first understand the current situation which will be used as a baseline for measuring and reporting purposes.

2. Identifying high-impact areas for reducing GHG emissions

The greenhouse gas inventory highlights important emission sources and help shape future discussions around climate-related aspects at the university (e.g. transportation, paper purchasing, waste management, etc.)

3. Communicating results and emission reduction efforts to Concordia's community

The GHG inventory can be used to highlight the impacts of the university's efforts in reducing its GHG emissions over the years since it compares the emissions at different years.

Introduction

Concordia University is committed towards sustainability leadership in higher education institutions. This commitment includes minimizing its greenhouse gas emissions level (i.e. "carbon footprint") through different initiatives such as increased energy efficiency of operations and cleaner energy consumption.

Concordia's 2014-2015 Greenhouse Gas (GHG) Inventory includes direct emissions (e.g. heating fuel consumption) as well as some indirect emissions (e.g. electricity production and transmission, commuting, landfill waste). Beside a quantitative analysis of GHG emissions, a short qualitative analysis is also included in order to raise awareness on potential or latent sources of emissions.

Some information is omitted due to lack of data. For example, indirect emissions from the purchase of food (production, transportation, etc.) were omitted because of the absence of any reliable data.

Summary

In 2014-2015, compared to 2010-2011, there was a decrease in direct (Scope 1) emissions of 7.2% mostly due to the conversion from natural gas to electricity for some systems. This increased indirect emissions from electricity (Scope 2) by 16.8% but overall, there was a decrease of emissions from our energy systems (Scope 1 + 2) since hydro-electricity is a cleaner energy source than natural gas.

	2010-2011		2014-2015		Trend
Scope 1	10143	tonnes CO2e	9412	tonnes CO2e	-7.2%
Scope 2	212	tonnes CO2e	248	tonnes CO2e	16.8%
Total 1+2	**10355**	**tonnes CO2e**	**9660**	**tonnes CO2e**	**-6.7%**
Scope 3	11849	tonnes CO2e	9107	tonnes CO2e	-23.1%
Total (all)	**22204**	**tonnes CO2e**	**18768**	**tonnes CO2e**	**-15.5%**

The emissions of other indirect sources (Scope 3) have been reduced substantially by about 23.1%. This is essentially due to a substantial decrease in emissions from commuting.

Highlights

Buildings:

- Buildings are responsible for 47.7% of overall GHG emissions and make up 95.1% of direct (Scope 1) emissions.
- Overall, emissions from buildings decreased by 6.4%, from 9,567 tonnes CO2e in 2010-2011 to 8,954 tonnes CO2e in 2014-2015.
- Emissions from buildings at the Loyola campus decreased by 20.3%, from 4,954 tonnes CO2e in 2010-2011 to 3,951 in 2014-2015.
- Emissions from buildings at the SGW campus increased by 8.5%, from 4,612 tonnes CO2e in 2010-2011 to 5,003 tonnes CO2e in 2014-2015.

Vehicles:

- Vehicles are responsible for 2.3% of overall GHG emissions.
- Emissions from vehicles increased by 25.2% from 344 tonnes CO2e in 2010-2011 to 431 tonnes CO2e in 2014-2015.
- Concordia Shuttle Buses are responsible for 70-80% of all vehicle emissions.

Refrigerants:

- Refrigerant losses are responsible for 1.5% of overall GHG emissions.
- Emissions from refrigerant losses decreased by 37.8%, from 450 tonnes CO2e in 2010-2011 to 280 tonnes CO2e in 2014-2015.

Scope 3 emissions:

- Measured Scope 3 indirect emissions make up nearly half (48.5%) of our total GHG emissions.
- Measured Scope 3 emissions decreased by 23.1% from 11,849 tonnes CO2e in 2010-2011 to 9, 107 tonnes in 2014-2015.
- Among measured indirect emissions, the largest contributor is personal transportation (excluding public transit) which represents 56.8% of Scope 3 indirect emissions.
- The composition of our waste in landfill is responsible for negligible emissions

Recommendations

In order to facilitate the monitoring and measurements of greenhouse gases at Concordia University, the following recommendations are proposed:

1. Maintain a list of buildings with their respective operational ownership in order to facilitate the calculations of electricity and fossil fuel consumption.
2. Maintain a centralized list of vehicles operating at the university, including vehicles used for academic purposes (e.g. research, transport of art materials).
3. All university vehicles operating on and off campus should have their fuel consumption periodically recorded.
4. When information is available, Scope 3 emissions (indirect emissions other than electricity purchasing) should be included in the inventory to raise awareness on the large quantity of secondary emissions.

Methodology

In the absence of a regulated methodology for greenhouse gas inventory for higher education institutions in Quebec, the current methodology was inspired from the Greenhouse Gas Protocol's Corporate Accounting and Reporting Standard[1]. This standard was adopted by the International Standard Organization (ISO) as the basis for its ISO 14064-1: *Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals*.

Boundaries of the Inventory

Prior to creating a greenhouse gas (GHG) inventory, boundaries of the institution to be included in the inventory must be defined. These boundaries can be temporal, organisational or operational.

a. Temporal Boundaries

Performance year of the inventory: Academic Year 2014 (May 2014 to April 2015)
Baseline year of the inventory: Academic Year 2010 (May 2010 to April 2011)

Future GHG inventories should keep the same baseline and time frame for trend analysis purposes.

b. Organisational Boundaries

Operational Control Approach

Under the operational control approach, a university accounts all GHG emissions from operations over which it or one of its subsidiaries has control, i.e. it has full authority to introduce and implements operating policies and procedures.

For the purpose of performance tracking, such an approach is the most appropriate since managers can only be held accountable for activities under their control.

In order to determine which types of space should be included in the inventory, all buildings on the university campus have been categorized under four potential types of ownership:

1. Spaces owned and used by Concordia (O/U)
2. Spaces owned by Concordia and leased to an external organisation (O/NU)
3. Spaces not owned but used by Concordia (rented from an external organisation) (NO/U)
4. Spaces whose ownership is shared with an external organisation (SHARED)

A detailed list of categorized buildings is found in Appendix 1.

[1] The Greenhouse Gas Protocol (2004) – A Corporate Accounting and Reporting Standard, Revised Edition (http://www.ghgprotocol.org/standards/corporate-standard)

What's included in the inventory?

All spaces owned by the University are included in the GHG inventory, regardless if they are used by Concordia or leased to someone else (category O/U and O/NU). Operations of areas owned by the University but used by tenants can still be controlled through contractual agreements.

All spaces not owned but used by the University are NOT included in the GHG inventory since the University is contractually restricted and does not have full operational control.

For areas with a shared ownership between the University and other organisations, proportional responsibility is acknowledged based on the ratio of surface area owned by the University.

c. Operational Boundaries

Types of emissions

Scope 1 – Direct GHG emissions

- Stationary emissions (e.g. buildings heating with natural gas or heating oil)
- Mobile emissions (e.g. operational vehicles fleet and shuttle bus)*
- Fugitive emissions (e.g. refrigerant losses)
- Internal composting operations (considered as carbon capture)
- Emissions from physical & chemical processes (e.g. dry ice, gaseous CO_2 or CH_4)

*Emissions from external delivery vehicles are not included as they are not under the university's operational control. These emissions should be included in external organisations' GHG inventory.

Scope 2 – Indirect GHG emissions
(from consumption of purchased electricity, heat or steam)

- Electricity purchased from Hydro-Quebec

Scope 3 - Other Indirect GHG emissions
(extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (ex.: T&D losses) not covered in Scope 2, outsourced activities, waste disposal, etc.)

- Solid waste sent to landfill (non-hazardous waste)
- Concordia's community commuting (personal vehicles only, not public transit system)*
- Fossil fuel production (for fuel consumption of vehicles fleet only, not commuting)
- Office paper production (for paper purchased through central purchasing services only)

*This inventory includes emissions occurring from personal transportation only. Emissions from public transit system are not included since they are independent of campus activities.

Assumptions

The following emissions are considered negligible (based on literature review and report of others universities):

1. Emissions from external wastewater treatment ensuing from the university's operations
2. Emissions from external drinking water production consumed at the university
3. Emissions from the transportation of office paper consumed at the university (but production of paper is included)
4. Emissions from the transportation of waste, recycling, and composting

Global Warming Potential (GWP) and Emission Factor (EF)

a. Definitions

Global Warming Potential (GWP): A relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide.

Emission Factor (EF): The average emission rate of a given greenhouse gas for a given source, relative to units of activity (e.g. per unit of volume, of mass, of energy).

b. References

Different references exist for the values of Global Warming Potentials (GWP) and Emission Factors (EF). This is mainly due to an ever increasing body of knowledge regarding climate change but also depends on the reference timeframe (e.g. 20-year or 100-year) that is chosen.

See Appendix 2 for GWP and Emission Factor values used in this inventory.

Calculations

Internal information resources:

- Operational information was gathered internally from different departments and units. A complete list of contact persons is available in Appendix 3.

Scope 1 – Direct GHG emissions

1. Fossil fuel combustion

Direct GHG emissions are calculated for each building and vehicle operated by the university by using the appropriate emission factor for each type of GHG. All GHG emissions are then converted to CO2e (CO_2 equivalent emissions) by using the global warming potential (GWP) of each type of GHG.

For each building/vehicle:

- *CO2e annual emissions = CO_2 annual emissions + (CH_4 annual emissions * CH_4 GWP) + (N_20 annual emissions * N_20 GWP)*

Where, for each building/vehicle:

- *CO_2 annual emissions = Fossil fuel consumed * CO_2 EF for that type of fossil fuel*
- *CH_4 annual emissions = Fossil fuel consumed * CH_4 EF for that type of fossil fuel*
- *etc.*

2. Fugitive sources from refrigerants

Fugitive sources or leaks from air conditioning and refrigeration systems are potential sources of GHG emissions especially considering that some refrigerants have extremely high global warming potential.

Fugitive sources or leaks can occur during normal operations of systems. In order to evaluate the quantity of emissions, the amount of refrigerant added annually in a system is assumed to be equal to the amount of refrigerant that was lost/emitted annually by that same system.

For each type of refrigerant:

- *CO2e annual emissions = Quantity of added refrigerant * specific refrigerant GWP*

3. Internal composting operations

Composting organics at the university can be considered a carbon storage activity even though some greenhouse gases can be emitted during the process. The net result is usually a reduction in equivalent CO_2 emissions if operations are managed in a way that minimizes the amount of methane that is emitted (as opposed to typical anaerobic processes in landfills).

Net composting CO2e emissions = (Collection & Transportation) + (Operations) + (Carbon Storage)

Where:

- *Collection & Transportation = Emissions if composting operations are outside campus. For internal operations, this is assumed to be null.*
- *Operations = Emissions from the transformation process.*
- *Carbon Storage = Negative emissions (i.e. storage) by locking carbon into the compost and enriching carbon-depleted soil. This has been evaluated by the U.S. Environmental Protection Agency (EPA) to*

-0.18 metric tonne of CO2e emissions per metric tonne of organic materials processed into compost [2](i.e. each metric tonne of organic waste diverted for composting locks-in 0.18 metric tonne of CO2e emissions in the soil).

Any CO_2 emitted during the composting process is disregarded and not considered a climate forcing GHG as it is part of the natural growth/decomposition process.

Hence:

*Net composting CO2e emissions = (Quantity of wet organic waste * CH_4 composting EF * CH_4 GWP) +*
*(Quantity of wet organic waste * N_20 composting EF * N_20 GWP) +*
*(Quantity of wet organic waste * [-0.18 tonne of CO2e/tonne])*

4. Physical & Chemical Processes

Some products used in research labs can have a greenhouse effect when emitted. Since no information is available on the actual manipulation of these products, purchased products in a specific year are assumed to have been emitted.

GHG-emitting products considered are:

- Pure CO_2 products (gaseous CO_2 and dry ice)
- Gaseous CH_4

These products' respective emissions are calculated with their respective Global Warming Potential.

Scope 2 – Indirect GHG emissions

1. Electricity production and transmission

Electricity production and distribution is, to some extent, responsible for greenhouse gas emissions even in the case of hydro-electricity (e.g. fossil fuel powered generators, biomass decomposition in reservoirs, etc.). Also, the energy mix for electricity in Quebec includes a very small fraction of non-hydro electricity.

Another GHG emission source in the production and distribution of electricity is the use of sulfur hexafluoride (SF_6) as an interrupting medium in high-voltage circuit-breakers. Even though SF_6 emissions might be very small, it accounts for about 20% of GHG emissions in Quebec's electricity system due to SF_6 extremely high Global Warming potential (GWP).

All electricity consumption is attributed to buildings since even other electricity consuming devices (e.g. electric vehicles) would use electricity from a building's electric outlet.

[2] United States Environmental Protection Agency – Solid Waste Management and Greenhouse Gases, Documentation for Greenhouse Gas Emission and Energy Factors in the Waste Reduction Model (WARM) - Management Practices and Background, Composting.
(http://epa.gov/epawaste/conserve/tools/warm/pdfs/Composting.pdf)

For each building:

- *CO_2e annual electricity emissions =*
  *(Quantity of electricity consumed annually * CO_2 EF for electricity distribution) +*
  *(Quantity of electricity consumed annually * CH_4 EF for electricity distribution * CH_4 GWP) +*
  *(Quantity of electricity consumed annually * N_20 EF for electricity distribution * N_20 GWP) +*
  *(Quantity of electricity consumed annually * SF_6 EF for electricity distribution [in CO2e / kWh]*

Scope 3 – Other indirect GHG emissions

1. Solid waste sent to landfill

When solid waste are sent to a landfill, they decompose under anaerobic decomposition (i.e. without oxygen) and becomes a source of methane emissions. Any CO_2 emissions during decomposition are considered to be part of the normal decomposition cycle of organic material, hence non-climate forcing emissions.

*CO2e landfill emissions = Quantity of waste sent to landfill * CH_4 EF for anaerobic decomposition of landfill waste * CH_4 GWP)*

2. Community commuting (personal vehicles only)

For emissions due to Concordia's community commuting, the following assumption were made:
- Only usage of personal vehicles was considered.
- Users of the public transit system cannot be included since these emissions are outside the operational control of the university (i.e. the vehicles would be emitting regardless if a Concordia user would be using it or not).
- The average light-duty vehicle fuel efficiency was evaluated at 9L / 100km (or 0.09L per km).
- Distance calculated from a modal split survey of Concordia's community (including both students and employee).
- Usage of emission factors for gasoline combustion in light-duty vehicles (Tier 2).

For each group (students and employee)

*CO2e commuting emissions = Total annual distance travelled [km] *Standard light-duty vehicle fuel efficiency [0.09L/km] * { (CO_2 EF for gasoline * CO_2 GWP) + (CH_4 EF for gasoline * CH_4 GWP) + (NO_2 EF for gasoline * NO_2 GWP) }*

3. Fossil fuel production

Fossil fuels used in buildings or vehicles have indirect emissions associated with their production. Associated emissions are calculated in the same way as with fossil fuel consumption above but with a different emission factor associated to their production process instead of their combustion process.

4. Office paper production

The manufacturing process of paper is a source of GHG emissions essentially due to the fact the trees are carbon sinks in nature. Emissions from paper manufacturing varies depending on the amount of post-consumer fibres (PCF) used since fresh pulp necessarily comes from the cutting of trees.

For each proportion of PCF in paper:

*CO2e emissions for paper production = Quantity of paper with X% PCF purchased * CO2e EF for that type of paper with X% PCF*

Results

SCOPE 1 and SCOPE 2

Building Emissions (Scope 1 & 2)

		2010 - 2011		2014 - 2015	
LOYOLA CAMPUS	**Type of emission**	**Source**	**GHG [tonne CO2e]**	**Source**	**GHG [tonne CO2e]**
LOY-North[1]	Direct	Natural Gas	3694.97	Natural Gas	3247.42
	Indirect	Electricity	47.09	Electricity	71.54
LOY-BB & BH	Direct	Natural Gas	18.13	Natural Gas	18.81
	Indirect	Electricity	0.07	Electricity	0.07
LOY-DO	Direct	Natural Gas	441.22	Natural Gas	415.01
	Indirect	Electricity	0.60	Electricity	0.87
LOY-HA-HB-HC[4]	Direct	Natural Gas	0.00	Natural Gas	122.60
	Indirect	Electricity	0.00	Electricity	2.01
LOY-JR	Direct	Natural Gas	0.00	Natural Gas	0.00
	Indirect	Electricity	1.12	Electricity	1.27
LOY-South[2]	Direct	Natural Gas	738.65	Natural Gas	55.88
	Indirect	Electricity	5.01	Electricity	6.98
LOY-TA	Direct	#2 heating oil	7.58	#2 heating oil	8.60
	Indirect	Electricity	0.02	Electricity	0.02
TOTAL-LOYOLA	**Direct (Scope 1)**		**4900.56**		**3868.32**
	Indirect (Scope 2)		**53.91**		**82.75**
	Total		**4954.47**		**3951.07**

		2010 - 2011		2014 - 2015	
SGW CAMPUS	**Type of emission**	**Source**	**GHG [tonne CO2e]**	**Source**	**GHG [tonne CO2e]**
SGW-B	Direct	Natural Gas	0.00	Natural Gas	0.00
	Indirect	Electricity	0.27	Electricity	0.32
SGW-CI	Direct	Natural Gas	31.56	Natural Gas	32.21
	Indirect	Electricity	0.06	Electricity	0.04
SGW-D	Direct	Natural Gas	37.79	Natural Gas	38.96
	Indirect	Electricity	0.04	Electricity	0.04
SGW-EN	Direct	Natural Gas	28.27	Natural Gas	29.25
	Indirect	Electricity	0.13	Electricity	0.08
SGW-EV	Direct	Natural Gas	453.18	Natural Gas	635.28
	Indirect	Electricity	47.18	Electricity	46.15
SGW-FA	Direct	Natural Gas	14.94	Natural Gas	16.40
	Indirect	Electricity	0.03	Electricity	0.02

SGW-FB	Direct Indirect	Natural Gas Electricity	158.21 14.96	Natural Gas Electricity	238.21 14.61
SGW-FG[3]	Direct Indirect	Natural Gas Electricity	0.00 0.00	Natural Gas Electricity	58.90 3.89
SGW-GM	Direct Indirect	Natural Gas Electricity	434.86 12.84	Natural Gas Electricity	322.56 13.97
SGW-GN	Direct Indirect	Natural Gas Electricity	819.27 5.66	Natural Gas Electricity	870.12 7.41
SGW-H	Direct Indirect	Natural Gas Electricity	1571.37 29.47	Natural Gas Electricity	1590.67 29.60
SGW-K	Direct Indirect	Natural Gas Electricity	35.82 0.09	Natural Gas Electricity	43.40 0.09
SGW-LB	Direct Indirect	Natural Gas Electricity	77.63 25.43	Natural Gas Electricity	67.33 25.81
SGW-M	Direct Indirect	Natural Gas Electricity	14.42 0.04	Natural Gas Electricity	20.05 0.04
SGW-MB	Direct Indirect	Natural Gas Electricity	66.26 13.31	Natural Gas Electricity	140.41 14.22
SGW-MI	Direct Indirect	Natural Gas Electricity	0.00 0.04	Natural Gas Electricity	0.00 0.03
SGW-MT	Direct Indirect	Natural Gas Electricity	66.24 0.12	Natural Gas Electricity	94.66 0.12
SGW-MU	Direct Indirect	Natural Gas Electricity	32.91 0.04	Natural Gas Electricity	31.26 0.03
SGW-P	Direct Indirect	Natural Gas Electricity	22.35 0.03	Natural Gas Electricity	19.27 0.03
SGW-PR	Direct Indirect	Natural Gas Electricity	38.00 0.05	Natural Gas Electricity	40.98 0.05
SGW-Q	Direct Indirect	Natural Gas Electricity	14.42 0.02	Natural Gas Electricity	11.38 0.03
SGW-R	Direct Indirect	Natural Gas Electricity	16.05 0.04	Natural Gas Electricity	19.85 0.03
SGW-RR	Direct Indirect	Natural Gas Electricity	0.00 0.31	Natural Gas Electricity	0.00 0.32
SGW-S	Direct Indirect	Natural Gas Electricity	15.07 0.07	Natural Gas Electricity	17.57 0.05
SGW-SB	Direct Indirect	Natural Gas Electricity	136.67 0.97	Natural Gas Electricity	136.23 1.01
SGW-T	Direct Indirect	Natural Gas Electricity	13.89 0.05	Natural Gas Electricity	15.47 0.05
SGW-TD	Direct Indirect	Natural Gas Electricity	78.01 0.38	Natural Gas Electricity	63.29 0.24

SGW-V	Direct	Natural Gas	19.72	Natural Gas	28.99
	Indirect	Electricity	0.05	Electricity	0.03
SGW-VA	Direct	Natural Gas	228.34	Natural Gas	223.69
	Indirect	Electricity	6.69	Electricity	6.93
SGW-X	Direct	Natural Gas	10.44	Natural Gas	11.97
	Indirect	Electricity	0.05	Electricity	0.06
SGW-Z	Direct	Natural Gas	18.15	Natural Gas	19.03
	Indirect	Electricity	0.06	Electricity	0.06
TOTAL-SGW	**Direct (Scope 1)**		**4453.82**		**4837.40**
	Indirect (Scope 2)		**158.50**		**165.38**
	Total		**4612.33**		**5002.78**

Notes: 1. LOY-North includes the following buildings: AD, CC, CJ, FC, PS, PT, PY, RF, SC, SH, SP, VE, VL, GE
2. LOY-South includes the following buildings: PC, RA, PB and athletics fields
3. SGW-FG: The values for 2010 were included with the SGW-FB. The operational boundary for SGW-FG and SGW-FB changed between 2010 and 2014 (i.e. different surface area ownership)
4. In 2010, LOY-HA-HB-HC values were included in LOY-North

Buildings Summary

		2010 - 2011	2014 - 2015
		GHG [tonne CO2e]	GHG [tonne CO2e]
TOTAL-BUILDINGS	**Direct (Scope 1)**	**9354.39**	**8705.72**
	Indirect (Scope 2)	**212.41**	**248.13**
	Total	**9566.80**	**8953.86**

Vehicle Emissions (Scope 1)

<table>
<tr><th></th><th></th><th>2010 - 2011</th><th>2014 - 2015</th></tr>
<tr><th>Vehicles</th><th>Department/Unit</th><th>GHG [tonne CO2e]</th><th>GHG [tonne CO2e]</th></tr>
<tr><td>Dodge Grand Caravan (2010)</td><td>Athletics</td><td>0.00</td><td>6.65</td></tr>
<tr><td>Varsity Coach Buses</td><td>Athletics</td><td>13.07</td><td>13.07</td></tr>
<tr><td>Toyota Tacoma V6 (2012)</td><td>Biology</td><td>0.00</td><td>3.36</td></tr>
<tr><td>Ford F150 Supercrew (2010)</td><td>Biology</td><td>5.34</td><td>5.34</td></tr>
<tr><td>Jeep Patriot (2009)</td><td>Biology</td><td>0.00</td><td>0.62</td></tr>
<tr><td>Chevrolet Express Cutaway (1999)</td><td>Distribution</td><td>2.37</td><td>4.96</td></tr>
<tr><td>Chevrolet Express Cutaway (1999)</td><td>Distribution</td><td>1.80</td><td>5.55</td></tr>
<tr><td>Dodge Caravan (2008)</td><td>Distribution</td><td rowspan="2">2.01</td><td rowspan="2">5.24</td></tr>
<tr><td>Ford Escape Hybrid (2010)</td><td>Distribution</td></tr>
<tr><td>Dodge Sprinter 2500 (2006)</td><td>Distribution</td><td>2.99</td><td>6.34</td></tr>
<tr><td>John Deere Snowplough</td><td>Distribution</td><td>0.11</td><td>0.16</td></tr>
<tr><td>Freightliner MCV (1997)</td><td>Distribution</td><td>3.75</td><td>4.56</td></tr>
<tr><td>GMC 5500 (2005)</td><td>Distribution</td><td>5.28</td><td>6.92</td></tr>
<tr><td>Ford DRW 550 (2000)</td><td>Distribution</td><td>6.72</td><td>8.71</td></tr>
<tr><td>Concordia Shuttle Buses</td><td>Facilities (SGW)</td><td>272.30</td><td>308.29</td></tr>
<tr><td>Chevrolet Express (2000)</td><td>Facilities (Loyola)</td><td rowspan="2">6.34</td><td rowspan="2">10.94</td></tr>
<tr><td>GMC Sierra (2006)</td><td>Facilities (Loyola)</td></tr>
<tr><td>Ford F350 4x4 (2005)</td><td>Facilities (Loyola)</td><td rowspan="5">7.23</td><td rowspan="5">12.57</td></tr>
<tr><td>Ferris Tractor IS4500 (2010)</td><td>Facilities (Loyola)</td></tr>
<tr><td>John Deere Pepin (1992)</td><td>Facilities (Loyola)</td></tr>
<tr><td>John Deere Lawnmoyer (1992)</td><td>Facilities (Loyola)</td></tr>
<tr><td>John Deere Trail-gator HPX (2005)</td><td>Facilities (Loyola)</td></tr>
<tr><td>Toyota Tacoma (2011)</td><td>Geography</td><td>0.00</td><td>2.16</td></tr>
<tr><td>Toyota RAV4 (2009)</td><td>Geography</td><td>0.00</td><td>4.37</td></tr>
<tr><td>Ford F150-XLT (2009)</td><td>Mech. & Ind. Eng. /SAE</td><td>2.54</td><td>6.70</td></tr>
<tr><td>Chevrolet Suburban (2000)</td><td>Mech. & Ind. Eng. /SAE</td><td>2.46</td><td>6.48</td></tr>
<tr><td>Chevrolet Equinox (2005)</td><td>Parking Services</td><td>5.15</td><td>4.44</td></tr>
<tr><td>Mazda 5 GS (2010)</td><td>Security</td><td>2.98</td><td>1.94</td></tr>
<tr><td>Dodge Grand Caravan (2015)</td><td>Theatre</td><td>0.00</td><td>1.62</td></tr>
<tr><td>Dodge Grand Caravan (2007)</td><td>Theatre</td><td>1.67</td><td>0.00</td></tr>
<tr><td colspan="2">TOTAL-VEHICLES</td><td>344.10</td><td>430.98</td></tr>
</table>

Note: - Vehicles without emissions for 2010 have been acquired later on. Vehicles without emissions for 2014 have been given away prior to that year.
- Emissions from ice resurfacing vehicles are included in the respective building which supplied the natural gas.

Physical and Chemical Processes (Scope 1)

Physical & Chemical Processes	Source	2010 - 2011 GHG [tonne CO2e]	2014 - 2015 GHG [tonne CO2e]
Gaseous CO2	Research labs	0.45	0.79
Dry Ice (Solid CO2)	Research labs	0.71	0.17
Gaseous CH4	Research labs	0.58	0.00
TOTAL - PHYSICAL PROCESSES		**1.74**	**0.96**

Fugitive Emissions from Refrigerants (Scope 1)

Fugitive Emissions (Refrigerants)	Source	2010 - 2011 GHG [tonne CO2e]	2014 - 2015 GHG [tonne CO2e]
HCFC-22	Cooling systems	449.46	49.10
HFC-134a	Cooling systems	0.00	34.38
HFC-404a	Cooling systems	0.00	51.12
HFC-407a	Cooling systems	0.00	144.94
TOTAL-REFRIGERANTS		**449.46**	**279.54**

Internal Composting Operations (Scope 1)

Internal Composting	Source	2010 - 2011 GHG [tonne CO2e]	2014 - 2015 GHG [tonne CO2e]
Wet organic waste	Waste bins	-6.93	-4.86
TOTAL - INTERNAL COMPOSTING		-6.93	-4.86

Note: Composting is considered a carbon storage activity with negative net emissions.

SCOPE 3

Waste (Scope 3)

Waste	Source	2010 - 2011 GHG [tonne CO2e]	2014 - 2015 GHG [tonne CO2e]
Landfill Waste[3]	Anaerobic Decomp.	**4.63**	**3.33**
TOTAL - WASTE		**4.63**	**3.33**

Commuting (Scope 3)

Commuting	Source	2010 - 2011 GHG [tonne CO2e]	2014 - 2015 GHG [tonne CO2e]
Student	Private vehicle	5251.38	3658.68
Employee	Private vehicle	2456.76	1518.52
TOTAL - COMMUTING		**7708.14**	**5177.20**

Fuel- & Energy-related Activities (Scope 3)

Fuel- & Energy-related Activities	Source	2010 - 2011 GHG [tonne CO2e]	2014 - 2015 GHG [tonne CO2e]
Natural gas	Buildings	3,893.39	3,622.77
Gasoline	Vehicles	16.23	34.88
Diesel	Vehicles	133.82	153.69
Light fuel oil	Buildings	2.40	2.72
TOTAL - FUEL & ENERGY		**4045.84**	**3814.06**

Office Paper Production (Scope 3)

Office Paper Production	Source	2010 - 2011 GHG [tonne CO2e]	2014 - 2015 GHG [tonne CO2e]
Virgin paper (0% PCF)	Purchasing Services	13.09	18.87
30% PCF paper	Purchasing Services	77.13	27.40
50% PCF paper	Purchasing Services	0	62.98
100% PCF paper	Purchasing Services	0	3.19
TOTAL - PAPER PRODUCTION		**90.22**	**112.44**

[3] ADDENDUM: Due to a unit conversation error as well as an error in the emissions factor used, the previously reported figures for landfill waste were 5615.5 tonnes CO2e in 2010-2011 and 4252.7 tonnes CO2e in 2014-2015.

Qualitative Assessment

Many potential sources of emissions are not captured by this GHG inventory. Some sources might have a latent potential for emitting greenhouse gases which should be acknowledged while for other sources, the information regarding emissions is simply not available. Acknowledging these sources in a qualitative manner helps to highlight operational areas that should be monitored or where data acquisition should be facilitated.

Latent sources

Ed Meagher Arena (Loyola Campus) – Refrigeration System

The modernized arena features the latest and most cutting-edge technology on the market today — a more eco-friendly ice refrigeration system using carbon dioxide (CO_2) instead of ammonia. While the CO_2 refrigeration system is a closed system and does not produce GHG emissions, a potential system failure could let the CO_2 leak. If such event was to happen, it should be recorded in a GHG inventory.

Buildings' Air Conditioning and Refrigeration Systems

While system losses are recorded in the current GHG inventory (by recording the amount of refrigerant used in refilling the system), it should be noted that all systems have a charge quantity of refrigerant. As in the case for the arena's refrigeration system, any refrigeration system failure should be recorded.

Unavailability of data

Food Purchasing

Due to the complexity of the supply chain, the exact amount of GHG emissions for food production and transportation is unknown. Sustainable food habits (e.g. consumption of local and/or organic products) can reduce the climate change impact of the food supply chain even though the exact quantity of GHG emissions is usually unknown.

Hazardous Waste Disposal

Emissions from hazardous waste disposal are not included in the GHG inventory especially due to the low operational control over the rigid legal procedure but also due to a lack of data. The disposal of hazardous waste that stems from the university's operations (mostly from research activities) is done through a specialized contractor who do not necessarily record all data pertaining to the GHG emissions of its operations (e.g. incineration of waste).

Business Travel

Emissions from faculty/staff travelling for research and business purposes (conferences, meetings, etc.) are not included due to a lack of information on the effective distance travelled. Reported travel expenses rarely include the exact distance that is travelled. Furthermore, faculty travels is usually not part of the university's operational control, especially when paid through external research grants.

Appendix 1 – List of Buildings and Space Type (SGW & Loyola Campuses)

GREEN	**To be FULLY included**
YELLOW	**To be PARTIALLY included**
RED	**NOT to be included**

SGW	O/U	O/NU	NO/U	SHARED
B	X			
CB			X	
CI	X			
CL			X	
D	X			
EN	X			
EV	X	X		
FA	X			
FB	X	X		
FG	X	X	X	X
GM	X	X		X
GN	X			
H	X			
K	X			
LB	X			
M	X			
MB	X	X		
MI	X			
MT	X			
MU	X			
OS			X	
P	X			
PR	X			
Q	X			
R	X			
RR	X			
S	X			
SB	X	X		
T	X			
TD	X	X		
V	X			
VA	X			
X	X			
Z	X			

LOYOLA	O/U	O/NU	NO/U	SHARED
AD	X			
BB	X	X		
BH	X	X		
CC	X			
CJ	X			
DO	X	X		
FC	X			
GE	X			
HA	X			
HB	X			
HC	X			
JR	X			
PC	X			
PS	X			
PT	X			
PY	X			
RA	X			
RF	X			
SC	X			
SH	X			
SI			X	
SP	X			
TA	X			
VE	X			
VL	X			

O/U = Spaces owned and used by Concordia
O/NU = Spaces owned by Concordia and leased to an external organisation
NO/U = Spaces not owned but used by Concordia (rented from an external organisation)
SHARED = Spaces shared with an external organisation (shared ownership)

Appendix 2 – Global Warming Potentials (GWPs) and Emission Factors (EFs)

Global Warming Potentials (GWPs)			
	Value	**Unit**	**Reference**
CO_2	1	kg CO_2e / kg CO_2	IPCC AR5 (2013), 100-year
CH_4	86	kg CO_2e / kg CH_4	IPCC AR5 (2013), 20-year
N_2O	298	kg CO_2e / kg N_2O	IPCC AR5 (2013), 100-year
(Refrigerants)			
HCFC-22	5280	kg CO_2e / kg HCFC-22	IPCC AR5 (2013), 20-year
HFC-32	2430	kg CO_2e / kg HFC-32	IPCC AR5 (2013), 20-year
HFC-125	6090	kg CO_2e / kg HFC-125	IPCC AR5 (2013), 20-year
HFC-134a	3790	kg CO_2e / kg HFC-134a	IPCC AR5 (2013), 20-year
HFC-143a	6940	kg CO_2e / kg HFC-143a	IPCC AR5 (2013), 20-year
HFC-404a (blend)	6440	kg CO_2e / kg HFC-404a	IPCC AR5 (2013), 20-year & U.S. EPA
HFC-407a (blend)	4438	kg CO_2e / kg HFC-407a	IPCC AR5 (2013), 20-year & U.S. EPA

Notes on Global Warming Potential (GWPs)

- Values from IPCC AR5 (2013), Chapter 8 Anthropogenic and Natural Radiative Forcing, Table 8.7 (p.714).
- GWPs values are those with climate-carbon feedback as it is considered a more consistent methodology (IPCC AR5, p.717).
- GHG not found in Table 8.7 have values from Table 8.A.1 (p.731) but do not include climate-carbon feedback (not available).
- GHG with a short lifetime in the atmosphere (<50 years) are using the GWP values at 20 years.
- For methane (which has an atmospheric lifetime of 12 years), it makes much more sense to use the GWP at 20 years instead of 100 years. Discussions on this subject can be found at:
  1. http://www.scientificamerican.com/article/how-bad-of-a-greenhouse-gas-is-methane/
  2. http://www.eenews.net/assets/2014/07/30/document_gw_02.pdf
  3. http://westcoastclimateforum.com/casestudy/global-warming-potential-gwp-factor

Emission Factors (EFs)		Value	Unit	Reference
		Value	Unit	Reference
Natural Gaz (Combustion)				
Stationary				
	CO2 intensity	1.887	kg / m3	Environment Canada (2015), Part 2, A6.1, p.194
	CH4 intensity	3.7E-05	kg / m3	Environment Canada (2015), Part 2, A6.1, p.194
	N2O intensity	3.5E-05	kg / m3	Environment Canada (2015), Part 2, A6.1, p.194
Vehicles				
	CO2 intensity	1.9E-03	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	CH4 intensity	9.0E-03	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	N2O intensity	6.0E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
Light Fuel Oil (Combustion)				
	CO2 intensity	2.753	kg / L	Environment Canada (2015), Part 2, A6.1, p.195
	CH4 intensity	2.6E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.195
	N2O intensity	3.1E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.195
Gasoline (Combustion)				
Light-duty Vehicles - Tier 2				
	CO2 intensity	2.316	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	CH4 intensity	1.4E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	N2O intensity	2.2E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
Light-duty Vehicles - Tier 1				
	CO2 intensity	2.316	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	CH4 intensity	2.3E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	N2O intensity	4.7E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
Light-duty Trucks - Tier 2				
	CO2 intensity	2.316	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	CH4 intensity	1.4E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	N2O intensity	2.2E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
Light-duty Trucks - Tier 1				
	CO2 intensity	2.316	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	CH4 intensity	2.4E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	N2O intensity	5.8E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
Propane (Combustion)				
Stationary				
	CO2 intensity	1.515	kg / L	Environment Canada (2015), Part 2, A6.1, p.194
	CH4 intensity	2.4E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.194
	N2O intensity	1.08E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.194
Vehicles				
	CO2 intensity	1.515	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
	CH4 intensity	6.4E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199

	Value	Unit	Reference
N_2O intensity	2.8E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.199

	Value	Unit	Reference
Diesel (Combustion)			
Light-duty Diesel Trucks (Advanced Control)			
CO_2 intensity	2.69	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
CH_4 intensity	6.8E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
N_2O intensity	2.2E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
Heavy-duty Diesel Vehicles (Advanced Control)			
CO_2 intensity	2.69	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
CH_4 intensity	1.1E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
N_2O intensity	1.51E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
Electricity (Prod., Trans, Dist.)			
CO_2 intensity	0.002	kg CO_2 / kWh	Environment Canada (2015), Part 3, A11, p.77
CH_4 intensity	2.0E-07	kg CH_4 / kWh	Environment Canada (2015), Part 3, A11, p.77
N_2O intensity	1.0E-07	kg N_2O / kWh	Environment Canada (2015), Part 3, A11, p.77
Others			
Internal composting			
CO_2 intensity	N/A	(Not considered a climate forcing GHG, cycle of growth/decomposition)	
CH_4 intensity	0.004	kg / tonne	IPCC (2006) EFDB, basic search
N_2O intensity	0.00024	kg / tonne	IPCC (2006) EFDB, basic search
CO_2e intensity	-0.18	tonne / tonne	U.S. EPA (2016), WARM version 14, Composting
Natural Gas (Production)			
CO_2 intensity	0.3144	kg / m3	Natural Resources Canada (2013), GHGenius v4.03a
CH_4 intensity	3.9E-03	kg / m3	Natural Resources Canada (2013), GHGenius v4.03a
N_2O intensity	0	kg / m3	Natural Resources Canada (2013), GHGenius v4.03a
Gasoline (Production)			
CO_2 intensity	0.5994	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
CH_4 intensity	0.0056	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
N_2O intensity	3.5E-05	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
Diesel (Production)			
CO_2 intensity	0.6584	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
CH_4 intensity	0.0061	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
N_2O intensity	3.9E-05	kg / L	Natural Resources Canada (2013), GHGenius v4.03a

	Value	Unit	Reference
Light Fuel Oil (Production)			
CO2 intensity	0.3965	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
CH4 intensity	0.0056	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
N2O intensity	0	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
	Value	**Unit**	**Reference**
Propane (Production)			
CO2 intensity	0.2532	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
CH4 intensity	0.0036	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
N2O intensity	0	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
Solid waste in landfill			
CO2 intensity	N/A	(Not a climate forcing GHG, cycle of growth/decomposition)	
CH4 intensity	0.05	kg / tonne	Environment Canada (2015), Part 1, p.179
N2O intensity	0.005	kg / tonne	IPCC (2006) EFDB, basic search
Paper (Production)			
Virgin paper - CO2e intensity	1.47	tonnes / tonne	Environment Canada (2009), GHG Calc. for Waste Mgmt.
30% PCF paper - CO2e intensity	1.31	tonnes / tonne	Environment Canada (2009), GHG Calc. for Waste Mgmt.
50% PCF paper - CO2e intensity	1.2	tonnes / tonne	Environment Canada (2009), GHG Calc. for Waste Mgmt.
100% PCF paper - CO2e intensity	0.93	tonnes / tonne	Environment Canada (2009), GHG Calc. for Waste Mgmt.
Standard light-duty vehicle fuel efficiency (Canada)			
For commuting purposes only:			
Evaluated at 9 L / 100 km (based on page 15)			Environment Canada (2013) - Canada's Emissions Trends
--> equals 0.09L per km			(ISSN 2291-9392)

Notes on Emission Factors (EFs):

- Emission Factors from the production of Light Fuel Oil were calculated in GHGenius v4.03a by using the Higher Heat Value (HHV) and density of diesel.
- Emission Factors from the production of Paper were calculated with the GHG Calculator for Waste Management (Environment Canada) by using the Global Warming Potentials indicated in the GWPs table above.

Appendix 3 – Internal References for Data

List of internal references for data acquisition:

Name	Position	Department	Topic
Barrette, Gerry	Property/Operations Manager, Loyola	Facilities Management	Distributions & Loyola Vehicles
Berardelli, Alex	Supervisor, Mechanical	Facilities Operations	Refrigerants
Boghen, Eric	Marketing Coordinator	Recreation/Athletics	Vehicles
Brown, Grant	Professor	Biology	Vehicles
Cooper, Marvin	Manager, Facilities Planning/Development	Recreation/Athletics	Vehicles & Motorized Equipment
Croce, Bernardo	Truck Driver	Facilities Management	Distributions & Loyola Vehicles
De Santis, Thomas	Buyer	Purchasing Services	Chemicals Purchasing
Gauthier, Daniel	Building Performance Coordinator	Facilities Management	Buildings
Jaeger, Jochen	Associate Professor	Geography, Planning & Env.	Vehicles
Li, Rita	Risk Analyst, Corporate Risks Portfolio	Office of Treasurer	Vehicles
Li, Xin	Refrigeration Mechanic	Facilities Management	Refrigerants
McDonald, Helen	Buyer	Purchasing Services	Paper Purchasing
Muncs, Norberts	Director of Performance Production	Theatre	Vehicles
O'Neill, Desmond	Manager, Distributions/Transport/Mail	Facilities Management	Distributions & Loyola Vehicles
Russo, Antonio	Receiver/Shipper, Distributions/Transport	Facilities Management	Distributions & Loyola Vehicles
Shennib, Faisal	Environmental Coordinator	Environmental Health & Safety	Waste