

CONCORDIA UNIVERSITY

2014-2015 GREENHOUSE GAS INVENTORY

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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 opportunities to reduce GHG emissions

A greenhouse gas inventory will help shape discussions around climate-related aspects at the university (e.g. transportation, paper purchasing, waste management, etc.)

3. Communicate 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.

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 emissions of about 7% mostly due to the conversion from natural gas to electricity for some systems. This increased indirect emissions from electricity by 17% but overall, there was a decrease of direct and indirect emissions at Concordia by about 7%. This is due to the use of hydro-electricity, a cleaner energy source than natural gas.

	2010-2011	2014-2015	Trend
Scope 1	10142 tonnes CO2e	9412 tonnes CO2e	-7.2%
Scope 2	212 tonnes CO2e	248 tonnes CO2e	16.8%
Total 1+2	10354 tonnes CO2e	9660 tonnes CO2e	-6.7%
Scope 3	17460 tonnes CO2e	13356 tonnes CO2e	-23.5%

The emissions of other indirect sources (Scope 3) have been reduced substantially by about 24%. This is essentially due to a substantial decrease in emissions from commuting but also to a decrease in emissions by a reduction in landfill waste.

Highlights

Buildings:

- Buildings are responsible for more than 92% of overall GHG emissions.
- 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 20.25%, 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 3-5% of overall GHG emissions.
- Emissions from vehicles increased by 25.25% 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 3-4% of overall GHG emissions.
- Emissions from refrigerant losses decreased by 38%, from 450 tonnes CO2e in 2010-2011 to 280 tonnes CO2e in 2014-2015.

Scope 3 emissions:

- Measured Scope 3 indirect emissions are about 1.5 times larger than direct emissions (Scope 1).
- Measured Scope 3 emissions decreased by about 25% from 17,460 tonnes CO₂e in 2010-2011 to 13,356 tonnes in 2014-2015.
- Among measured indirect emissions, the largest contributor is personal transportation (excluding public transit) which represents about 40% of Scope 3 indirect emissions.
- Indirect emissions from landfill waste amount to more than 30% of Scope 3 indirect 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 Standard¹. 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 CO₂ or CH₄)

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.

For the purpose of this inventory, the following references are used:

Global Warming Potentials (GWP):

- Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC AR5)²
- United States Environmental Protection Agency (EPA) – Ozone Layer Protection³

Emission Factors (EF):

- Environment Canada 2015 UNFCCC National Inventory Report (NIR)⁴

² IPCC AR5 (2013), Chapter 8 Anthropogenic and Natural Radiative Forcing, Table 8.7 (p.714)
(http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf)

³ United States Environmental Protection Agency (EPA) – Composition of Refrigerant Blends
(<http://www3.epa.gov/ozone/snap/refrigerants/refblend.html>)

⁴ Environment Canada (2015) – National Inventory Report, Greenhouse Gas Sources and Sinks in Canada, 1990-2013, The Canadian Government's Submission to the UN Framework Convention on Climate Change

- Environment Canada 2013 Canada's Emissions Trends⁵
- Environment Canada 2009 GHG Calculator for Waste Management⁶
- Natural Resources Canada GHGenius⁷
- United States Environmental Protection Agency (EPA) – Waste Reduction Model (WARM)⁸

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 (CO₂ equivalent emissions) by using the global warming potential (GWP) of each type of GHG.

For each building/vehicle:

- o $CO_2e \text{ annual emissions} = CO_2 \text{ annual emissions} + (CH_4 \text{ annual emissions} * CH_4 \text{ GWP}) + (N_2O \text{ annual emissions} * N_2O \text{ GWP})$

Where, for each building/vehicle:

- o $CO_2 \text{ annual emissions} = \text{Fossil fuel consumed} * CO_2 \text{ EF for that type of fossil fuel}$
- o $CH_4 \text{ annual emissions} = \text{Fossil fuel consumed} * CH_4 \text{ EF for that type of fossil fuel}$
- o etc.

(http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/can-2015-nir-17apr.zip)

⁵ Environment Canada (2013) – Canada's Emissions Trends

(<https://www.ec.gc.ca/Publications/default.asp?lang=En&xml=1723EA20-77AB-4954-9333-69D1C4EBD0B2>)

⁶ Environment Canada (2009) – Greenhouse Gases (GHG) Calculator for Waste Management

(<https://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=D6A8B05A-1>)

⁷ Natural Resources Canada (2003) – GHGenius, A model for lifecycle assessment of transportation fuels v4.03a

(<http://www.nrcan.gc.ca/energy/efficiency/transportation/7597>)

⁸ United States Environmental Protection Agency (2015) – WARM Version 13 Documentation, Section 5 – Composting (http://www3.epa.gov/epawaste/conserve/tools/warm/pdfs/WARM_Documentation.pdf)

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:

- $CO_2e \text{ annual emissions} = \text{Quantity of added refrigerant} * \text{specific refrigerant GWP}$

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).

$Net \text{ composting } CO_2e \text{ emissions} = (\text{Collection \& Transportation}) + (\text{Operations}) + (\text{Carbon Storage})$

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 -0.265 metric tonne of CO_2e emissions per metric tonne of organic materials processed into compost ⁹(i.e. each metric tonne of organic waste diverted for composting locks-in 0.265 metric tonne of CO_2e 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:

$Net \text{ composting } CO_2e \text{ emissions} = (\text{Quantity of wet organic waste} * CH_4 \text{ composting EF} * CH_4 \text{ GWP}) + (\text{Quantity of wet organic waste} * N_2O \text{ composting EF} * N_2O \text{ GWP}) + (\text{Quantity of wet organic waste} * [-0.265 \text{ tonne of } CO_2e/\text{tonne}])$

⁹ 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/conserves/tools/warm/pdfs/Composting.pdf>)

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.

For each building:

- o 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_2O EF for electricity distribution * N_2O GWP) +
(Quantity of electricity consumed annually * SF_6 EF for electricity distribution [in CO_2e / 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 * CH₄ EF for anaerobic decomposition of landfill waste * CH₄ 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] * { (CO₂ EF for gasoline * CO₂ GWP) + (CH₄ EF for gasoline * CH₄ GWP) + (NO₂ EF for gasoline * NO₂ 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)

LOYOLA CAMPUS	Type of emission	2010 - 2011		2014 - 2015	
		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

SGW CAMPUS	Type of emission	2010 - 2011		2014 - 2015	
		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	Natural Gas	158.21	Natural Gas	238.21
	Indirect	Electricity	14.96	Electricity	14.61
SGW-FG ³	Direct	Natural Gas	0.00	Natural Gas	58.90
	Indirect	Electricity	0.00	Electricity	3.89
SGW-GM	Direct	Natural Gas	434.86	Natural Gas	322.56
	Indirect	Electricity	12.84	Electricity	13.97
SGW-GN	Direct	Natural Gas	819.27	Natural Gas	870.12
	Indirect	Electricity	5.66	Electricity	7.41
SGW-H	Direct	Natural Gas	1571.37	Natural Gas	1590.67
	Indirect	Electricity	29.47	Electricity	29.60
SGW-K	Direct	Natural Gas	35.82	Natural Gas	43.40
	Indirect	Electricity	0.09	Electricity	0.09
SGW-LB	Direct	Natural Gas	77.63	Natural Gas	67.33
	Indirect	Electricity	25.43	Electricity	25.81
SGW-M	Direct	Natural Gas	14.42	Natural Gas	20.05
	Indirect	Electricity	0.04	Electricity	0.04
SGW-MB	Direct	Natural Gas	66.26	Natural Gas	140.41
	Indirect	Electricity	13.31	Electricity	14.22
SGW-MI	Direct	Natural Gas	0.00	Natural Gas	0.00
	Indirect	Electricity	0.04	Electricity	0.03
SGW-MT	Direct	Natural Gas	66.24	Natural Gas	94.66
	Indirect	Electricity	0.12	Electricity	0.12
SGW-MU	Direct	Natural Gas	32.91	Natural Gas	31.26
	Indirect	Electricity	0.04	Electricity	0.03
SGW-P	Direct	Natural Gas	22.35	Natural Gas	19.27
	Indirect	Electricity	0.03	Electricity	0.03
SGW-PR	Direct	Natural Gas	38.00	Natural Gas	40.98
	Indirect	Electricity	0.05	Electricity	0.05
SGW-Q	Direct	Natural Gas	14.42	Natural Gas	11.38
	Indirect	Electricity	0.02	Electricity	0.03
SGW-R	Direct	Natural Gas	16.05	Natural Gas	19.85
	Indirect	Electricity	0.04	Electricity	0.03
SGW-RR	Direct	Natural Gas	0.00	Natural Gas	0.00
	Indirect	Electricity	0.31	Electricity	0.32
SGW-S	Direct	Natural Gas	15.07	Natural Gas	17.57
	Indirect	Electricity	0.07	Electricity	0.05
SGW-SB	Direct	Natural Gas	136.67	Natural Gas	136.23
	Indirect	Electricity	0.97	Electricity	1.01
SGW-T	Direct	Natural Gas	13.89	Natural Gas	15.47
	Indirect	Electricity	0.05	Electricity	0.05
SGW-TD	Direct	Natural Gas	78.01	Natural Gas	63.29
	Indirect	Electricity	0.38	Electricity	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)

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

Note: Vehicles without emissions for 2010 have been acquired later on. Vehicles without emissions for 2014 have been given away prior to that year.

Physical and Chemical Processes (Scope 1)

		2010 - 2011	2014 - 2015
Physical & Chemical Processes	Source	GHG [tonne CO2e]	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)

		2010 - 2011	2014 - 2015
Fugitive Emissions (Refrigerants)	Source	GHG [tonne CO2e]	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)

		2010 - 2011	2014 - 2015
Internal Composting	Source	GHG [tonne CO2e]	GHG [tonne CO2e]
Wet organic waste	Waste bins	-7.73	-5.42
TOTAL - INTERNAL COMPOSTING		-7.73	-5.42

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

SCOPE 3

Waste (Scope 3)

		2010 - 2011	2014 - 2015
Waste	Source	GHG [tonne CO2e]	GHG [tonne CO2e]
Landfill Waste	Anaerobic Decomp.	5615.46	4252.70
TOTAL - WASTE		5615.46	4252.70

Commuting (Scope 3)

		2010 - 2011	2014 - 2015
Commuting	Source	GHG [tonne CO2e]	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)

		2010 - 2011	2014 - 2015
Fuel- & Energy-related Activities	Source	GHG [tonne CO2e]	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)

		2010 - 2011	2014 - 2015
Office Paper Production	Source	GHG [tonne CO2e]	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

Qualitative Assessment

Other potential sources of emissions might exist which are not captured by this greenhouse gas 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 (CO₂) instead of ammonia.

While the CO₂ refrigeration system is a closed system and does not produce GHG emissions, a potential system failure could let the CO₂ leak. If such event was to happen, its impact should be recorded for GHG emission measurements.

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 in terms of GHG emission measurements.

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 often unknown. More sustainable food habits such as consumption of local and organic products help reduce the climate change impact of the food supply chain even though the exact quantity of GHG emissions are usually unknown.

Hazardous Waste Disposal

The 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).

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
CO2	1	kg CO2e / kg CO2	IPCC AR5 (2013), 100-year
CH4	86	kg CO2e / kg CH4	IPCC AR5 (2013), 20-year
N2O	298	kg CO2e / kg N2O	IPCC AR5 (2013), 100-year
(Refrigerants)			
HCFC-22	5280	kg CO2e / kg HCFC-22	IPCC AR5 (2013), 20-year
HFC-32	2430	kg CO2e / kg HFC-32	IPCC AR5 (2013), 20-year
HFC-125	6090	kg CO2e / kg HFC-125	IPCC AR5 (2013), 20-year
HFC-134a	3790	kg CO2e / kg HFC-134a	IPCC AR5 (2013), 20-year
HFC-143a	6940	kg CO2e / kg HFC-143a	IPCC AR5 (2013), 20-year
HFC-404a (blend)	6440	kg CO2e / kg HFC-404a	IPCC AR5 (2013), 20-year & U.S. EPA
HFC-407a (blend)	4438	kg CO2e / 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
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

N2O intensity	2.8E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
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	Value	Unit	Reference
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Diesel (Combustion)

Light-duty Diesel Trucks
(Advanced Control)

CO2 intensity	2.69	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
CH4 intensity	6.8E-05	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
N2O intensity	2.2E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199

Heavy-duty Diesel Vehicles
(Advanced Control)

CO2 intensity	2.69	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
CH4 intensity	1.1E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199
N2O intensity	1.51E-04	kg / L	Environment Canada (2015), Part 2, A6.1, p.199

Electricity (Prod., Trans, Dist.)

CO2 intensity	0.002	kg CO2 / kWh	Environment Canada (2015), Part 3, A11, p.77
CH4 intensity	2.0E-07	kg CH4 / kWh	Environment Canada (2015), Part 3, A11, p.77
N2O intensity	1.0E-07	kg N2O / kWh	Environment Canada (2015), Part 3, A11, p.77

Others

Internal composting

CO2 intensity	N/A	(Not considered a climate forcing GHG, cycle of growth/decomposition)	
CH4 intensity	0.24	kg / tonne	U.S. EPA (2015), WARM version 13, Composting
N2O intensity	0.1465	kg / tonne	U.S. EPA (2015), WARM version 13, Composting
CO2e intensity	-0.265	tonne / tonne	U.S. EPA (2015), WARM version 13, Composting

Natural Gas (Production)

CO2 intensity	0.3144	kg / m3	Natural Resources Canada (2013), GHGenius v4.03a
CH4 intensity	3.9E-03	kg / m3	Natural Resources Canada (2013), GHGenius v4.03a
N2O intensity	0	kg / m3	Natural Resources Canada (2013), GHGenius v4.03a

Gasoline (Production)

CO2 intensity	0.5994	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
CH4 intensity	0.0056	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
N2O intensity	3.5E-05	kg / L	Natural Resources Canada (2013), GHGenius v4.03a

Diesel (Production)

CO2 intensity	0.6584	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
CH4 intensity	0.0061	kg / L	Natural Resources Canada (2013), GHGenius v4.03a
N2O intensity	3.9E-05	kg / L	Natural Resources Canada (2013), GHGenius v4.03a

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
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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	81.62	kg / tonne	Environment Canada (2015), Part 1, p.179
N2O intensity	N/A		

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
(ISSN 2291-9392)

--> equals 0.09L per km

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		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