INVENTORY OF GREENHOUSE GAS

YEAR 2018-2019

FINAL REPORT
MAY 5

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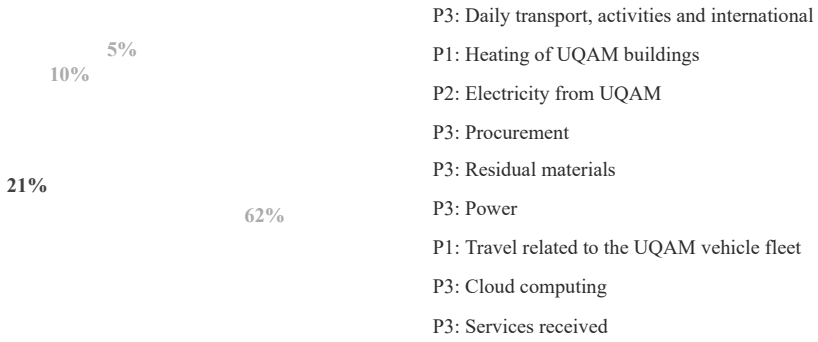
EXECUTIVE SUMMARY

The University of Quebec in Montreal (UQAM) is committed to actively participate in the fight to climate change. Among several actions that she puts forward is the realization of its greenhouse gas (GHG) inventory for the 2018-2019 school year. This inventory consisted of listing all the activities, resources consumed and residual materials

generated and apply GHG emission factors to them in order to establish an overall assessment.

The inventory is divided into three perimeters grouping together nine categories: perimeter 1 (P1) lists the direct GHG emissions from the combustion of fossil fuels used by UQAM for the heating and transportation of its vehicles; scope 2 (P2) encompasses the indirect emissions linked to the use of electricity for its buildings and perimeter 3 (P3) includes GHG emissions from other products and services necessary for the activities of UQAM for food, transport, supply, data storage IT, services received by the university and residual materials.

UQAM's total GHG emissions for the 2018-2019 school year are 36,993 tonnes eq. CO_2 , which represents 0.95 tonne eq. CO_2 per student (Figure 1).



Total: 36,993 tonnes eq. CO_2

Figure 1 : Breakdown of UQAM's GHGs by category of emissions

The GHG inventory is dominated by the category related to commuting, activities and internationally, contributes mainly to UQAM's GHG emissions, followed by the heating and electricity of buildings. Recommendations for all categories have been set out, including the implementation of measures to encourage active transportation and collective and recognized measures in the energy efficiency of buildings.

1. CONTEXT AND OBJECTIVES

The Université du Québec à Montréal (UQAM) is a French-speaking public university in international reach offering more than 300 programs and welcoming more than 38,000 students per session (fall / winter). In order to pursue its mission of offering training, research and a living environment that meets the expectations of its community, the service of organizational development at UQAM mandated CT Consultant to carry out its greenhouse gas (GHG) inventory for the 2018-2019 school year. CT Consultant has enthusiastically accepted to carry out this mandate in collaboration with UQAM.

In line with its concrete commitment to participate in the fight against change climate, the realization of this GHG inventory aims at the following four objectives.

STUDY OBJECTIVES

1 **Carry out the GHG inventory (perimeters 1, 2 and 3) of UQAM for the year 2018-2019**

2 **Identify the largest contributors to emissions from GHG**

3 **Compare UQAM's GHG inventory with that other universities**

Propose reduction measures that can fuel

4 **UQAM's strategic planning**

2. METHODOLOGY

STEPS

To carry out this inventory, the following procedure was carried out:

1) Kick-off meeting to determine the scope of analysis (April 8, 2020);
2) Data collection (April 13, 2020 to March 12, 2021)
3) Research of GHG emission factors;
4) Quantification of GHG emissions for each category of emissions;
5) Presentation of preliminary results to the Institutional Policy Committee in UQAM eco-responsibility (CIME) (March 12, 2021);
6) Carrying out the comparative analysis with the GHG inventories of other universities (March 2021);
7) Search for generic reduction measures (April 2021);
8) Submission of the final carbon inventory report (April 2021);

FIELD OF STUDY

The field of study was determined with the objective of carrying out an inventory that is both relevant and comprehensive, while considering the time and burden required for data collection. The activities, products and resources consumed, as well as residual materials related to UQAM's downtown campus activities were considered. Thus, the Laval campuses and Saint-Constant were excluded from the inventory.

The inventory has been divided into nine categories of emissions (see Figure 2):

1) **Heating UQAM buildings** : natural gas, propane, fuel oil n o 2 diesel colored;
2) **Travel related to the UQAM vehicle fleet** : travel for the entire fleet UQAM vehicles (administrative, academic and research trips);
3) **Electricity from UQAM** : electricity from the Hydro-Québec network and panels photovoltaic systems installed on campus to meet electricity demand (heating, lighting, elevators, outlets, etc.);
4) **Food** : food, dishes and packaging for meals prepared in the cafeterias, bar and catering services (excluding student cafes);

Figure 2: Breakdown of GHG emissions by emission category

5) **Daily transport, activities and international:** daily trips of the community to get to and from UQAM, Business travel from teaching staff and employees, travel for sports and school activities, student travel during international sessions.
6) **Procurement** : all purchases of material goods from UQAM, except food, electricity and fossil fuels;
7) **Cloud computing** : external data storage linked to IT activities offered by UQAM to employees, faculty and students;
8) **Services received** : IT, professional, snow removal and landscaping services;
9) **Residual** materials: recyclable materials, compostable materials, final waste, wastewater, hazardous materials, batteries and waste from wastewater technologies information and communications (ICT).

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To facilitate comparison with GHG inventories of other universities and to highlight evidence the categories of programs that are directly under the control of UQAM, categories of emissions have been classified according to the perimeters (scopes) defined by the Protocol GES, better known by its English name *GHG Protocol Corporate Accounting Standard* . According to Under the terms of the GHG Protocol, GHG emissions can be divided into three perimeters:

- **Scope 1** : Direct GHG emissions from the combustion of fossil fuels used by UQAM (heating and transport). This perimeter includes categories 1 and 2.
- **Scope 2** : Indirect GHG emissions from the use of electricity for the building. This perimeter corresponds to category 3.
- **Scope 3** : Other indirect GHG emissions, that is to say the GHG emissions from other products and services related to UQAM's activities. This perimeter includes categories 4 to 9.

In addition, the principles of transparency, accuracy and completeness set out in the protocol GES were monitored for the realization of this inventory. To learn more about this method GHG Accounting for Organizations, please see Appendix A.

DATA GATHERING

Data collection consisted of identifying the amount of activities, products, resources and of outgoing materials related to UQAM activities. The collection was carried out by Cynthia Philippe, UQAM Sustainable Development Advisor, with the collaboration of several university employees and services. For data relating to the daily trips of

the UQAM community to get to the downtown campus, the Regional Authority of transport métropolitain (ARTM) provided an overall portrait of trips based on a supplement to the 2018 origin-destination survey [1]. In the absence of quality data concerning the characterization of UQAM's ultimate waste and recyclable materials, the study of residual materials characterization carried out by Cégep St-Jean-sur-Richelieu in 2017 [2] was used. This study was selected, since it was easily accessible (public), very detailed and deemed sufficiently representative of the situation at UQAM.

GHG EMISSION FACTORS

To quantify GHG emissions, the method adopted is to use emission factors of GHGs for each element included in the nine categories of emissions. Two types of factors programs were used:

- **Process** : GHG emission factors that relate to a product or a resource and includes the extraction of its raw materials until it leaves the factory of manufacturing. Emissions are reported per unit produced (kg GHG / kg product, kg GES / kWh of energy, kg GES / unit of product, kg GES / L of product).
- **Input / Output** : GHG emission factors per money spent on the production of a finished product or service in several industrial sub-sectors. Shows expressed per dollar spent (kg GHG / Canadian dollar).

The types of emission factors used for each emission category are presented in Table 2.

Table 2: Categories of emissions and elements included in the inventory by type of factor emissions used

PERIMETER	CATEGORY	ELEMENT	TYPE OF FACTOR ENTRY / EXIT PROCESS	
1	**HEATING UQAM BUILDINGS**	-Natural gas, -No2 fuel oil -Propane -Diesel for generator	✓	-
1	**TRAVEL RELATED TO THE VEHICLE FLEET FROM UQAM**	-Movements of the entire fleet of UQAM vehicles (administrative trips, academic and research)	✓	-
2	**UQAM ELECTRICITY**	-Electricity -Photovoltaic panels	✓	-
3	**FOOD**	-Food -Disposable tableware and packaging	-	✓
3	**DAILY TRANSPORT, ACTIVITIES AND INTERNATIONAL**	-Daily transport -Transport sports activities -Transport sessions to the international	✓	-
		- Business travel from teaching staff and employees -Transport for school activities	-	✓

Table 2 (Continued): Categories and elements included in the inventory by type of emission factor used

PERIMETER	CATEGORY	ELEMENT	TYPE OF FACTOR ENTRY / EXIT PROCESS	
3	**PROCUREMENT**	-Hardware -Water -Cleaners -Chlore (Pool) and salt icebreaking -Painting (Construction) -Paper -Laboratory (Apparatus and products) -Printed resources (library) -Furnishings -Construction materials -Clothing -Other equipment	✓	-
3	**CLOUD**	-Data storage at external related to activities IT offered by UQAM to employees, faculty and students; (course, research, association, etc.)	✓	-
3	**SERVICES RECEIVED**	-IT services -Accounting services -Services in law (legal) -Snow clearance services -Landscaping services -Other services	-	✓
3	**RESIDUAL MATERIALS**	- Ultimate waste -Recyclable materials -Compostable materials -Hazardous Material -TIC -Batteries -Waste	✓	-

To maintain the best possible data quality, emission factors of type "Processes" were used first. Thus, if the data to be listed were not available in the form of a physical unit (mass, unit or energy), the monetary data was then considered.

In the case of elements using " **Process** " type factors :

- The steps included in the categories Heating of UQAM buildings, Electricity of UQAM, Food and Supply, is the extraction of raw materials, transport to the place of production, factory production and factory transport up to UQAM.
- The stages included in the categories Travel related to the vehicle fleet of UQAM and Daily Transport, Activities and International are the production and fuel combustion, the manufacture and maintenance of the means of transport and the construction of infrastructure (road). Emission factors specific to the means of transport used (eg automobile, bus, plane, etc.) were used.
- The stages included in the Residual materials category are transport (truck of collection) and the treatment of residual materials (e.g. recycling or landfill). For this category, specific emission factors by type of material (eg. metals, plastics, paper / cardboard, etc.) were used.

Note. By their "life cycle" nature (which includes scopes 1, 2 and 3), "Process" emission factors, such as those related to means of transport do not include not only the emissions associated with the combustion of fuel, but also the the means of transport themselves and their infrastructure. Thus, this expansion of steps considered greatly increase GHG emissions (twice as high) compared to the emission factors used in the calculators accessible free of charge which are limited to scope 1 (direct emissions) (Annex D).

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The steps included are summarized in Figure 3 for the elements using the factors of type "Process":

STEPS INCLUDED	STEPS INCLUDED	STEPS INCLUDED
1. Extraction of materials firsts	1. Fuel production	1. Transportation
2. Transport to the place of production	2. Fuel combustion	2. Treatment
3. Production	3. Manufacture of the means of transport	
4. Transport to UQAM	4. Maintenance of the means of transport	
	5. Construction of infrastructure	

Figure 3: Life cycle stages included in "Process" type emission factors for items belonging to the different emission categories

The "Process" type emission factors come from the inventory database of the Ecoinvent v3.6 [3] lifecycle and scientific articles.

In the case of elements using “Input / Output” type factors, the factors of GHG emissions come from the global enviro-economic database Exiobase v.3.4 [4], relating to the Canadian economic context. This database contains emission factors for 112 categories of goods and services (e.g. air transport services, cattle breeding, cement, lime and plaster, chemicals).

CALCULATION METHODOLOGY

To illustrate the calculation methodology, here is the example of GHG emissions related to the use natural gas for heating the premises of UQAM and domestic water.

7 845 833.5 kg eq. CO_2 issued for the year 2018-2019 **= 2,563,007** m^3 natural gas (97 137 965.3 MJ) **x 0.081** kg eq. CO_2 / MJ

For more details on the methodology used, please see appendices A, B and C.

INVENTORY REPRESENTATIVITY AND DATA QUALITY

All the data provided by UQAM for this GHG inventory were used. Through lack of time for data collection, some items were excluded (e.g. food sold by student cafes and transport abroad for students who have not not received financial assistance from UQAM) and could be included in the next inventory. He The same is true for several elements related to cloud computing (eg emails and videoconferences). The complete and detailed list of items included and excluded for each category of emissions can be found can be found in Appendix B. In addition, the primary data are deemed to be of good quality since they come directly from UQAM, with the exception of the study by characterization of residual materials. With regard to GHG emission factors, these are considered to be the best available in terms of reliability, geographical representativeness and temporal representativeness. Therefore, this GHG inventory is considered representative of UQAM's situation and respects the principles of relevance, completeness, accuracy and transparency.

3. RESULTS OF THE GLOBAL GHG INVENTORY OF UQAM 2018-2019

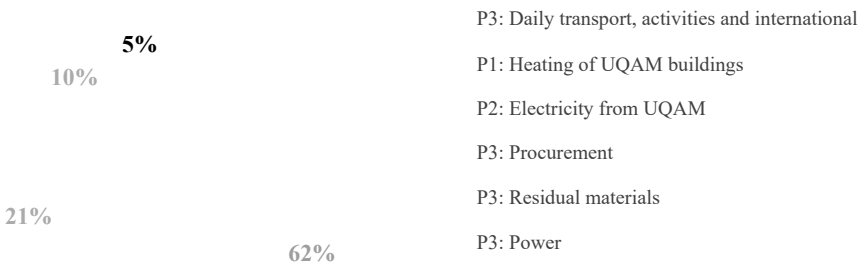
UQAM's global GHG inventory represents the sum of the inventories related to the three perimeters encompassing the nine categories of emissions considered: Heating of buildings UQAM, Travel related to the fleet of UQAM vehicles, UQAM Electricity, Food, Daily transport, activities and international, Supply, Cloud computing, Services received and Residual materials.

For the year 2018-2019, the global inventory, the inventory by regular student and the inventory by square meter of gross area are shown below.

36,993	0.95	0.08
tonnes eq. CO_2	tonnes eq. CO_2 per student	tonnes eq. CO_2 per m^2 gross area

The global GHG inventory broken down by emission category is presented in Figure 4 with the share (%) attributable to each of them. Table 3 presents the GHG emissions by category.

2018-2019 GHG inventory



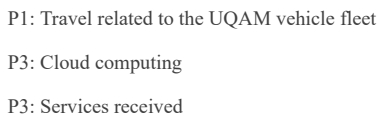


Figure 4: Global inventory - Distribution of GHG emissions by major category

Table 3 : Global inventory - Breakdown by emission category

CATEGORY	GHG (T CO2eq)	SHARE OF IMPACTS
P3: DAILY TRANSPORTATION, ACTIVITIES AND INTERNATIONAL	23,034	62%
P1: HEATING OF UQAM BUILDINGS	7 928	21%
P2: UQAM ELECTRICITY	3,726	10%
P3: PROCUREMENT	1,801	5%
P3: RESIDUAL MATERIALS	197	<1%
P3: POWER SUPPLY	165	<1%
P1: TRAVEL RELATED TO THE FLEET OF UQAM VEHICLES	65	<1%
P3: CLOUD	40	<1%
P3: SERVICES RECEIVED	37	<1%
TOTAL	**36,993**	**100%**

In view of these results, it emerges that the category Daily transport, activities and international is the most important category (62% of GHG emissions), followed by the Heating category for UQAM buildings (21%). Electricity-related emissions UQAM represent 10% of UQAM's total emissions. The Supply category represents a small part of emissions (5%), and the residual materials categories, Power, Cloud Computing and Received Services each represent less than 1% of emissions. In short, these results clearly show the preponderance of the Transport category daily, activities and international compared to other categories of programs.

Table 4 presents the GHG emissions for the three perimeters.

Table 4: Global inventory - Distribution of GHGs by scope (descending order)

PERIMETER	GHG (T CO2eq)	SHARE OF IMPACTS (%)
PERIMETER 3	25,274	68%
PERIMETER 1	7,993	22%
PERIMETER 2	3,726	10%
TOTAL	**36,993**	**100%**

Scope 3 represents the largest share of GHG emissions (68%). Perimeters 1 and 2 represent 22% and 10% of emissions respectively. Thus, the vast majority of emissions are not under the direct control of UQAM, since perimeters 2 and 3 represent a 78% share.

3.1 GHG EMISSIONS RELATED TO SCOPE 1

Scope 1 includes GHG emissions related to heating UQAM buildings and travel related to UQAM's fleet of vehicles. The distribution of emissions by element is shown in Figure 5 and Table 5.

P1: Natural gas

P1: Diesel for generator

P1: Fuel oil no2

P1: Travel related to the vehicle fleet of UQAM

P1: Propane

98%

Figure 5: Breakdown of GHG emissions by item included in scope 1

Table 5 : GHG emissions linked to scope 1

ELEMENT	GHG (T. CO_2 EQUITY)	SHARE OF IMPACTS (%)
NATURAL GAS	7 846	98%
DIESEL FOR GENERATOR	58	<1%
OIL NO2	21	<1%
FLEET MOVEMENTS UQAM VEHICLES	65	<1%
PROPANE	3	<1%
TOTAL	**7,993**	**100%**

Scope 1 emissions are largely dominated by the use of natural gas used for heating of buildings (98%).

3.2 GHG EMISSIONS RELATED TO SCOPE 2

The GHG emissions relating to scope 2, i.e. UQAM's electricity, are shown in Table 6.

Table 6: GHG emissions linked to scope 2

ELEMENT	GHG (T eq CO_2)	SHARE OF IMPACTS (%)
ELECTRICITY PURCHASED BY UQAM	3,724	99%
UQAM'S PHOTOVOLTAIC PANELS	3	<1%
TOTAL	**3,726**	**100%**

The GHG emissions in this scope are largely attributable to the electricity purchased by UQAM.

It is interesting to note that, despite a higher annual consumption of electricity than natural gas (388,550 GJ vs 97,113 GJ), the GHG emissions of electricity are much lower than those of natural gas (3,726 tonnes of CO_2 eq. vs. 7,846 tonnes of CO_2 eq.). This is explained by the low emission factor for electricity production in Quebec (mainly on hydroelectric power plants) compared to that of natural gas.

3.3 GHG EMISSIONS RELATED TO SCOPE 3

The GHG emissions in scope 3 paint a picture of the emissions of the products and services that procures UQAM excluding fossil fuels and electricity (Figure 6 and Table 7).

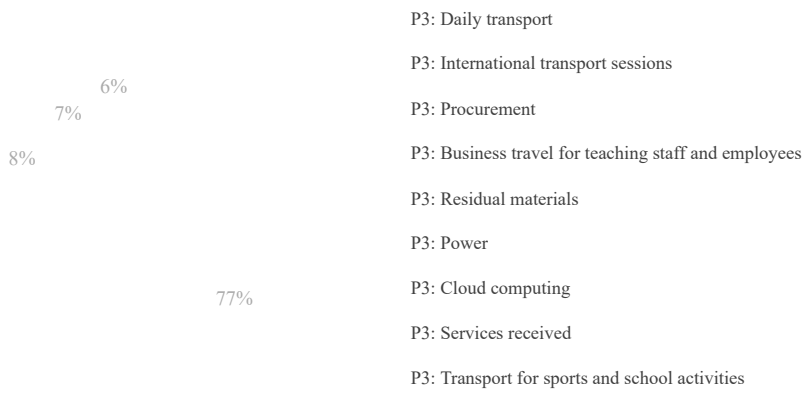


Figure 6: Breakdown of GHG emissions by item in scope 3

Table 7 : GHG emissions linked to scope 3

ELEMENT / CATEGORY	GHG (T. CO_2 EQUITY)	SHARE OF IMPACTS (%)
DAILY TRANSPORT	19,367	77%
INTERNATIONAL SESSIONS TRANSPORT	2,027	8%
PROCUREMENT	1,801	7%
STAFF BUSINESS TRAVEL TEACHER AND EMPLOYEES	1,625	6%
RESIDUAL MATERIALS	197	<1%
FOOD	165	<1%
CLOUD	40	<1%
SERVICES RECEIVED	37	<1%
TRANSPORT SPORTS ACTIVITIES AND SCHOOL	15	<1%
TOTAL	**25,274**	**100%**

UQAM's perimeter 3 GHG emissions are mainly produced by activities related to the daily transport of the UQAM community (round trip) (77%), followed by the

transport related to international sessions and staff business trips
teacher and staff. Together, these three elements represent 91% of the impacts of the perimeter 3.

3.3.1 DAILY TRANSPORT

Daily transportation is the main contributor to total GHG emissions. To put in shed light on the relative contribution of each means of transport used to travel to UQAM, the GHG emissions linked to daily transport are divided into sub-elements at the Figure 7 in Table 8.

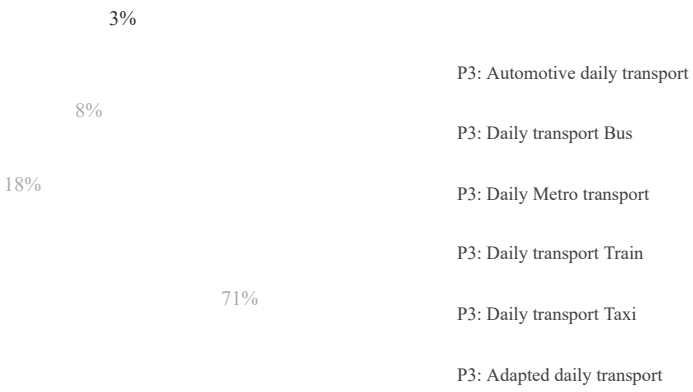


Figure 7: Distribution of GHG emissions by mode of transport for daily transport

Table 8 : GHG emissions by mode of transport for daily transport

ELEMENT	GHG (T. CO_2 EQUITY)	SHARE OF IMPACTS (%)

	AUTOMOTIVE	13 755	71%
	BUS	3,445	18%
TRANSPORT	SUBWAY	1,590	8%
DAILY	TRAIN	520	3%
	TAXI	56	<1%
	ADAPTED TRANSPORT	1	<1%
TOTAL		**19,367**	**100%**

These results indicate that the majority of GHG emissions from the daily transportation of employees and students to get to UQAM are attributable to automobile transportation

(71%). The bus represents 18% of emissions linked to daily transport, and transport in metro accounts for 8% of emissions.

To better interpret the origin of the contribution of these different modes of transport, a analysis of the ARTM source data was carried out in order to better understand the influence of number of users per mode of transport, as well as the person value * km, i.e. the distance total traveled by users opting for a specific mode (Table 9). It is to highlight that the number of people for each mode includes direct and multimodal transport. It emerges that the majority of kilometers traveled by daily transport are made by metro. It is also to note that the proportion of people taking the bus daily is higher the number of people using the automobile. However, the total number of kilometers traveled by car is greater than the distance traveled by bus. This can be interpreted by the fact that bus trips are generally made on

shorter distances than the automobile, especially when people live in more remote areas and less well served by public transport.

Table 9 : Distribution of the number of users of each mode of daily transport (for one way ticket - ARTM)

MEANS OF TRANSPORT	NUMBER OF PEOPLE	SHARE OF PEOPLE	PERSON-KM	PART OF PEOPLE.KM
SUBWAY	26,959	50%	171,987	42%
BUS	15,171	28%	90,061	22%
AUTOMOTIVE	9,827	18%	129,323	31%
TRAIN	17 97	3%	19,149	5%
TAXI	63	<1%	452	<1%
ADAPTED TRANSPORT	7	<1%	8	<1%
TOTAL	**53 824**	**100%**	**410,979**	**100%**

Regarding daily transport by car, it is possible to note that 40% are single drivers who make the direct trip (only one mode of transport without carpooling) and that 45% are single drivers who also use a second mode transport (multimodal transport) (Table 10). Thus, it appears that 85% of people use the car alone with or without a second mode of transport. The drivers solo cars (direct and multimodal) also represent 85% of the distance traveled.

Table 10 : Number of users and people * km for daily transport involving

an automobile (for a one-way ticket - ARTM)

TYPE OF USE OF AUTOMOTIVE	NUMBER OF PEOPLE	GO	PERSON * KM	GO
SELF-DRIVING - DIRECT	3,906	40%	61 176	47%
SELF-DRIVING - MULTIMODAL	4 383	45%	49,773	38%
CAR PASSENGER - DIRECT *	527	5%	8 839	7%
AUTO PASSENGER - MULTIMODAL *	1,011	10%	9,536	7%
TOTAL	**9,827**	**100%**	**129,323**	**100%**

* According to the ARTM methodology, passenger car transport is calculated separately from transport automobile drivers. To carry out the GHG inventory, passenger journeys were assimilated to drivers' trips because the emissions factor of a car is based on the distance traveled, and this, regardless of the number of people in the vehicle.

The details of the assumptions concerning the Daily transport category are listed in Appendix C.

3.3.2 BUSINESS TRAVELS FOR TEACHING STAFF AND EMPLOYEES

The GHG emissions associated with business travel by teaching staff and employees include air transportation, accommodation and bus transportation and represent 6% of scope 3 (Table 11).

Table 11 : GHG emissions linked to the business transportation of teaching staff and employees

ELEMENT		GHG (T CO_2 EQUITY)	SHARE OF IMPACTS (%)
TRAVEL BUSINESS OF STAFF	FLIGHTS	1516	93%
	ACCOMMODATION	103	6%
TEACHER AND EMPLOYEES	BUS	6	<1%
TOTAL		**1,625**	**100%**

3.3.3 PROCUREMENT

The Supply category represents approximately 5% of the overall inventory. Shows related to the different items in this section are detailed in Table 12.

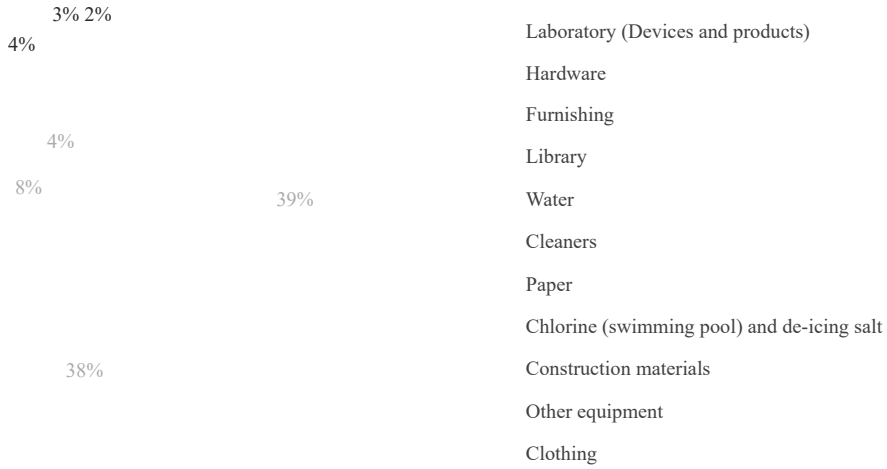


Figure 8: Distribution of GHG emissions by element included in the supply

Table 12: Supply-related GHG emissions

CATEGORY	GHG (T eq CO_2)	SHARE OF IMPACTS (%)
LABORATORY (APPARATUS AND PRODUCTS)	709	39%

	HARDWARE	688	38%
	FURNISHING	147	8%
	LIBRARY	77	4%
	WATER	63	4%
PROCUREMENT	CLEANERS	51	3%
	PAPER	33	2%
	CHLORINE (POOL) AND SALT DE-ICING	14	<1%
	MATERIALS CONSTRUCTION	12	<1%
	OTHER EQUIPMENT	4	<1%
	CLOTHING	2	<1%
TOTAL		**1,801**	**100%**

It appears that the majority of emissions in the Supply category are associated with two items: laboratory products and equipment (39%) and computer hardware (38%).

3.3.4 FEEDING

Representing less than 1% of the overall inventory, the Food category includes food and drinks served in the three cafeterias, the bar and the two service levels caterers, their packaging and disposable tableware. The breakdown of GHG emissions by element is presented in Figure 9, the results in terms of tonnes of CO_2 eq. are presented at Table 13.

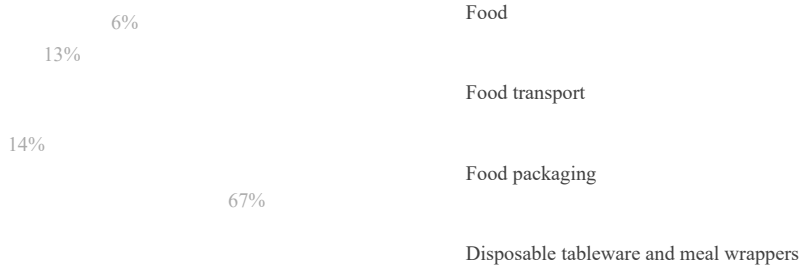


Figure 9: Food - Distribution of elemental GHGs

Table 13 : Food-related GHG emissions

CATEGORY		GHG (T. CO_2 EQUITY)	SHARE OF IMPACTS (%)
FOOD	FOOD	111	67%
	TRANSPORTATION FOOD	23	14%
	PACKAGING FOOD	21	13%
	DISPOSABLE DISHES AND MEAL PACKAGING	10	6%
TOTAL		**165**	**100%**

Food accounts for the largest share of GHG emissions in this category with a share of 67%, the transport and packaging of food before arriving at UQAM represents respectively 14% and 13% of emissions. Disposable tableware and meal wrappers at UQAM represent only 6% of total GHG emissions from food.

3.3.5 RESIDUAL MATERIALS

The residual materials category includes nine streams: Ultimate waste (landfill), Recyclable materials (paper, cardboard, metal, plastics, etc.), Compostable materials (organic), Hazardous materials (radioactive, biomedical and chemical waste), ICT (computer equipment), Batteries and Wastewater.

The annual emissions associated with the transport and treatment of residual materials are 197 tons eq. CO_2 (less than 1% of the overall inventory). The distribution of emissions by flow of residual materials is shown in Figure 10.

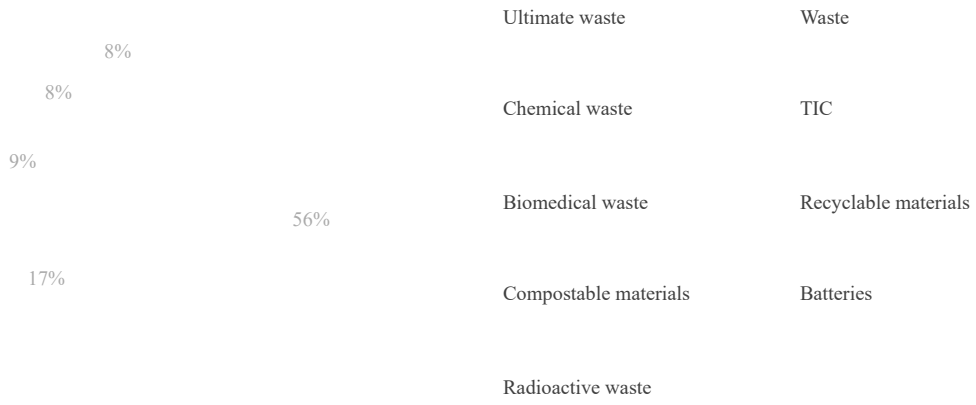


Figure 10: Breakdown of GHG emissions by waste stream

Table 14: GHG emissions linked to residual materials

CATEGORY	GHG (T eq CO_2)	SHARE OF IMPACTS (%)
ULTIMATE WASTE	110	56%
WASTE	34	17%

	CHEMICAL WASTE	18	9%
	TIC	16	8%
RESIDUAL MATERIALS	WASTE BIOMEDICAL	15	8%
	MATERIALS RECYCLABLE	<1	<1%
	MATERIALS COMPOSTABLES	<1	<1%
	BATTERIES	<1	<1%
	RADIOACTIVE WASTE	<1	<1%
TOTAL		**197**	**100%**

Ultimate waste is responsible for more than half of the GHG emissions of this category (56%), while wastewater treatment is responsible for slightly less than a quarter of emissions (17%). Chemical waste, for its part, generates 9% of emissions

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of GHGs linked to residual materials, and ICT and biomedical waste each contribute 8% shows. Recyclable and compostable materials, batteries and radioactive waste have a negligible contribution to the results (<1%). Finally, these results show the positive effect divert the maximum amount of residual materials from landfill, especially organic matter found in Ultimate Waste.

3.3.6 CLOUD

The Cloud Computing category includes external storage related to the IT activities of UQAM by teaching staff, employees and students (courses, research, association, etc.) on OneDrive and Sharepoint. The emissions linked to this storage are 40 tonnes of CO_2 equivalent to the year and represents less than 1% of emissions in the global inventory.

It should be noted that this category only takes into account the external storage part on OneDrive and Sharepoint on all cloud computing activities, which underestimates greatly the total emissions related to this category if other items (e.g. email and videoconferences) had been included.

3.3.7 SERVICES RECEIVED BY UQAM

The Services received by UQAM category constitutes less than 1% of the emissions in the inventory global and includes field services (snow removal, landscaping), IT service (development and software) and administrative services (law, accounting and others). The broadcasts related to the services received by UQAM are listed in Table 15.

Table 15 : Emissions inventory - Services received

CATEGORY		GHG (T eq CO_2)	SHARE OF IMPACTS (%)
SERVICES RECEIVED	SERVICES PROFESSIONALS	28	75%
	SERVICES COMPUTER SCIENCE	8	21%
	LANDSCAPING SERVICES	1	3%
	SNOW REMOVAL	<1	1%
TOTAL		**37**	**100%**

These results indicate that professional services (law, accounting and others) contribute three quarters of the GHG emissions in the Services received category. Field-related services (landscaper, snow removal) contribute little to emissions (between 1 and 3% of emissions).

3.4 LIMITS OF ' INVENTORY

This GHG inventory lists the GHG emissions for UQAM's activities for the year 2018-2019. However, certain limits to the realization of the inventory must be underlined for the sake of transparency.

Although the scope used is considered exhaustive, it remains that certain elements were excluded from the study for lack of reliable data. Here are the main elements that have been excluded:

1. Certain activities related to the international transport of students (activities at international, humanitarian aid, international student transport not funded by UQAM, accommodation for international students);
2. Food and drinks from student cafes;
3. Activities related to cloud computing (administrative and academic storage of UQAM externally (Google Drive, OneDrive, DropBox, etc.)), emails, video conferences, streaming and live videos (Teams, Google Meet, Youtube etc.), transactions digital);
4. Residual material: textiles;
5. Supplies purchased by students (art supplies);
6. Student purchases for their school activities (eg books, software, supplies artistic)

Emissions attributable to business trips by teachers and employees were taken into account in this inventory. As the information collected in the system UQAM's IT system aggregates expenses related to air travel, travel

automobiles and accommodation, a conservative approach was used, i.e. the total of expenses has been assimilated to air travel, the element that has the factor highest among the three elements. Thus, it is useful to point out that the emissions of GHG associated with this element remains undoubtedly overestimated.

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From the point of view of residual materials, the characterization data concerning waste and the recyclable materials of UQAM not being detailed enough, the characterization of residual materials from the Cégep de Saint-Jean-sur-Richelieu was used, which represents a limit on the reliability of GHG emissions related to this category.

In conclusion, it should be noted that this inventory is limited to GHG emissions and does not not cover other relevant environmental indicators such as water consumption, depletion of fossil fuels, acidification of the aquatic and terrestrial environment and depletion of the ozone layer. Thus, although GHG emissions remain a relevant and widely used indicator in terms of the environmental performance of a organization, it is suggested that the inventory be extended to other indicators in a future review of the UQAM inventory.

4. COMPARISON WITH OTHER INSTITUTIONS TEACHING

In order to compare UQAM's GHG inventory with that of other educational institutions in Quebec and the rest of Canada, a comparative analysis was carried out on the basis of GHG emissions per number of students in the fall semester (Figure 11). In theory, this base comparison remains valid. However, it is important to stress that institutions are not directly comparable given that their activities, facilities and contexts may turn out to be different. Thus, although the comparison exercise is relevant, it is However, the conclusions to be drawn must be qualified.

The educational institutions chosen for the benchmarking are the main Montreal universities (Polytechnique Montreal, McGill University, University of Montreal and Concordia University), other Quebec universities (Laval University and University of Sherbrooke), as well as an Ontario university (Carleton University) and a neo-Brunswick (University of New Brunswick). The Cégep de Saint-Jean-sur-Richelieu has has also been included in the comparison, since its GHG inventory refers to the year 2018-2019 and that it includes more or less the same categories as UQAM in scope 3.

From a methodological point of view, it is important to stress that most establishments do not consider that the combustion of fuel in the emissions of their vehicles (scope 1) and report fuel production as part of scope 3. In the present UQAM inventory, the production and combustion of fuel, but also the manufacture and maintenance of the vehicle and infrastructure are included in scope 1. Consequently, the emissions associated with scope 1 of UQAM may therefore be higher compared to other institutions given the different methodologies used. Also, some establishments have limited their GHG inventory to perimeters 1 and 2, which restricts the comparison to these two perimeters. In addition, it should be noted that the items included in the scope 3 vary a lot depending on the establishment, which makes a comparison difficult direct between the scopes 3. The summary table of the emissions of each establishment and of the categories included in perimeter 3 can be found in Appendix E.

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2018-2019 GHG inventory

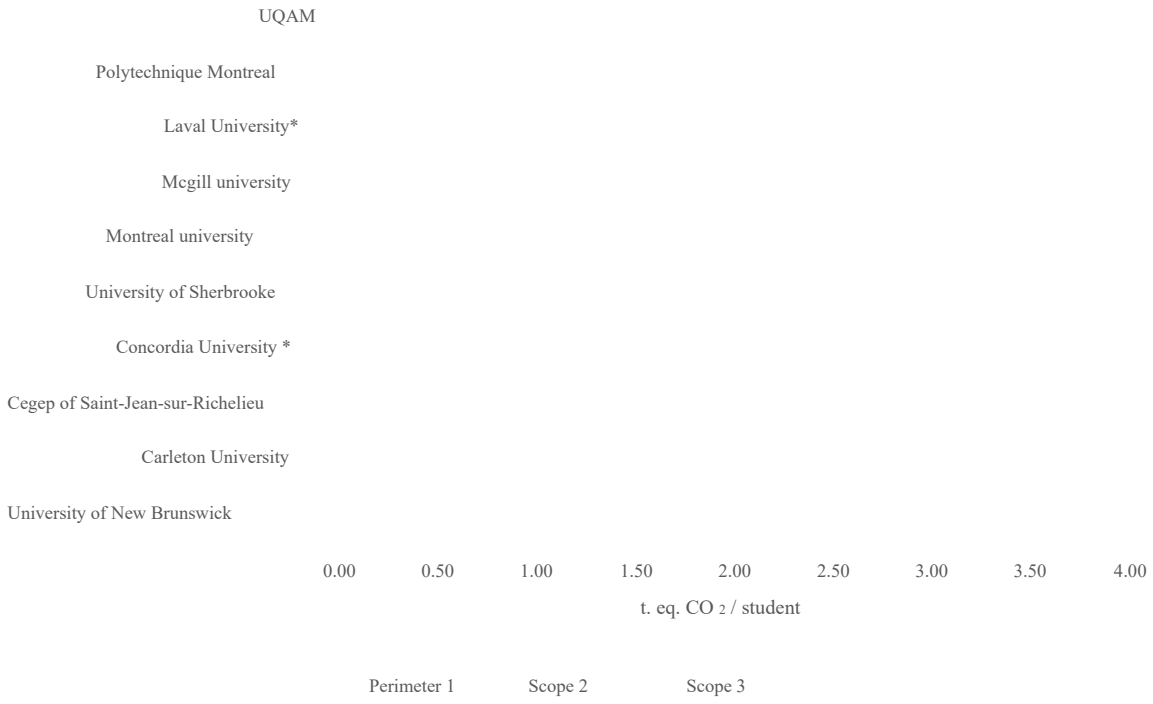

Figure 11: Comparative analysis of GHG inventories of different educational institutions

* These universities have associated carbon credits with composting (and in some cases with recycling). Profits outside UQAM were not taken into account in the inventory. To allow a consistent comparison, the carbon credits have not been included in this Figure.

The results of the comparative analysis show that UQAM is positioned as third university emitting the least GHGs per student for perimeters 1 and 2, behind the University de Sherbrooke and Concordia University. The University of New Brunswick is the university

emitting the most GHGs per student for its perimeters 1 and 2.

Regarding scope 3 - indicatively comparable given that the categories included are not the same - UQAM is the third most emitting institution of GHGs among the establishments having carried out the inventory of this perimeter, ahead of Polytechnique Montreal and the Cégep de Saint-Jean-sur-Richelieu. These last two establishments having categories similar to UQAM for this perimeter (see Appendix E), these can be considered more directly comparable than other universities.

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As the category Daily transport, activities and international representing 91% of emissions from scope 3 of the UQAM inventory, it is relevant to compare this category to that of other universities that have included it. However, it must be taken into account that there are differences in the sub-categories of transport included. Table 16 illustrates the GHG emissions by number of students and by university for the different subcategories included. The transportation subcategories for each university are listed below the the most similar sub-category of UQAM, which highlights the fact that transport does not are not aggregated in the same way. For example, McGill University takes into account the air transportation for employees and students, however in the case of UQAM, transportation by air is included in both business travel for teaching staff and employees and in Sessions abroad).

Table 16: Comparison of emissions from the category Daily transport, activities and international with other universities

		Sub-categories associated with Daily transport, activities and international				Total Calculated (tons of CO_2 eq. / student)
UQAM	**Sub-name category**	Travel business of staff teacher and employees	Daily	Activities sports and activities school	Transport during sessions at the foreigner (Plane)	**Total transport perimeter 3**
	GHG emissions per student (tons CO_2 eq. / Student	0.0419	0.4995	0.0004	0.0523	**0.5941**
Polytechnic Montreal	**Sub-name category**	Transport business ("Business Travel ")	Daily ("Commuting")	-	-	**Total transport perimeter 3**
	GHG emissions per student (tons CO_2 eq. / Student	0.4740	0.5816	-	-	**1.0556**
University Mcgill	**Sub-name category**	Air Transport ("Air travel")	Daily ("Commuting")	Transport by third parties + Sports team ("Third party fleet "+" Sports team ")	-	**Total transport perimeter 3**
	GHG emissions per student (tons CO_2 eq. / Student	0.2011	0.1690	0.0068	-	**0.3769**

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	Sub-name category	Travel professionals and

Laval University		study by plane + Travel professionals and study in car	Transport daily	-	-	**Total transport perimeter 3**
	GHG emissions per student (tons CO_2 eq. / Students	0.1299	0.2190	-	-	**0.3489**
University Concordia	**Sub-name category**	-	Transport daily ("Commuting students "+ "Commuting employees ")	-	-	**Total transport perimeter 3**
	GHG emissions per student (tons CO_2 eq. / Student	-	0.1116	-	-	**0.1116**
University of Sherbrooke	**Sub-name category**	Travel professionals	Travel home - university			**Total transport perimeter 3**
	GHG emissions per student (tons CO_2 eq. / Students	0.0355	0.3214	-	-	**0.3569**

It can be seen that the total emissions per student in the category Daily transport, activities and international at UQAM is lower than Polytechnique Montréal's total, and of the same order greater than the totals of the Universities of Sherbrooke, Laval and McGill. The score slightly higher of UQAM compared to these universities can be explained by the differences in subcategories taken into account:

- The University of Sherbrooke has included daily trips, trips land and air professionals, but did not take accommodation into account when business trips, transport, sports and school activities or air transport students in session abroad. In addition, the transport carried out in personal vehicles and public transport includes only fuel combustion;
- Université Laval has taken daily trips into account, and has included and aggregated the business and study travel (air and land). These overlap most likely the business travel subcategories of teaching staff and employees, School activities and Transport during sessions abroad, but do not *a priori* include transport related to sports activities and accommodation during business travel ;
- McGill University has included air travel for employees and students and these journeys can be assimilated to air transport of the subcategories Business travel for teachers and employees and Transportation during

sessions abroad. The university also included daily transportation, transportation shuttle between campuses and trips for sports activities. The transportation related to school activities, accommodation and ground transportation related to business trips were not included.

Concordia University has lower emissions than all other universities, which can be explained by the fact that this property only included daily transportation in this category.

Polytechnique Montréal has included Business Transportation and Daily Transportation. in its GHG inventory. The emissions of these categories in relation to the number of students are higher than those of UQAM, but the emissions related to Daily Transport are however of the same order of magnitude. To date, there is no public report on the inclusions, data collection methods and emission factors chosen by Polytechnique Montreal. It would be interesting to have access to this information which would allow to conclude on the differences between the programs of UQAM and Polytechnique for the category Daily transport, activities and international.

If we compare only the emissions per student linked to daily transport (84% of emissions linked to daily transport, activities and international), there is more variability important between universities. This can be explained by the difference in the location of the university campuses (size of the city, location of the university in the city, means of available transport) and by the different methods used to determine the emissions of

GES. For example, in the case of Université Laval located on a campus outside the city center city, these emissions were calculated mainly from the available data on parking stickers and a survey by the Réseau de Transport de la Capitale, survey used for calculations surrounding bus trips to campus. In the case of Concordia University, only automotive-related emissions were considered (the public transport has not been included). The choice of emission factors also has an impact on the results, McGill University relying in particular on the Quantification Guide greenhouse gas emissions (Ministry of Sustainable Development, Environment and the Fight against Climate Change in Quebec) and on the Inventory Report National Environment Canada. The University of Sherbrooke relied on several sources of emission factors, including Ecoinvent v 3.5, the GHG Protocol and Rapport Environment Canada's National Inventory.

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UQAM therefore has broadcasts similar to the majority of other universities that have included emissions associated with the Daily transport, activities and international category, except that UQAM carried out a more exhaustive assessment of the various sub-categories of transport, and therefore slightly higher emissions. It would be interesting to be able to access more information concerning Polytechnique Montréal's inventory in order to be able to draw more solid conclusions as to the real differences between them.

5. RECOMMENDATIONS

Based on the GHG inventory presented in this report, recommendations representing areas for improvement or best practices to reduce emissions related to activities of UQAM were developed. These recommendations are based on:

- strategies proposed by other universities as part of their GHG inventory;
- the suggestions made by the CIME during the presentation of the preliminary results of this inventory;
- strategies developed from our experience.

These recommendations are not exhaustive and do not constitute a feasibility analysis. He are realistic reduction measures based on generic reduction measures stated in the literature of other universities, and which have the potential to be considered and integrated into UQAM's strategic planning. This section discusses the main category of emissions recommendations, the full list of recommendations being available in Annex F.

These recommendations relate to four levels (Figure 12) in order to better coordinate the actions to be implemented and to facilitate the implementation of strategic planning. Concept taken and adapted from studies from the fields of transport and materials management (3R-V), the classification of these levels indicates that the more the action is in a the higher the GHG reduction potential.

REDUCE AT SOURCE

REORGANIZE

TO TRANSFER

IMPROVE

Figure 12: Classification of the four levels of recommendations

1) **Level 1** (Reduce at source) groups together actions aimed at avoiding GHG emissions while allowing the activity in question to be carried out.
2) **Level 2** (Reorganize) includes actions that aim to rethink or restructure the system, so that it is more optimized and sees its GHG emissions decrease in his outfit.
3) **Level 3** (Transfer) consists of implementing actions that change or replace existing technologies or systems with technologies or systems alternatives emitting less GHGs.
4) **Level 4** (Improve) groups together actions that improve or improve a technology existing, but without replacing or questioning it.

DAILY TRANSPORT, ACTIVITIES AND INTERNATIONAL

First contributor to UQAM programs, the category Daily transport, activities and international is responsible for 62% of total GHG emissions. Of this share, 84% are attributable to daily transportation, 9% are associated with student air travel during international sessions and 7% are related to employee business trips

(teachers, employees). The recommendations focus on these three elements mainly contributors to the GHG inventory.

5.1.1. DAILY TRANSPORT

Emissions linked to daily transport are mainly associated with journeys in automobile. The challenge of reducing emissions in this category seems high because UQAM has limited influence on user habits, although some measures allow encourage the use of other modes of transport that emit less GHGs.

One strategy would be to encourage active transportation by assessing the needs for facilities and developing the infrastructure if necessary (Level 1 in the classification of reduction). Some possible avenues are:

- Increase the number of bicycle racks and shelters as needed;
- Evaluate the relevance of establishing more bicycle repair centers;
- Facilitate access to showers for cyclists;

A second way to reduce GHG emissions linked to daily transport would be to implement measures favoring electric cars over vehicles with gasoline (Level 3). To do this, a proposal would be to increase the number of bounds of charging and places reserved for electric vehicles.

5.1.2. BUSINESS TRAVELS FOR TEACHING STAFF AND EMPLOYEES

Considering that business transport cannot be entirely abolished since some face-to-face meetings are sometimes essential, it is nevertheless important to limit certain long-distance trips (by car or plane). Where possible, these travel could be replaced by a means of communication that emits less GHGs, like videoconferences (Level 1). An additional reduction strategy would be encourage people to combine several trips into one in order to limit the number of travel (Level 4).

5.1.3. SESSIONS AT ' ABROAD

Regarding student air travel to follow a session abroad, it is would be preferable to encourage direct flights rather than transfer flights (Level 4). In Indeed, direct flights are shorter and avoid increasing take-offs, as these these represent the moments of the journey that emit the most GHGs.

HEATING OF BUILDINGS OF ' UQAM

The second most important source of emissions (21%), the category Heating of buildings UQAM has great potential for reducing natural gas consumption whether the necessary funds are invested and whether new investment criteria are considered.

In fact, it is recommended to replace natural gas heating equipment with electrical equipment (Level 2). An alternative with less reduction impact (Level 2) would be to replace them with more efficient equipment. To another extent it It would also be interesting to re-evaluate the temperature of the thermostats so that it does not lead to overconsumption of energy while respecting the comfort of the occupants of the UQAM buildings (Level 1).

ELECTRICITY OF ' UQAM

Contributing to 10% of total GHG emissions, UQAM's electricity consumption is the third most important source of emissions and could be reduced by following certain measures. As a first step, carrying out an energy audit would make it possible to draw a energy portrait of the university to identify and implement efficiency measures (Levels 1-4). One possible measure would be to change the lighting systems to systems consuming less electricity (Level 1). Raising the awareness of the UQAM community addressed in point 5.11 would also reduce electricity consumption (Level 4).

PROCUREMENT

Fourth largest contributor to the global inventory (5% of emissions), the category Procurement brings together the various material purchases of UQAM. However, the inventory of this category shows that 77% of GHG emissions are attributable to procurement in computer equipment and in laboratory apparatus and products. Other subcategories, like furniture, the purchase of resources for the library and water represent 8%, 4% and 4% of emissions, respectively. Taking into account this distribution of emissions, the recommendations that follow focus only on equipment purchases electronic / computing laboratory, telecommunications and technology information.

A first recommendation would be that UQAM reassess the renewal policy of its electronic / computer equipment in order to extend its useful life and avoid premature replacement of functioning devices (Level 2). In addition, a policy of refurbishing computers and other equipment would improve the performance of the equipment, while prolonging its useful life (Level 4).

RESIDUAL MATERIALS

The Residual materials category represents less than 1% of UQAM's overall inventory. Despite this minor contribution compared to the other categories, it is still appropriate to institute more sustainable practices, since residual materials are an issue priority in the eyes of a large part of the population.

Ultimate waste representing 56% of GHG emissions in the Residual materials category, a reduction strategy would be to develop multi-material islands making it possible to collect organic matter separately from final waste for composting purposes (Level 1). This would make it possible to reduce the proportion of residual materials sent to landfill. It is

however, it should be noted that this measure would only be really effective if it is coupled to an information, awareness and education campaign (see section 5.9).

Another measure to reduce the impact of residual materials would be to reduce food packaging waste and disposable tableware (Level 2), for example by removing or reducing the amount of disposable utensils available in cafeterias, or reducing the

amount of packaging used for food (taking care not to increase the food waste).

FOOD

Representing less than 1% of GHGs, the Food category represents a relatively low of total emissions. However, the reduction measures in this category affect quite a bit directly the meal preparers such as cafeterias and catering services, as well as consumers in the UQAM community. These measures do not require a significant investment on the part of UQAM, but constitute a challenge aimed at change certain consumer habits and, to a certain extent, initiate a reorganization of the food offer in cafeterias and caterers.

As a first step, it would be advisable to put in place measures to reduce the food waste (Level 1) by re-evaluating the portions put on the plate of consumers and by offering personalized meal portions (with prices adjusted

depending on the amount of food). At the same time, it would be interesting to set up a "sale to discounts "on expiring food.

Another strategy to explore would be to re-evaluate the content of the meals, especially the content in meat, poultry, fish, eggs and dairy products. Emission factors from Ecoinvent v3.6 of some categories of high protein foods have been listed in the Table 17 in order to highlight the GHG emissions associated with each food category.

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Table 17: GHG emission factor of 10 foods rich in protein

RANK	FOOD	EMISSIONS (KG CO2 EQUIVALENT / KG OF

		PRODUCT)
1	Lamb	25.6
2	Beef	21.7
3	Sea food	7.8
4	Cheese	5.4
5	Pork	3.8
6	Pisces	3.5
7	Egg	2.4
8	Chicken	1.9
9	Tofu	0.98
10	Legumes	0.43

It appears that meats, poultry, fish, eggs and dairy products have an emission factor between 2 and 26 times higher than the two categories of vegetarian products (tofu and legumes). It is clear that putting in place measures such as increasing the proportion entirely vegetarian dishes and reduce the portions of meat, poultry, fish, eggs and dairy products would reduce the GHG emissions associated with food (Level 2). In addition, prioritize the choice of certain meats with less impact from an emissions point of view GHG emissions in menu development would also be a reduction strategy to be taken into account. account (Level 3).

CLOUD

In this inventory, the Cloud computing category has a marginal contribution to emissions of GHGs (1%). However, given the pandemic context, distance education and the use of cloud computing services have become prevalent and will be represent a larger part of the emissions of future balance sheets. This is why it is recommended as a first step to set up a research project aimed at better characterize and quantify the environmental impact of this category. Once this measurement implementation of measures related to raising the awareness of the UQAM community in conjunction with

a choice of more eco-responsible cloud service providers could be established.

ECO-RESPONSIBLE PROCUREMENT

With the objective of sourcing the best products and equipment available and select the best possible suppliers from an environmental, social and economic, UQAM could, like more and more public institutions, acquire a responsible procurement policy. This policy relates to the choice of suppliers of goods and services and would aim to integrate environmental impact criteria and social in the decision-making process. Eco-responsible sourcing is therefore a transversal measure applicable to all goods and services purchased by UQAM, and would cover several categories of emissions (Heating, Electricity and UQAM vehicle fleet, Food, Procurement, Cloud Computing). Some examples of supply responsible can be cited:

- Prioritize responsible sourcing of food taking into account their environmental impact (seasonal, organic and / or local foods) [1] ;
- Stock up on computing devices that consume less energy, have a higher longer life and / or more easily repairable / upgradeable;
- Favor the purchase of electric vehicles rather than gasoline vehicles during the fleet renewal;
- Increase the share of recycled paper purchased in the paper supply printing and toilet paper;

[1] Foods sourced locally or certified organic may be preferable from a environmental, however this principle remains to be confirmed on a case-by-case basis. Indeed, although certified organic foods require fewer inputs, the production yield of organic food is often lower than that of crops traditional, it is therefore more difficult to decide on its environmental superiority. The situation is similar for "local" foods. While it is certainly preferable to reduce the transport distance traveled before the consumption, the cultivation technique (energy, fertilizer, greenhouse, water, etc.) is nevertheless often an even more determinant in the carbon footprint of a food. Thus, several parameters related to the production and transport of food can influence their overall GHG emissions and the choice of an organic or local food should be based on reports life cycle analysis or carbon footprints.

- Compare and choose construction materials with their declaration product environment during work preparation;
- When possible, choose clothing with low environmental impact manufactured locally;
- Select cloud computing service providers based on their location, their carbon footprint, their impact on the community;
- Prioritize professional service providers limiting their impact on the environment (eg prioritizing a landscaper limiting their use of pesticides).

INFORMATION, AWARENESS AND EDUCATION

In a transversal way, the implementation of measures as part of an information strategy, awareness-raising and education of the UQAM community would make it possible to reduce

GHG emissions globally.

This can take many forms (e.g. organizing awareness raising events, information sessions, send out informative leaflets, set up groups of awareness and discussion) and cover several categories. Some examples of measures information, awareness and education can be named:

- Produce an informative document concerning the GHG emissions linked to the various food categories in order to make the UQAM community aware of the impact of their food choices;
- Evaluate the possibility of scheduling “meat-free days” as part of the UQAM's GHG reduction approach;
- Encourage the use of reusable cups and cups by offering them for sale in the student café;
- Carry out an awareness campaign to encourage members of the community to use public transport or active transport, considering that transport daily car use represents 37% of UQAM's total annual GHG emissions (13,755 tonnes of CO_2 eq.);
- Open discussion with the community regarding the use of public transport. public transit and active transportation in order to decide which actions to consider;

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- Put in place an institutional policy aimed at limiting long journeys to trips essential;

- Raise awareness in the UQAM community to promote behavior change with regard to energy savings, p. ex. turn off lights, computers, avoid to use the elevator;
- Set up and maintain informative displays near the islets multi-material to help people sort their residual materials;
- Carry out surveys among the community concerning the motivations and obstacles sorting of residual materials;
- Bring together "green brigades" to sensitize the community to the reduction and sorting of residual materials, in particular people living in residences academics.

ADMINISTRATIVE MANAGEMENT

Recommendations on administrative management aimed at facilitating the production of the next GHG inventory should also be highlighted.

First of all, it would be interesting to study the feasibility and the relevance of having a centralized data processing to ensure standardization of input data and improve the accessibility of the data necessary for carrying out the GHG inventory. A of the many elements that would benefit from standardization and segmentation of data remains business travel, as some entries are currently aggregated in a single line of expenditure (plane, bus, accommodation). By adding to this the integration of emission factors to the UQAM accounting system, it would be possible to automate the calculation of the GHG inventory. This would make it possible to monitor emissions by category, opening up the possibility of establishing and monitoring intermediate objectives between each complete GHG inventory. In addition, this standardization of data could turn out to be useful in other inventory and assessment operations such as audits on energy efficiency based on energy consumption.

In addition, it would be relevant for UQAM to commission a characterization study of all of their residual materials. This would make it possible to assess waste emissions specific to UQAM and to submit recommendations tailored to your situation.

It should be noted that the problem of collecting inventory data is not specific to UQAM and was mentioned by other universities that have carried out their GHG inventory, such as than the University of Montreal.

6. CONCLUSION

UQAM's GHG inventory made it possible to report on the GHG emissions associated with university activities for the year 2018-2019 and the contribution of each category to overall result. Based on exhaustive data collection covering the vast majority of emissions from UQAM and the best available emission factors, this inventory meets the criteria of relevance, completeness, accuracy and transparency. The contribution of each of the nine categories of emissions in the comprehensive income are as follows: Daily transport, activities and international (62%), Heating of UQAM buildings (21%), Electricity of UQAM (10%), Supply (5%), Residual materials (<1%), Food (<1%), Related trips to the UQAM vehicle fleet (<1%), Cloud computing (<1%), Services received (<1%). Thanks to main contributors identified in this inventory, it is possible to set up specific reduction measures and develop an awareness-raising plan for the UQAM.

UQAM is thus positioning itself alongside other universities that have carried out an inventory of their GHG emissions, such as Polytechnique Montréal and Université de Sherbrooke. Note that all universities considered in the benchmarking did not include the

perimeter 3 in their field of study, and, when it is included, the categories of this perimeter do not not represent all the activities of the university in most cases. Indeed, only UQAM and Polytechnique Montréal have covered the majority of their activities in their inventory of GHGs. UQAM is therefore one of the few main universities in Quebec to have taken not only takes into account the emissions related to heating, vehicles and electricity in establishment, but also emissions related to all other related products and services with its activities.

7. REFERENCES

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APPENDIX A: STANDARDS USED

The methodology used to calculate the emissions is based on the following two standards:

- GHG Protocol Corporate Accounting and Reporting Standard - revised edition;
- ISO 14064-1: Greenhouse gases - Part 1: Specifications and guidelines, at the level organizations, for quantification and reporting of emissions and removals greenhouse gases.

The GHG Protocol divides an organization's GHG inventory into three scopes (Figure 13):

- Scope 1 (*Scope 1*): emissions linked to the combustion of fossil fuels on the site (fixed and mobile)
- Scope 2 (*Scope 2*): emissions linked to the use of electricity on the site
- Scope 3 (*Scope 3*): emissions related to all other products and services related to the activities of the organization

Figure 13: Three scopes used in the GHG Protocol

http://ghgprotocol.org/

APPENDIX B: FUNCTIONS AND SCOPE OF ANALYSIS

In close connection with the calculations of GHGs emitted by an organization, it is necessary to specify the whole of the functions and uses that it performs in a given year in order to put into perspective the quantity of GHGs emitted and to qualify the conclusions during possible comparisons with GHG inventories of other educational institutions.

For UQAM, the following functions or uses must be emphasized:

- Teach 38,772 students during the fall semester, 35,910 during the semester winter and 16,185 during the summer session;
- Welcome and support 3,345 professors and lecturers;
- Welcome and support 2,053 administrative and management employees, managers and support staff.

These functions or uses are accomplished in the following indoor and outdoor settings on the campus:

- 436,877 m ^{2} of gross area;
- 16,681 m ^{2} of surface area dedicated to sports activities;
- 17,134 m ^{2} of laboratories;
- 3 cafeterias, 1 bar and 2 levels of catering services

• 927 rooms in residence.

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Regarding the perimeter used for this inventory, the activities, resources and materials residuals included and excluded are presented in the table below, in correspondence with the Scope levels of the GHG Protocol and of the nine categories of this inventory.

PERIMETER	INCLUSION	EXCLUSION
SCOPE 1	**1) HEATING OF UQAM BUILDINGS** -Natural gas, -No2 fuel oil	-

		-Propane -Diesel for generator	
		2) MOVEMENTS OF THE VEHICLE FLEET FROM UQAM -Movements of the entire fleet of vehicles UQAM (administrative trips, academic and research)	-
SCOPE 2	**3) UQAM ELECTRICITY**	-Electricity -Photovoltaic panels	-
PERIMETER 3	**4) POWER SUPPLY**	-Food -Disposable tableware and packaging	**FOOD** -Student cafes
	5) DAILY TRANSPORTATION, ACTIVITIES AND INTERNATIONAL	-Daily transport -Transport sports activities -Transport international sessions -Staff business travel teacher and staff -Transport for school activities	**DAILY TRANSPORTATION, ACTIVITIES AND INTERNATIONAL** -Transport international activities -Transport of humanitarian aid -International student transport no funded by UQAM -International student accommodation
	6) PROCUREMENT	- Computer hardware (Desktop computers, Laptops, Monitors, Printers / Photocopiers, Projectors, Fixed telephones, Cell phones) -Water -Cleaning products (Soap, detergent, paper toilet paper, paper towels, waste bags) -Chlore (Swimming pool) -Salt deicing -Print paper and envelopes -Laboratory (Apparatus and chemicals) -Printed resources (library)	**PROCUREMENT** -Supplies purchased by students (art supplies)

-Furnishings (Classroom chairs,
desks, tables and boxes, armchairs, tables
white)
-Construction materials
-Painting (Construction)
-Clothing (Flame retardant clothing, clothing for
work, sportswear)
-Other equipment

7) CLOUD

-External storage linked to the activities of
UQAM of teaching staff,
employees and students (courses, research,
association, etc. : OneDrive and Sharepoint)

CLOUD

-Administrative and academic storage of
UQAM externally (employees, staff
teachers, organizational units: (Google
Drive, OneDrive, DropBox, etc.))
-Email
-Visioconferences and streaming videos
direct (Teams, Google Meet, etc.)
-Delayed streaming videos (Youtube, etc.)
-Digital transactions

8) SERVICES RECEIVED

-IT services
-Accounting services
-Services in law
-Snow removal services
-Landscaping services
-Other services

-

9) RESIDUAL MATERIALS

- Ultimate waste
-Recyclable materials
-Compostable materials
-Hazardous Material
-Dry materials
-Metals
-TIC
-Batteries
-Waste.

RESIDUAL MATERIALS

-Textiles

APPENDIX C: ASSUMPTIONS AND METHODS

CATEGORY	HYPOTHESES
HEATING OF BUILDINGS UQAM	- The annual quantities of fossil fuels used for heating have been converted to MJ / year using conversion factors given by the Ministry education and higher education.
VEHICLE MOVEMENTS OF THE UQAM FLEET	- To estimate the trips related to the UQAM vehicle fleet, the data concerning the quantity of gasoline consumed by all vehicles from the UQAM fleet were used. This quantity of gasoline was converted into km traveled by a large motor vehicle using the basis of Ecoinvent data v3.6.
UQAM ELECTRICITY	- The annual electricity production of UQAM's photovoltaic panels has was estimated at 33,697 kWh, this value from the life cycle analysis report carried out as part of the project to install photovoltaic panels on the roof of the Cœur des Sciences pavilion at UQAM.
FOOD	- To estimate the share of the different categories of food consumed, the data the most recent of the Directory of food consumption and distribution were used [5]; - To estimate the share of emissions from food attributable to its transport and on its packaging before arriving at UQAM, a literature review was carried out (CT Consultant, 2021, Literature review available on request).
DAILY TRANSPORT	- Data concerning the daily number of trips (going to the campus of city center), the average distance of trips and the means of transport have

been provided by the ARTM for an average autumn day;
- The result obtained was multiplied by 2 in order to represent the back and forth movements
UQAM;
- These data have been extrapolated to 15 weeks of 5 days per week (estimate
from UQAM for the fall session);
- The extrapolation to the winter and summer sessions was carried out according to the workforce
student;
- The number and distance of trips by automobile transport has been
considered as corresponding to the number and distance of the movements of
conductors supplied by the ARTM. Passenger transport therefore has no impact
on the distance or the number of car trips, it is included in the balance sheet
but has no additional impact on automobile transport.
- The distance of trips being provided by the ARTM per entire trip, it
is distributed as follows for multimodal transport: 1) when there is
had two transports, the assumption was made of 50% of the distance traveled
with each mode; 2) when there were three transports, 33% of the total distance was
been considered for each mode; 3) when there were 3 transports including a stopover
in a car, the assumption was made of 50% of the distance traveled in
automobile, 25% of the distance with each of the other two modes;

TRANSPORT SCHOOL ACTIVITIES AND SPORTS

- Transport related to sports activities was estimated using data on
the number of people transported (team and coach) and the distances
transportation provided for each team.
- Transportation related to school activities was estimated using data on
the amount spent on bus transportation and vehicle rental.

BUSINESS TRAVELS FROM TEACHING STAFF AND EMPLOYEES

- Business travel for teaching staff and employees has been
estimated from the travel expense register. This data has been sorted
by keyword in a conservative (maximizing) way in order to best estimate the
shares of impacts attributable to aircraft, accommodation and buses. The data
being aggregated (e.g. total price for accommodation and plane), this approach does not
not allow to separate the data perfectly. The results therefore overestimate
emissions due to business trips, data on expenses
of trips would therefore deserve to be reworked in order to be more easily

	exploitable during a next inventory.
INTERNATIONAL TRANSPORT	- Data concerning the number of students in session outside UQAM and their country destination were used to estimate international transport. One go-return by plane was considered for each person.
PROCUREMENT	- Purchasing data (quantities, prices) were used to estimate the following supplies: water, chlorine (swimming pool), de-icing salt, paper, cleaning products, chemicals, printed resources (library), laboratory equipment, paint, construction materials, clothing and other equipment. - To estimate the supply of computer equipment, data concerning the number of active devices and their average lifespan before replacement were used.
CLOUD	- To estimate cloud computing (external data storage linked to activities IT services offered by UQAM to employees, faculty and students), data concerning storage (in GB) on the platforms OneDrive and Sharepoint were used.
SERVICES RECEIVED	- The services received were estimated thanks to the amounts present in the invoices issued by service providers or in amounts spent by UQAM.
RESIDUAL MATERIALS	- Data concerning the quantity of recyclable materials and ultimate waste were provided by UQAM. The characterization of these residual materials and their destination are based on the residual materials characterization study performed by Cégep St-Jean-sur-Richelieu in 2017. - The quantities of compostable materials and the destination of these materials provided by UQAM were used to estimate this element. - Data concerning the quantities, characterization and destination of hazardous materials were used to estimate waste streams biomedical, chemical waste and radioactive waste. - The quantity of wastewater has been estimated to be the same as the supply. - The quantity of metals and their destination were used to model the flow of metal. - The quantity of dry materials supplied by UQAM and the destination of the waste results of the Cégep St-Jean-sur-Richelieu study were used to estimate the flow of dry materials. - The quantities of batteries and their destination provided by UQAM have been used to model the flow of batteries. - It was considered that the quantity of IT equipment corresponds to the annual quantity of ICT waste, the destination of this waste was based on the study of Cégep St-Jean-sur-Richelieu

APPENDIX D: COMPARISON OF FACTORS OF GHG EMISSIONS

There are several GHG calculators that are available for free online. However, it is relevant to mention that the GHG emission factors used in these calculators do not generally not cover all stages of the life cycle upstream of the final process with as a consequence of underestimating the overall impacts of the use of a resource. The following table presents some key emission factors used in this inventory (Ecoinvent, Exiobase and scientific articles) and those from the FAQDD calculator [6].

ACTIVITY/ PRODUCT	UNIT	POSTMAN EMISSIONS USED IN THIS INVENTORY	POSTMAN EMISSIONS OF FAQDD (2017)	GAP EXPLANATION	
Car - gasoline	kg eq. CO_2 / km	0.353	0.21	41%	The factor used in this inventory (Ecoinvent v3.6) includes production and gasoline combustion, construction and vehicle maintenance, construction and road maintenance, as well as weighted emissions for the fleet of Quebec cars, while the postman of the FAQDD uses only combustion gasoline.
Plane < 4000km	kg eq. CO_2 / km	0.28	0.17	38%	The factor used in this inventory (Ecoinvent v3.6) includes the impact of forcing radiative at high altitude [7].
					The factor used in this inventory

Plane> 4000 km	kg eq. CO_2 / km	0.22	0.11	49%	(Ecoinvent v3.6) includes the impact of forcing radiative at high altitude.
Electricity - Quebec	kg eq. CO_2 / kWh	0.035	0.0018	95%	The factor used in this inventory [8] comes from recent research concerning the GHG emissions of the electricity production and distribution of Hydro Quebec taking into account importation and increase in emissions linked to land flooding, while the FAQDD factor seems to be

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					limit GHG emissions linked to operation of a central hydroelectric (without construction and interview).
Natural gas	kg eq. CO_2 / m_3	3.06	1.89	38%	The factor used in this inventory (Ecoinvent v3.6) considers the density energy of Canadian natural gas according to Natural Resources Canada, and the heat production from gas natural (includes infrastructure and efficiency equipment).

APPENDIX E: COMPARISON WITH OTHER INSTITUTIONS TEACHING

Results in tonnes of CO_2 equivalent

Perimeter 1 | Scope 2 | Scope 3 (Transport)

University	Year																									
UQAM	2018-2019	38772 7928	65	-	-	-	**7993**	3726	**3726**	**11669**	1625 19367	15	2027 23034 165 1726 63	12	37 40 -	197	-	-	**25274 36993**							
Polytechnic Montreal	2016-2017	8205	3038	30	-	-	-	**3069**	85	**85**	**3153**	3889 4772	-	-	8661	-	8010	3270	-	-	1709 27	-	-	**21678 24831**		
Mcgill university	2017	40971 32885 584 1515 643 -	**35627**	3631	**3631**	**39258**	8240 6924	277	-	15441	454 -	-	-	-	-	21	830	**16746 56004**								
Laval University*	2017-2018	37360 26468 567 310 -	-	**27345**	325	**325**	**27670**	4852 8181	-	-	13034 -	140 -	-	-	-	-	-1196	-	-	**11977 39648**						
University Concordia *	2014-2015	46 378 8706	431 281 -	-5 **9412**	248	**248**	**9660**	-	5177	-	-	5177	-	112 -	-	-	-	3814 4253	-	-	**13356 23016**					
University of Sherbrooke	2017-2018	42548 6315	173 310 -	-	**6798**	384	**384**	**7182**	1511 13674	-	-	15185 -	150 73	-	-	-	7910 942	-	1501 **25761 32943**							
University of Montreal	2018	45630 22 526 262 -	230 -	**23017**	95	**95**	**23112**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**23112**	
Cégep de St-Jean-on-Richelieu	2018-2019	3202	1379	6	-	-	-	**1385**	164	**164**	**1549**	-	-	-	-	6487	282 162	-	11 -	-	41	-	-	**6982**	**8531**	
Carleton University 2015		23961 18360 -	-	-	-	**18360**	5428	**5428**	**23788**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**23788**
University of New Brunswick	2015-2016	8723	10154 144 -	-	-	**10298**	20647	**20647 30945**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**30945**	

* These universities have associated carbon credits with composting (and in some cases with recycling). Profits outside UQAM have not been taken into account in the inventory. For the sake of consistency, carbon credits are not counted. The impacts on the residual materials of these universities are therefore underestimated compared to those that did not record credits associated with composting or recycling.

APPENDIX F: TABLE OF RECOMMENDATIONS

Perimeter	Category resignation	Strategy	Recommendation	Source
Perimeter 1	Heating of buildings UQAM	Reduce the consumption natural gas	- Replace natural gas heating equipment with electrical equipment - Replace natural gas heating equipment current by more efficient equipment - Set a thermostat temperature appropriate to the weather conditions and individual needs - Improve insulation (windows, insulation) to limit heat losses	GHG inventory of Cégep de Saint-Jean-sur-Richelieu GHG inventory of University of Montreal
	Travel connected to the fleet of vehicles of the UQAM	Reduce the consumption fuel	- Favor the purchase of electric vehicles during the fleet renewal - Modify the vehicle renewal policy to extend their lifespan	GHG inventory of University of Montreal, CT Consultant
Scope 2	Electricity UQAM	Reduce the consumption electricity	- Change the lighting systems for more models energy efficient - Carry out an energy audit leading to the establishment of efficiency measures - Raise awareness in the UQAM community to promote behavior changes, eg. ex. turn the lights off, computers, avoid using the elevator	GHG inventory of Polytechnic Montreal GHG inventory of University of Montreal GHG inventory of Polytechnic Montreal
Scope 3	Food Reduce waste food		- Offer personalized meal portions - Offer discounts on expiring foods - Organize the redistribution of unsold food to community organizations	GHG inventory of Cégep de Saint-Jean-sur-Richelieu
		Review the offer food from cafeterias and caterers	- Reduce the portions of meat, poultry, fish and products dairy - Increase the proportion of entirely vegetarian dishes - Prioritize the choice of certain meats in the preparation of menus	GHG inventory of Cégep de Saint-Jean-sur-Richelieu
		Reduce the impact linked to the purchase of food	- Prioritize responsible food sourcing by taking into account their environmental impact (food season, organic and / or local)	GHG inventory of Cégep de Saint-Jean-sur-Richelieu
	Transport daily	Reduce emissions due to transport daily	- Decrease the share of solo cars in favor of other modes of transportation such as active transportation and public transit - Evaluate the relevance of increasing the accommodation offer by UQAM residences to reduce daily transportation - Evaluate the relevance of promoting an application promoting carpooling - Increase the number of charging stations and places reserved for electric vehicles - Evaluate the needs for facilities promoting active transportation (bike racks, showers, bike repair centers,	GHG inventory of University of Sherbrooke GHG inventory of Cégep de Saint-Jean-sur-Richelieu GHG inventory of Cégep de Saint-Jean-sur-Richelieu GHG inventory of University of Sherbrooke GHG inventory of Cégep de Saint-

		self-service bicycles)	Jean-sur-Richelieu

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Travel business of staff teacher and employees	Reduce emissions due to transport business	- Encourage videoconferences rather than travel long-distance business (automobile or plane)	GHG inventory of University of Montreal
Transport international	Reduce emissions due to transport international of students in exchange	- Favor direct flights to flights with transfer	GHG inventory of Cégep de Saint-Jean-sur-Richelieu
Stocked is lying	Reduce the consumption water	- Evaluate the relevance of reusing rainwater for supply sanitary equipment	GHG inventory of Polytechnic Montreal
	Reduce the impact related to purchases equipment	- Reassess the equipment renewal policy in order to extend the duration of use - Prioritize the refurbishment of equipment rather than replacement - Prioritize more durable equipment and more energy efficient	GHG inventory of Cégep de Saint-Jean-sur-Richelieu
Materials residual	Reduce the number of materials residual	- Reduce food packaging while ensuring avoid food waste - Eliminate or reduce disposable dishes - Eliminate or reduce the supply of bottled water	GHG inventory of University of Sherbrooke, CT Consultant
	Collect them materials organic to ends of composting	- Establish multi-material islands (recyclable materials, compostable materials, final waste)	GHG inventory of Cégep de Saint-Jean-sur-Richelieu, CT Consultant
Cloud computing	Evaluate and reduce impacts	- Integrate environmental and social criteria in the choice from the cloud service provider	CT Consultant
		- Encourage the establishment of a research project aimed at determine the environmental impact of activities related to cloud computing	CT Consultant

Procurement environmentally friendly	Reduce the impact of purchasing products and services	- Obtain supplies from eco-responsible suppliers, locals, actors of social development and the economy circular - Include environmental impact as a purchasing criterion (carbon footprints, life cycle analyzes, declarations environmental products)	GHG inventory of University of Montreal, Sherbrooke, CT Consultant
Information, awareness and education	Achieve the goals of reduction of UQAM emissions across all categories emissions	- Inform and mobilize the UQAM community (Information, awareness and education) p. ex. planning awareness-raising events, sessions information, by transmitting leaflets.	CT Consultant
Management administrative	Facilitate the production of inventory	- Standardize all input data for example - Study the relevance of having a treatment system centralized data - Evaluate the feasibility of integrating emission factors of GES to automate the inventory calculation - Set intermediate reduction targets (e.g. everyone every three years) of GHG reductions	GHG inventory of University of Montreal, CT Consultant

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Other	Reduce consumption energy and promote biodiversity	- Evaluate the relevance and feasibility of opting for roofs green instead of conventional roofs at the end of the roof's life	GHG inventory of University of Montreal, CT Consultant
	Broaden the field of study of next carbon footprint	- Evaluate the impact of investments and target responsible investments - Consider the storage of biogenic carbon in green spaces belonging to UQAM	CIME Committee UQAM
	Offset GHG emissions from UQAM	- Consider the purchase of carbon credits	CIME Committee UQAM

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INVENTORY OF GREENHOUSE GAS

YEAR 2018-2019