Methodological guide to the carbon footprint
Universite de Montreal

A. Introduction

The purpose of this guide is to detail the methodology used by the Sustainable Development Unit of the University of Montreal (hereafter "University") to establish the carbon footprint of the institution. The reference university period for this guide is from May 1er 2020 to April 30 2021. This period was chosen because we had a greater number of emission sources than in previous years. We chose an academic fiscal year instead of a calendar year because the majority of the raw data is inventoried this way by the University for reporting to the government. Some data are only available in calendar years, so we took them as is.

The presentation of the methodology used to carry out the carbon footprint will allow external or internal evaluators, as well as future managers of this activity, to trace the steps taken to complete such a project. It will also allow them to evaluate the accuracy of the methodology and, if necessary, to improve it.

It should be noted that due to the difficulty of accessing some raw data for several emission sources, assumptions had to be made in order to estimate the carbon footprint. Specifically, the annual energy consumption by energy source category is taken from the University Building Energy Survey (UBES), available on the Quebec Ministry of Higher Education website, and not from the invoices paid by the University to energy suppliers. This document provides the energy consumption reported in standard units by Quebec universities for each university period since 1999. For each of the emission sources where such a situation occurred, a note was added indicating what future steps should be added to improve the accuracy of the results.

To this end, this guide will be updated annually, if possible, to take into account methodological developments.

B. How the guide works

In order to reflect the structure of our first carbon footprint, the guide will be sectioned by the University's emissions sources, with each source categorized according to the Scope (1, 2 or 3) of the GHG Protocol to which it belongs.

In addition, for each of the sources, the following information will be detailed:

- The data collection process
- Data holders
- Responsible parties by emission sector
- Calculation methods
- The coefficients
- The assumptions
- Bibliographic references used for the quantification
- Other remarks (if applicable)

For each emission source, the result is presented in tons of CO_2 equivalent ("TCO_{2eq}").

C. The categories

As mentioned earlier, a carbon footprint is broken down by emission source according to whether it belongs to Scope 1, 2 or 3.

Scope 1 includes all emissions from sources under the control of the organization.

Scope 2 includes emissions generated by resources that it has consumed but over which it does not have control.

Finally, scope 3 is a category seen as "more optional". It includes all other sources that the organization does not own or control, but that are related to its activities. There is no pre-established list of what this level of reporting should contain. We have chosen (list of emissions) as do most research universities that report their GHG emissions.

Table 1 - List of UdeM emission sources by scope

Scope 1	Scope 2	Scope 3
• Buildings - Natural Gas (m)^3 • Buildings - Steam (Lb) • Buildings - Oil 2 (L) • Buildings - Fuel Oil 5/6 (L) • Real Estate - Diesel (L) • Fugitive emissions (kg) • Agricultural emissions (unit) • Vehicles - Fuel (L)	• Electricity (kWh)	• Commuting (unit) • Business travel and students (unit) • Paper (unit) • T&D loss (kWh) • Drinking water consumption (m)^3 • Wastewater (m)^3 • Food (kg) • Rented space (kWh/m)^3 • Investment ($)

D. Contents

Source of emission	Holders of raw data	Responsible for At UdeM	Raw data required
Scope 1			
Natural Gas	• Real estate management • MESQ • Energize	Real Estate Department	Natural gas consumption in **m^3** for the academic period studied.
Steam	• Real estate management • MESQ	Real Estate Department	Steam production in **lb** for the academic period studied.
Oil 2	• Real estate management • MESQ	Real Estate Department	Fuel oil consumption 2 in **liters** for the academic period studied.
Fuel oil 5/6	• Real estate management • MESQ	Real Estate Department	Fuel oil consumption 5/6 in **liter** for the period university studied.
Diesel	• Real estate management • MESQ	Real Estate Department	Diesel consumption in **liters** for the university period studied.
Fugitive emissions	• Direction Buildings • Manufacturing companies • Literature review	Real Estate Department	• Brand of the device • Model of the device • Date of installation of the device • In charge of cooling **(kg)** • Period of use per year **(in months)** • Emission of operation **(%)** • End of life emission **(%)** • Duration the device **(in years)**

Agricultural emissions	• Center University Veterinary Hospital of At UdeM	Faculty of Veterinary Medicine from	• Animal categories • Number of heads per category
Vehicles - Fuel	• Direction of Supply	Division of supplies	• Volume of diesel and of gasolinein **liter**

	• Foss National Leasing		purchased at academic term
Scope 2			
Electricity	• Direction Buildings • MESQ	Real Estate of Departme nt	• Consumption of electricity in **kWh** for the university period
Scope 3			
Commuting	• Registrar's Office • Direction Human Resources • CGD Smart Travel • Diagnosisof mobility mobilit y (2013) • Literature review	Sustainable fro Development m Unit	• Full-time equivalent student population • Number of full-time University employees • Statistics on the use of transport modes by category of individuals • Average distance travelled in **km** by mode of transport • Carbon footprint per **km** by mode of transport
Student business and travel	• The International House of UdeM • Literature review	Not applicable	• Different modes of transportation • Number of people per category (students or professionals) • Number of kilometres travelled per categories of individuals by transport category
Paper	• Service UdeM's printing department	UdeM printing service	• Paper volume consumed by paper category
T&D loss	• Building Managemen t • MESQ	Real Estate of Departme nt	• Consumption of electricity in **kWh** for the university period • Quebec T&D loss factor in **%.**
Drinking water consumption	• Building Managemen	Building Management	• Volume of drinking water in **m^3** consumed

	t		in an academic year
Wastewater	*Geographic versus institutional drivers of nitrogen footprints: a comparison of two urban universities*" by Talbot et al. (2020)	Direction of Buildings	• Volume of wastewater in **m³** produced in an academic year
Food	• Gordon Food Service Canada • Dubé Loiselle Student Café	• UdeM Food Service • Student Cafés	• Food categories • Volume purchased in **kg** per category
Rented spaces	• Real Estate Affairs	• Real Estate Affairs	• List of leased assets and area (building)
Investment	• Finance Department	• Finance Department	• Dollars invested

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E. Scope 1

1. Buildings - Natural Gas

- Data collection process

In order to calculate the carbon footprint of natural gas consumption by the University, it is necessary to collect the consumption of this energy source in m^3 for the academic period under study.
As part of the carbon footprint, this data was collected in the GEMS. This document provides the natural gas consumption in m^3 .

- Data holders

There are three holders of the raw data on natural gas consumption by the University, one internal, and two external:

Internal: **Direction des Immeubles** de l'Université de Montréal, through the Excel file entitled "EnerUNIV", compiled annually.
External: **Ministère de l'Enseignement Supérieur du Québec** and **Energir**.

- The people in charge

The department that operates this emission source is the University of Montreal's Direction des Immeubles (DI)

- Calculation method

$$kgCO2éq = \sum Gaz\ naturelm3 * (FEco2 * PRPco2 + FECH4 * PRPCH4 + FEN2O * PRPN2O)$$

$$_2\,TCOéq = kgCO_2\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent Natural gas:
Fuel type

EF: Emission factor for type of greenhouse gas (CO_2, CH_4, N_2O)
GWP: Global Warming Potential for greenhouse gas type (CO_2, CH_4, N_2O)

- Coefficient

FE kg of CO_2 per m^3 of natural gas: 1.887
EF kg of CH_4 per m^3 of natural gas: 0.000037 EF
kg of N2O per m^3 of natural gas: 0.000035
GWP of CO_2: 1
GWP of CH_4: 28
GWP of N2O: 265

- Assumption

s Not applicable.

- References used for quantification

Source Emission Factor (EF): *Conversion tables used for the reporting and inventory of greenhouse gases in the institutional sector - Transition Énergétique Québec* Source Global Warming Potential (GWP): *IPCC Fifth Assessment Report*

- Other remarks

In order to ensure the accuracy of the results, the raw data on the University's natural gas consumption should be collected from the monthly bills that the University pays to Energir. At the time of writing this guide, these invoices are not available to the team responsible for the carbon footprint. We have not been able to perform a spot check.

In addition, it is necessary to validate with the ID at what temperature the buildings are heated, in order to correctly estimate the volume of natural gas consumed per pavilion because the density of the gas changes according to the pressure and temperature (reference: Conversion factors

and units frequently used in the North American Energy Information Cooperation (NAEC) (nrcan.gc.ca)).

Finally, the natural gas emission factors for CO2, CH4 and N2O are an estimate from the conversion table provided by Transition Énergétique Québec. Once the monthly consumption values will be available (Energir invoice), we will be able to use real emission factors, taking into account the gross calorific value and the average temperature.

2. Buildings - Steam

- Data collection process

In order to calculate the carbon footprint of the University's steam production, it is necessary to collect data on the production of this energy source for the academic period studied. It should be noted that the University does not consume steam, it is a net exporter. In fact, it produces steam from natural gas to supply a school next to the Marie-Victorin Pavilion.
As part of the carbon footprinting process, this data was collected in the UBP. This document provides the steam production in pounds (lb).

- Data holders

There are two holders of the University's raw steam generation data, one internal, and one external.

Internal: **Direction des Immeubles** de l'Université de Montréal, through the Excel file entitled "EnerUNIV", compiled annually.
External: **Quebec Ministry of Higher Education**.

- The people in charge

The department that operates this emission source is the University of Montreal's Direction des Immeubles (DI)

- Calculation method

$$kgCO2éq = \sum VapeurLb * (FEco2 * PRPco2 + FECH4 * PRPCH4 + FEN2O * PRPN2O)$$

$$_2\,TCOéq = kgCO_2\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent EF: Emission factor for type of greenhouse gas (CO_2, CH_4, N_2O)

GWP: Global Warming Potential for greenhouse gas type (CO_2, CH_4, N_2O)

- Coefficient

FE kg of CO_2 per lb of steam: 0.0755 FE
kg of CH_4 per lb of steam: 0.00001 FE kg
of N_2O per lb of steam: 0.00001 CO_2 GWP:
1
GWP of CH_4: 28
GWP of N2O: 265

- Assumption

s Not applicable.

- References used for quantification

Source Emission Factor (EF): *Conversion tables used for the reporting and inventory of greenhouse gases in the institutional sector - Transition Énergétique Québec*

Source Global warming potential (GWP): *IPCC Fifth Assessment Report*

- Other remarks

100% of the steam produced by the University comes from the natural gas consumption of the Marie-Victorin building.
The GHG emissions related to steam production are included in the volume emitted by natural gas consumption.

3. Buildings - Oil 2

- Data collection process

In order to calculate the carbon footprint of the University's fuel oil 2 consumption, it is necessary to collect the consumption of this energy source for the academic period studied.
As part of the carbon footprint, this data was collected in the UBMR. This document provides the consumption of fuel oil in liters.

- Data holders

There are two holders of the raw data on fuel oil 2 consumption by the University, one internal, and one external.

Internal: **Direction des Immeubles** de l'Université de Montréal, through the Excel file entitled "EnerUNIV", compiled annually.
External: **Quebec Ministry of Higher Education**.

- The people in charge

The department responsible for this emission source is the University of Montreal's Department of Buildings.

- Calculation method

$$kgCO2éq = \sum Mazout_{2L} * (FEco2 * PRPco2 + FECH4 * PRPCH4 + FEN2O * PRPN2O)$$

$$_2\,TCOéq = kgCO_2\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent Fuel oil 2:
Type of fuel
EF: Emission factor for type of greenhouse gas (CO_2, CH_4, N_2O)
GWP: Global Warming Potential for greenhouse gas type (CO_2, CH_4, N_2O)

- Coefficient

FE kg of CO_2 per L of fuel oil 2: 2.753

EF kg of CH_4 per L of fuel oil 2 : 0.000026 EF

kg of N2O per L of fuel oil 2 : 0.000031 GWP

of CO_2 : 1

GWP of CH_4: 28

GWP of N2O: 265

- Assumption

s Not applicable.

- References used for quantification

Source Emission Factor (EF): *Conversion tables used for the reporting and inventory of greenhouse gases in the institutional sector - Transition Énergétique Québec*

Source Global warming potential (GWP): *IPCC Fifth Assessment Report*

- Other remarks

The raw consumption data should be collected from the supplier's invoices.

4. Buildings - Oil 5/6

- Data collection process

In order to calculate the carbon footprint of the University's fuel oil consumption 5/6 it is necessary to collect the consumption of this energy source for the academic period under study.
As part of the carbon footprint, this data was collected in the UBMR. This document provides the consumption of fuel oil 5/6 in liters.

- Data holders

There are two holders of the raw data on fuel oil consumption 5/6 by the University, one internal, and one external.

Internal: **Direction des Immeubles** de l'Université de Montréal, through the Excel file entitled "EnerUNIV", compiled annually.
External: **Quebec Ministry of Higher Education**.

- The people in charge

The department responsible for this emission source is the University of Montreal's Department of Buildings.

- Calculation method

$$kgCO2éq = \sum Mazout_{\ 5/6L} * (_{FEco2} * _{PRPco2} + _{FECH4} * _{PRPCH4} + FEN2O * PRPN2O)$$

$$TCO_2éq = \frac{kgCO2éq}{1000}$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent Oil 5/6:
Type of fuel
EF: Emission factor for type of greenhouse gas (CO_2, CH_4, N_2O)
GWP: Global Warming Potential for greenhouse gas type (CO_2, CH_4, N_2O)

- Coefficient

FE kg of CO_2 per L of fuel oil 5/6 : 3.156
FE kg of CH_4 per L of fuel oil 5/6 : 0.000057
EF kg of N2O per L of fuel oil 5/6: 0.000064
GWP of CO_2: 1
GWP of CH_4: 28
GWP of N2O: 265

- Assumption

s Not applicable.

- References used for quantification

Source Emission Factor (EF): *Conversion tables used for the reporting and inventory of greenhouse gases in the institutional sector - Transition Énergétique Québec*

Source Global warming potential (GWP): *IPCC Fifth Assessment Report*

- Other remarks

The University's last consumption of 5/6 fuel oil was in 2001-2002.

The raw consumption data should be collected from the supplier's invoices.

5. Buildings - Diesel

- Data collection process

In order to calculate the carbon footprint of the University's consumption of diesel fuel (building), it is necessary to collect the consumption of this energy source for the academic period studied. As part of the carbon footprint, this data was collected in the UBP. This document provides the diesel consumption in liters.

- Data holders

There are two holders of the raw data on diesel consumption by the University, one internal, and one external.

Internal: **Direction des Immeubles** de l'Université de Montréal, through the Excel file entitled "EnerUNIV", compiled annually.
External: **Quebec Ministry of Higher Education**.

- The people in charge

The department that operates this emission source is the University of Montreal's Direction des Immeubles (DI)

- Calculation method

$$kgCO2éq = \sum Diesel_L * (FEco2 * PRPco2 + FECH4 * PRPCH4 + FEN2O * PRPN2O)$$

$$_2 TCOéq = kgCO_2 éq/1000$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent Diesel: Type of fuel
EF: Emission factor for type of greenhouse gas (CO_2, CH_4, N_2O)
GWP: Global Warming Potential for greenhouse gas type (CO_2, CH_4, N_2O)

- Coefficient

FE kg of CO_2 per L of diesel: 2.681
EF kg of CH_4 per L of diesel: 0.000078 EF
kg of N_2O per L of diesel: 0.000022 GWP
of CO_2: 1
GWP of CH_4: 28
GWP of N2O: 265

- Assumption

s Not applicable.

- References used for quantification

Source Emission Factor (EF): *Environment Canada - Emission Factor (Table A6.1-5: Emission Factors for Refined Petroleum Products)*

Source Global warming potential (GWP): *IPCC Fifth Assessment Report*

- Other remarks

It is necessary to find out who is the supplier of the diesel fuel and for what purpose it is used.

The raw consumption data should be collected from the supplier's invoices.

6. Fugitive emissions

- Data collection process

In order to calculate the carbon footprint of fugitive emissions by the University, it was necessary to collect a list of all chillers and condensers owned by the institution, as well as the following information for each piece of equipment:

  - Brands
  - Models
  - Date of installation
  - Cooling load
  - Period of use per year
  - Operating emission

- Data holders

Data holders vary depending on the category of data used and the make and model of the device:

  - Trademark: La **Direction des Immeubles** de l'Université de Montréal.
  - Model: La **Direction des Immeubles** de l'Université de Montréal.
  - Date of installation: U of M **Real Estate Management**.
  - Cooling load: Manufacturing company of the device
  - Period of use per year (in months): **Building Management** of the University of Montreal.
  - Operating Program: Literature Review
  - End-of-Life Broadcasting: A Review of the Literature
  - Device Lifetime: Literature Review

- The people in charge

The department that operates this emission source is the University of Montreal's Direction des Immeubles (DI)

- Calculation method

Step 1

$$Fuite\ de\ réfrigérant = Charge\ de\ réfrigérant * (émission\ de\ fonctionnement\ annuel + (\frac{Émission\ de\ fin\ de\ vie}{Durée\ de\ vie\ estimée})$$

Step 2

$$kgCO2éq = \sum_{-}^{n} Fuite\ de\ réfrigérant * {}_{PRP(HFC\text{-}R134A\ |\ HFC\text{-}R410A\ |HFC\text{-}R407C\ )} * \frac{Période\ utilisation\ en\ mois}{12}$$

$$_2\,TCOéq = kgCO_2\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of $_{CO2}$ equivalent N: Number of units in operation
Refrigerant charge : Volume in kg of refrigerant that a unit can hold GWP: Global warming potential for refrigerant gas type

- Coefficient

GWP of HFC-R134A: 1,300.00
GWP of HFC-R410A: 1,923.50
GWP of HFC-R407C: 1,624.21
GWP of HFC-R23: $12,400.00

- Assumptions
    - Note 1: For operating emissions, we have estimated the percentage of emissions based on the age of the chiller/condenser installation; the older the chiller/condenser, the higher the percentage. This estimate is based on the sources described below. The table describing the percentage by year of installation is also listed below. The scientific literature indicates a decrease in the emission rate of

The models of the last years reach 0.5% per year.

- Note 2: End-of-life emissions are estimated at 10% of the refrigerant charge of the unit. This value corresponds to the average of what is commonly estimated in the scientific and industrial literature, i.e. values ranging from 5% to 15% of the refrigerant charge.

- Note 3: The life of the equipment is estimated at 30 years.

- References used for quantification

  - *Calculation methodology:* Intergovernmental Panel on Climate Change. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3. Industrial Processes and Product Use.

  - *Chiller and condenser model*: "Chiller_Equipment record - emissions. xlsx" file provided by the UdeM Buildings Directorate (2020).

  - *Refrigerant charge in kg*: The refrigerant charge in kg for each model was extracted from the manufacturer's website; when this information was not available, we estimated the refrigerant charge in relation to the cooling charge and by applying a rule of three to the models for which the information was available. See in the Excel file "Cooler Equipment Record - Emissions. xlsx" in the column "Refrigerant charge (kg)" to have the value per unit.

  - *Operating emission per year in percent:*
    - 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3: Industrial Processes and Product Use. Table 7.9
    - IOR - Reducing Refrigerant Emissions (2009)
    - Annual leakage rate (%) for the refrigeration/air-con/HVAC : Support (accuvio.com)
    - IN BRIEF CHILLERS - UNDERSTANDING METRICS FOR TOTAL EMISSIONS - Fluorocarbons
    - IPCC/TEAP Special Report: Safeguarding the Ozone Layer and the Global Climate System Chapter 5

- DEPARTMENT OF ENVIRONMENT AND CLIMATE CHANGE (MELCC). Guide to quantifying greenhouse gas emissions, 2019, 107 pp.

Year installation	Operating emission (% of the load per year)	Estimated life span
2018 and up	0.5%	30
After 2010	2%	30
Before 2010	8.5%	30

- *Estimated lifetime:* IPCC/TEAP Special Report: Safeguarding the Ozone Layer and the Global Climate System Chapter 5

- *Global warming potential (GWP) of refrigerant gases*: Scientific Assessment of Ozone Depletion, World Meteorological Organization (2014) - AR5 IPCCs

- *End-of-Life Emissions of Chillers in %*: IPCC/TEAP Special Report: Safeguarding the Ozone Layer and the Global Climate System Chapter 5

- Other remarks

Note 1: In order to follow the GHG Protocol Corporate Standard methodology, HCFC leakage emissions are not included in the balance sheet, as these are covered by the Montreal Protocol.

Note 2: The university should maintain a record of its halocarbon emissions. Payment of invoices from service providers for these products should be conditional on the submission of a certificate indicating the volume, type of halocarbon and its chemical formula.

7. Agricultural emissions

- Data collection process

In the framework of the University's carbon footprint, agricultural emissions only concern emissions related to enteric fermentation, and manure management, in the case of horse, poultry, pig and dairy cow rearing. The breeding of these animals is carried out for educational purposes. The academic period for the estimation of agricultural emissions is 2017-2018, due to the fact that it was not possible to collect raw data for subsequent years. In order to calculate the carbon footprint of the University's agricultural activities, it was necessary to collect the number of heads for each of these 4 animal species. For the purposes of the carbon footprint, this data was collected from the Centre hospitalier universitaire vétérinaire in Saint-Hyacinthe.

- Data holders

The holder of the raw animal husbandry data by the University is the **University Veterinary Hospital** (CHUV) of the University.

- The people in charge

The entity responsible for this emission source is the Faculty of Veterinary Medicine, St-Hyacinthe campus of the Université de Montréal.

- Calculation method

$$kgCO2éq = \sum_{-}^{n} Nombre\ de\ têtes * FE\ _{\frac{\frac{CH4}{tête}}{année}}$$
-

$$_2\,TCOéq = kgCO_2\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent N: Animal category

EF: CH4 emission factor per head per year for enteric fermentation and manure management.
GWP: Global Warming Potential for CH_4

- Coefficient

EF kg CH_4 per year per head of dairy cow: 142.2 (enteric fermentation) and 39 (manure management)
FE kg CH_4 per year per horse: 18 (enteric fermentation) and 2.6 (manure management)
EF kg CH_4 per year per pig: 1.5 (enteric fermentation) and 4.2 (manure management) EF kg CH_4 per year per poultry: 0 (enteric fermentation) and 0.021 (manure management) GWP $_{CH4}$: 28

- Assumption

s Not applicable.

- References used for quantification

Source Emission Factor (EF): *United Nations Framework Convention on Climate Change - Handbook of Agriculture Sector Simulation of Inventory Elaboration* *and* Environment Canada, 2021. National Inventory Report 1990-2019, Part 2). See Tables A3.4-8, A6.4-2, A6.4-6, A3.4-18.

Source Global warming potential (GWP): *IPCC Fifth Assessment Report*

- Other remarks

The animals owned by UdeM on this campus are for the purpose of learning veterinary medicine and not for production to be sold on the market.
For the sake of accuracy of results, the University's raw animal husbandry data should be updated annually. The latest data is from 2017-2018.

8. Vehicles - Fuel

- Data collection process

In order to calculate the carbon footprint of fuel consumption by the University, it is necessary to collect the consumption of this energy source (both diesel and gasoline) for the academic period under study.
In conducting the carbon footprint, this data was collected from the University's sole fuel card provider, Foss National leasing.

- Data holders

There are two holders of the raw fuel consumption data by the University, one internal, and one external.

Internal : **Direction des Approvisionnements** de l'Université de Montréal.
External: **Foss National Leasing** (manager of credit cards used for fuel)

- The people in charge

The entity responsible for collecting the data is the Procurement Division of the Université de Montréal. UdeM's vehicles are distributed within departments and faculties.

- Calculation method

$$kgCO2éq = \sum_{-}^{n} VolumeLitres * (FEco2 * PRPco2 + FECH4 * PRPCH4 + FEN2O * PRPN2O)$$

$$_2\,TCOéq = kgCO_2\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent N: Type of fuel (diesel or gasoline)
EF: Emission factor for CO_2

- Coefficient

FE kg of CO_2 per liter of diesel: 2.681
FE kg of CH_4 per liter of diesel : 0.000086
FE kg of N2O per liter of diesel : 0.00074
FE kg of CO_2 per liter of gasoline: 2.307
FE kg of CH_4 per liter of gasoline : 0.000116
FE kg of N2O per liter of gasoline: 0.00031
CO_2 GWP: 1
GWP of CH_4: 28
GWP of N2O: 265

- Assumptions

Although the Procurement Division is the holder of UdeM's vehicle registration certificates, we were unable to correlate consumption data by vehicle model. The emission factor for diesel and gasoline was therefore estimated from the average emission factor for heavy-duty vehicles, light-duty vehicles and trucks.

- References used for quantification

Source Emission Factor (EF): *Conversion tables used for the reporting and inventory of greenhouse gases in the institutional sector - Transition Énergétique Québec*

Source Global warming potential (GWP): *IPCC Fifth Assessment Report*

- Other remarks

The time period in question for the latest available results is for the 2019 calendar year, and thus do not accurately reflect the 2018-2019 academic period. This is because Foss National Leasing's accounting follows a calendar year, we took their data as is.

In addition, since the emission factors vary according to the weight of the vehicle and its year of manufacture, it is recommended that the calculations be made for each vehicle, and then the emissions of all the vehicles be added together.

We should require, at the contract level with the service provider, an accounting on the basis of an academic year as well as the indication of the vehicle's license plate for each consumption.

F. Scope 2

1. Electricity

- Data collection process

In order to calculate the carbon footprint of electricity consumption by the University, it is necessary to collect the consumption of this energy source for the academic period under study.

As part of the carbon footprinting process, this data was collected in the UBP. This document provides the electricity consumption in kWh for the University.

- Data holders

There are two holders of the raw data on electricity consumption by the University, one internal, and one external.

Internal: **Direction des Immeubles** de l'Université de Montréal, through the Excel file entitled "EnerUNIV", compiled annually.
External: **Quebec Ministry of Higher Education**.

- The people in charge

The department that operates this emission source is the University's Buildings Department.

- Calculation method

$$kgCO2éq = \sum \text{É}lectricitékWh * (_{FEco2} * _{PRPco2} + _{FECH4} * _{PRPCH4} + FEN2O * PRPN2O)$$

$$_2\,TCOéq = kgCO_2\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of $_{CO2}$ equivalent Electricity:
Type of fuel
EF: Emission factor for type of greenhouse gas ($_{CO2}$, $_{CH4}$, $_{N2O}$)

GWP: Global Warming Potential for greenhouse gas type (CO_2, CH_4, N_2O)

- Coefficient

FE kg of CO_2 per kWh of electricity: 1.5 (year 2018)
FE kg of CH_4 per kWh ofelectricity: 0.0002
FE kg of N2O per kWh of electricity: 0.0001
CO_2 GWP: 1
GWP of CH_4: 28
GWP of N2O: 265

- Assumption

s Not applicable.

- References used for quantification

Source Emission Factor (EF): *National Inventory Report - 2020 Edition Part 3 Table A13-6*

Source Global warming potential (GWP): *IPCC Fifth Assessment Report*

- Other remarks

For the sake of accuracy, the raw data on the University's electricity consumption should be collected from the monthly bills that the University pays to Hydro-Québec. At the time of writing this guide, these were not available to us.

G. Scope 3

1. Commuting

- Data collection process

The University's commuting carbon footprint includes both student and institutional employee travel.
The collection of the following data categories was required for the calculation of the footprint for this category:

- Full-time equivalent student population
- Number of full-time University employees
- Statistics on the use of transport modes by category of individuals
- Average distance travelled in km by mode of transport
- Carbon footprint per km by mode of transport

The carbon footprint for this emission source was only calculated for the years 2013 and 2018 due to the lack of data for the other years. UdeM conducted an origin-destination (OD) survey in 2012. Modal shares were updated in 2013 from the ARTM OD survey. These figures were updated from the modal share changes of Polytechnique Montréal, which conducted its OD in 2018 and still has the same modal share profile as UdeM.

- Data holders

Data holders vary by category:

- Full-time equivalent student population: **Registrar's Office of** the Université de Montréal
- Number of full-time employees of the University: **Direction des ressources humaines de** l'Université de Montréal
- Statistics on the use of transport modes by category of individuals : **calculated by the CGD Voyagez futé**
- Average distance travelled in km by mode of transportation: **Diagnostic de mobilité durable campus de l'Université de Montréal, 2013**

- Carbon footprint per km per km by mode of transport: **Literature review**

- The people in charge

The UdeM Sustainable Development Unit is responsible for mobility measures.

- Calculation method

$$gCO2éq = \sum_{-}^{n}(Mode\ de\ _{transport\%} * Effectif\ totalemployé) * ((Distance\ _{moyennekm} * 2 * Nombre\ déplacementsJours) *\ _{FEgCO2/}km)$$
$$+ \sum_{-}^{n}(Mode\ de\ _{transport\%} * Effectif\ totalétudiant) * ((Distance\ _{moyennekm} * 2 * Nombre\ déplacementsJours) *\ _{FEgCO2éq/}km)$$

$$TCO2éq = kgCO2éq/10000$$

TCO2eq: Sum of GHG emissions in tons of $_{CO2}$ equivalent
N: Mode of transportation (car, carpooling, public transit, multi-mode, "kiss n ride", walking, cycling)
Mode of Transportation %: Percentage of total workforce that uses this mode of transportation Total workforce: Total number of individuals in the category in question (employee or student) Average Distance km: Average distance traveled by mode of transportation for a one-way trip
Number of trips in days: Number of trips in a year by category of individual.
EF: Emission factor in gCO2eq/km by mode of transport

- Coefficient

FE g of $_{CO2eq}$ per km of self-drive: 212.71 FE
g of CO2eq per km of carpooling: 70.9

FE g CO2eq per km public transport: 47.4 FE g
CO2eq per km multimode: 130.055 FE g CO2eq
per km walking: 0
FE g of CO2eq per km of bicycle: 0

- Assumptions

The number of travel days per year is estimated at 335 days, or one year minus 30 vacation days, for all categories.
For multi-modal transportation, the emission factor is the average of that of car and public transit.

- References used for quantification

  - Statistics on the means of transport for commuting: Evolution of modal shares 2013-2018 - *Voyagez Futé*
  - Statistics on the average distance travelled by means of transportation for commuting in km: *Diagnostic de mobilité durable campus de l'Université de Montréal, 2013*
  - Employee and student count data for 2013-2018: *Provided by the UdeM Human Resources office.*
  - Volume of emissions in gCO2eq by mode of transport :
    - Carpooling: *Conversion tables used for institutional sector reporting and greenhouse gas inventory - Transition Energétique Québec*
    - Public transportation: *http://stm.info/sites/default/files/pdf/fr/pdd2025i.pdf - page 12 of the report*

- Other remarks

Some of the data (travel statistics) are from 2013 or 2018; therefore, the results may not reflect current reality. It is recommended that a means of collecting this data more frequently be established.

The number of travel days per year is an assumption made by the team responsible for conducting the assessment, but does not necessarily reflect the current reality. It is recommended that a means of collecting more accurate data on this variable be established.

To estimate the modal share of travel (car, carpooling, public transit, multi-mode, walking, cycling) for students and employees, UdeM relies on a document provided by the organization "Voyagez futé". This document uses the results of a survey applied to the Polytechnique and makes the assumption that students and employees of both institutions have similar behaviours. It will be necessary to conduct a data collection exercise (e.g. survey or continuous measurement) at UdeM to obtain a more representative picture of the modes of transportation used by employees and students at the University.

Modal shares are an average. There may be large differences in travel habits depending on where one lives, for example Deux-Montagnes vs. the Plateau-Mont-Royal.

2. International students and business trips

- Data collection process

Two categories of data are used to calculate the carbon footprint of business and student travel: the number of kilometers traveled by University professionals and students by mode of transportation, and the CO_2 emissions in kg per mode of transportation.

Data on the number of kilometers traveled by professionals and students were obtained from the Maison Internationale de l'UdeM for student trips and from a survey for professional trips (including those of professors). For their part, the CO_{2eq} emission factors in kg per means of transportation were provided by SIMAP. Data entry and calculation of results were done directly on the SIMAP platform.

- Data holders

There are two holders of the raw data on the carbon footprint of business and student travel, namely :

- Mileage covered by student trips: the **International House of** the University of Montreal.
- Professional mileage: Arsenault J*, Talbot J, Boustani L, Gonzalès R, Manaugh K. 2019. The environmental footprint of academic and student mobility in a large research-oriented university. Environmental Research Letters 14: 095001.

- Managers Not

applicable.

- Calculation method

$$kgCO2éq = \sum_{-}^{n} Catégorie\ de\ _{transportkm} * FEkgCO2éq/km * \text{RFI}$$

$$_{2}\,TCOéq = kgCO_{2}\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of $_{CO2}$ equivalent n :

Transport category (bus, plane, train, car)

Transport category km: total distance travelled in km per year by transport category

EF: Emission factor in kg CO2eq per km travelled by transport category
RFI : Radiative Force Index emission factor

- Coefficient

The emissions factors are provided directly by the SIMAP platform. SIMAP is an online carbon and nitrogen emissions accounting platform developed by the University of New Hampshire and made available to higher education institutions worldwide.

- Assumption

s Not applicable.

- References used for quantification

Emission Factor (EF) Source: Conversion tables used for the reporting and inventory of greenhouse gases in the institutional sector - Énergie et Ressources Naturelles Québec
Source RFI : N Iken and F-X Aguessy 2022 IOP Conf. Ser.: Earth Environ. Sci. 952 012002

- Other remarks

The data on total distance traveled by mode of transportation for University faculty is from a survey

and estimate done as part of an academic research study; more accurate data using travel-related invoices should be used. The author of the research states that while his sample is not representative, the result (tons/year/faculty) is in the same order of magnitude as other research universities that have done more rigorous work.

3. Paper

- Data collection process

Two categories of data are used to calculate the carbon footprint of the University's printing paper usage: the number of units used per paper category, and the CO_2 emissions in kg per paper category.
The data on the number of sheets of paper used by category comes from the University of Montreal's Printing Service ("SIUM") for the 2017/2018 period. For their part, the CO_{2eq} emission factors in kg per paper category come from a government source (British Columbia Ministry of Environment).

- Data holders

There is one holder of the raw data on printing paper use at the University, the University of Montreal Printing Service.

- The people in charge

University of Montreal Printing Service

- Calculation method

$$kgCO2éq = \sum_{-}^{n} Volume\ de\ papier\ consommés * FEkgCO2éq/feuille$$

$$_2\,TCOéq = kgCO_2\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent n : Paper category
Volume of paper consumed: Number of sheets used in a year. EF: Emission factor in kg CO2eq per sheet category

- Coefficient

PCR Content (%)	Emission Factor (kg CO_2e/ pkg)		
	8.5" x 11"	8.5" x 14"	11" x 17"
0	6.358	8.094	12.743
10	6.123	7.795	12.272
20	5.888	7.496	11.802
30	5.653	7.197	11.331
40	5.418	6.898	10.860
50	5.184	6.599	10.390
60	4.949	6.300	9.919
70	4.714	6.001	9.449
80	4.479	5.703	8.978
90	4.244	5.404	8.508
100	4.010	5.105	8.037

Note: emission factors for office paper are based on a 500-sheet package of 20-pound bond paper weighing 2.27, 2.89 and 4.55 kg, respectively, for the three paper sizes.

The values in the above table are given per pack of 500 sheets, so the values are divided by 500 to find the value per sheet.

- Assumption

s Not applicable.

- References used for quantification

Source emission factor (EF): 2018 B.C. METHODOLOGICAL GUIDANCE FOR QUANTIFYING GREENHOUSE GAS EMISSIONS. Table 13

- Other remarks

Emission factors are from 2018; more recent values should be used.

4. T&D loss

- Data collection process

In order to calculate the carbon footprint of transmission and distribution (hereafter T&D) losses of electricity at the University, it is necessary to collect the consumption of this energy source for the university period studied, as well as the T&D loss factor applicable to the production of this energy source in the province of Quebec.
As part of the carbon footprint, electricity consumption was collected in the UBP. This document provides the electricity consumption in kWh per academic year and per university. The T&D factor was collected from an official document from the electricity supplier, Hydro-Québec.

- Data holders

There are two holders of the raw data on electricity consumption by the University, one internal, and one external.

Internal: **Direction des Immeubles** de l'Université de Montréal.
External: **Ministry of Higher Education of Quebec**.

- The people in charge

The department responsible for this emission source is the Direction des Immeubles of the University of Montreal.

- Calculation method

$$_{N2O2}\, kgCOéq = (\sum \text{É}lectricité_{kWh} * FE_{co2} * PRP_{co2} + FE_{CH4} *_{CH4} + FE_{N2O} * PRP\ ))$$

$$* (FP_{\ TkWh} + FP\ DkWh)$$

$$_{2}\, TCOéq = kgCO_2\ éq/1000$$

TCO2eq: Sum of GHG emissions in tons of $_{CO2}$ equivalent Electricity:
Energy source
EF: Emission factor for type of greenhouse gas ($_{CO2}$, $_{CH4}$, $_{N2O}$)

GWP: Global Warming Potential for greenhouse gas type (CO_2, CH_4, N_2O)
FP T&D : Transmission and distribution loss factor

- Coefficient

Transmission loss factor: 5.6% per kWh
Distribution loss factor: 2.2% per kWh CO_2 FE g
per kWh of electricity: 1.7
FE kg of CH_4 per kWh ofelectricity: 0.0002
FE kg of N2O per kWh of electricity: 0.0001
CO_2 GWP: 1
GWP of CH_4: 28
GWP of N2O: 265

- Assumption

s Not applicable.

- References used for quantification

Source transmission and distribution loss factor: *2014-2023 INTEGRATED NETWORK SUPPLY PLAN. Hydro- Québec. 2013 & 2015 PROGRESS REPORT ON THE 2014-2023 SUPPLY PLAN. Hydro-Québec. 2015*

Source Emission Factor (EF): *Conversion tables used for the reporting and inventory of greenhouse gases in the institutional sector - Transition Énergétique Québec*

Source Global warming potential (GWP) :: *IPCC Fifth Assessment Report*

- Other remarks

The T&D factor is from 2015; it would be good to update this factor with the state of the system in 2021.

5. Drinking water consumption

- Data collection process

To calculate the equivalent carbon footprint of the University's drinking water consumption, it is necessary to determine the volume in m^3 consumed in a year, as well as the emission factor for the production of drinking water by the City of Montreal.
As part of the carbon footprint, the consumption of drinking water in m^3 was collected by the Direction des Immeubles. The emission factor for the production of drinking water by the City of Montréal is collected from the 2015 inventory of greenhouse gas emissions from municipal activities in the Montréal agglomeration.

- Data holders

There is one holder of the University's raw water consumption data, the
Direction des Immeubles de l'Université de Montréal.

- The people in charge

The department responsible for this emission source is the Direction des Immeubles of the University of Montreal.

- Calculation method

$$gCO2éq = \sum \text{drinking water}_{\text{consumption}m^3} * FEgCO2éq/m^3$$

$$_2\,TCOéq = gCO_2\,éq/10000$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent
Drinking water consumption: Sum of drinking water consumption per house in m^3
EF: Emission factor in g CO2eq per m^3 consumed

- Coefficient

EF g CO_2eq per m^3 consumed: 1.62

- Assumption

s Not applicable.

- References used for quantification

Source Emission Factor (EF): Greenhouse Gas Emissions from Municipal Activities in the Agglomeration of Montreal. INVENTORY 2015. Service de l'environnement. Ville de Montréal. 2017. 34 pages. (BAnQ digital)

- Other remarks

6. Wastewater

- Data collection process

To calculate the equivalent carbon footprint of the wastewater produced by the University, it is necessary to determine the volume in m^3 produced in a year, as well as the N_2O emission factor emitted by this wastewater.
Due to the unavailability of raw data on wastewater generation at the University at the time of writing, the results of the equivalent carbon footprint of this emission source were taken from the article "*Geographic versus institutional drivers of nitrogen footprints: a comparison of two urban universities*" by Talbot et al. (2020), a research study led by Julie Talbot, a researcher and professor in the Department of Geography at the University of Montreal. In this research, the volume of wastewater was extrapolated from the University of Sherbrooke's volume using the number of employees and students.

- Data holders

There is one holder of the University's raw water consumption data, the
Direction des Immeubles de l'Université de Montréal.

- The people in charge

The department responsible for this emission source is the Direction des Immeubles of the University of Montreal.

- Calculation method

See "Geographic versus institutional drivers of nitrogen footprints: a comparison of two urban universities" by Talbot et al. (2020).

- Coefficient

See "Geographic versus institutional drivers of nitrogen footprints: a comparison of two urban universities" by Talbot et al. (2020).

- Assumption

s Not applicable.

- References used for quantification

See "Geographic versus institutional drivers of nitrogen footprints: a comparison of two urban universities" by Talbot et al. (2020).

- Other remarks

In a future iteration of the University's carbon footprint, raw data on the volume of wastewater generated by the institution should, if available, be used.
UdeM is currently installing water meters to measure its consumption at each junction with the municipal aqueducts.

7. Food

- Data collection process

To calculate the carbon footprint of food consumption at the University, is required the volume purchased per category of food that is consumed in a university period, as well as the emission factor per kg for the production of each of these categories.
Volume by food category was collected by analyzing velocity reports from the University's two food suppliers, Gordon Food Service Canada and Dubé Loiselle.
In addition, as part of a credit course, a careful survey of food inputs in each of the student cafés on campus was conducted. These cafés are independent and UdeM does not manage them. However, it provides them with the usual university services free of charge.
The emission factors were identified through a literature search.

- Data holders

There are two holders of raw data on food consumption by the University, Gordon's Food Service Canada, Dubé Loiselle and the student cafés

- The people in charge

The department responsible for this source is the University of Montreal Food Service and student cafes.

- Calculation method

$$kgCO2éq = \sum_{-}^{n} Volumekg * FEkgco2éq/kg$$

$$_2\,TCOéq = kgCO_2\,éq/1000$$

TCO2eq: Sum of GHG emissions in tons of $_{CO2}$ equivalent Volume:

Volume of the purchased feed category in kg

N : Food category

EF: Emission factor per kg of the feed category in $_{kgCO2}$ equivalent related to its production.

- Coefficient

Category	Footprint kgCO2eq/kg produced
Coffee	15.33
Lamb	14.2
Beef	14
Butter	7.5
Pork	4.43
Duck	6
Turkey	6
Marinade	6
Chicken	6
Vinaigrette	6
Cheese	5.4
Fish	5
Chocolate	4.8
Rice	4
Cream	3
Nuts	1.17
Mayonnaise	2.4
Ketchup	2.25
Vegetable	0.4
Sauce	2
Paste	1.81
Egg	1.6
Yogurt	1.5
Flour	1.4
Barley	1.4
Quinoa	1.4
Tomato	1.4
Bread	1.244
Paste	1.244
wheat	0.2

Juice	1
Tortillas	1
Milk	0.93
Spice	0.87
Fruit	0.7
Sugar	0.6
Honey	0.5
Margarine	0.48
Lens	0.4
Tea	0.4
Beef veal	0.4
Fruit	0.3
soybeans	0.27
Maple syrup	0.2151
Mustard	0.03

- Assumption

s Not applicable.

- References used for quantification

See Excel file "Empreinte_aliment.xlsx" in the appendix for reference. For each food category, under the "Footprint" column, the reference is indicated.

- Other remarks

Not applicable.

8. Rented spaces

- Data collection process

In order to calculate the carbon footprint of the leased spaces held by the University, it is necessary to collect the list of the University's leased spaces and the annual volume of natural gas (m^3) and electricity (kWh) consumption. Since these volumes are not currently available, the average consumption value per m^2 for the different categories of buildings of the institution for these two energy sources was used. At this stage of the analysis, only the buildings and premises leased by the University are taken into account.

It should be noted that the University does not have operational control of the buildings and premises.
For the purposes of the carbon footprint, this data was collected with the help of Real Estate Affairs, which provided a list of assets and their surface area in m^2 , as well as the type of activity carried out.

- Data holders

There is one data holder for the list of buildings and/or premises leased by the University, i.e. an internal:

Internal: University of Montreal **Real Estate Affairs**

There is one holder of the raw data on natural gas and electricity consumption by building by the University, which is an internal:

Internal: **Direction des Immeubles** de l'Université de Montréal, through the Excel file entitled "EnerUNIV", compiled annually.

- The people in charge

The department that operates this source is Real Estate

- Calculation method

$$kgCO2éq = \sum Gaz\ naturelm3 * (FEco2 * PRPco2 + FECH4 * PRPCH4 + FEN2O * PRPN2O) + \sum ÉlectricitékWh * (FEco2 * PRPco2 + FECH4 * PRPCH4 + FEN2O * PRPN2O)$$

$$_2\ TCOéq = kgCO_2\ éq/1000$$

TCO2eq: Sum of GHG emissions in tons of CO_2 equivalent Natural gas: Fuel type

EF: Emission factor for type of greenhouse gas (CO_2, CH_4, N_2O)
GWP: Global Warming Potential for greenhouse gas type (CO_2, CH_4, N_2O)

- Coefficient

FE kg of CO_2 per kWh of electricity: 1.5 (year 2018)
FE kg of CH_4 per kWh ofelectricity: 0.0002
FE kg of N2O per kWh of electricity: 0.0001

FE kg of CO_2 per m^3 of natural gas: 1.887
EF kg of CH_4 per m^3 of natural gas: 0.000037 EF
kg of N2O per m^3 of natural gas: 0.000035
GWP of CO_2: 1
GWP of CH_4: 28
GWP of N2O: 265

- Assumption

s Not applicable.

- References used for quantification

Source Emission Factor (EF): *Conversion tables used forthereporting and inventory of greenhouse gases in the institutional sector - Transition Énergétique Québec* Source Global Warming Potential (GWP): *IPCC Fifth Assessment Report*

- Other remarks

Not applicable.

8. Investment

- Data collection process

The calculation of the carbon footprint of the investments of the University of Montreal's endowment fund was carried out by the institution's Finance Department: responsible investment - University of Montreal (umontreal.ca)

- Data holders

There is one holder of the data on the amounts invested in the endowment fund of the Université de Montréal, namely the Direction des Finances

- The people in charge

The department that operates this source of issuance is the Finance Department

- Calculation method

See: responsible investing - Université de Montréal (umontreal.ca)

- Coefficient

See: responsible investing - Université de Montréal (umontreal.ca)

- Assumption

s Not applicable.

- References used for quantification

Not applicable

- Other remarks

Not applicable.

H. Carbon sequestration

- Data collection process

At present, only the trees in the Édouard-Montpetit woodland on the Mountain campus have been studied to estimate their sequestration potential.
In order to calculate this potential, it is necessary to record the species and diameter of the trees. To this end, a sampling process was carried out in various areas of the woodlot in order to collect data representative of the whole.
Carbon sequestration potential by species by year was extracted from a literature review.

- Data holders

The UdeM Sustainable Development Unit is the sole data holder.

- The people in charge

The department responsible for maintaining UdeM's carbon sequestration potential is the Sustainable Development Unit and the Buildings Directorate.

- Calculation method

Step 1: Sample Estimation

$$\text{ÉchantillonTCO2} = \sum^{n} NombresEspèces * CSTCO2/année$$

Step 2: Estimate for total area

$$Total_{TCO2} = Superficie\ totale * \left(\frac{\text{ÉchantillonTCO2}}{Superficie\ échantilon}\right)$$

$_{TCO2}$: Sum of GHG removals in tons of $_{CO2}$

Numbers: Number of trees per species present on the studied area N:
Sampling areas
SC: Sequestration capacity - volume of CO_2 sequestered per year by each tree.

- Coefficient

See "Carbon Sequestration by Trees on the U of M Campus" by Marcela Vera. 2016/08/08. Page 26-27. Table 9

- Assumptions

We estimate that the characteristics of the trees distributed over the total area are similar to those included in the sample, in terms of numbers, species, and diameter.

- References used for quantification

Carbon Sequestration by Trees on the U of M Campus" by Marcela Vera. 2016/08/08. Page 26-27. Table 9

- Other remarks

An exhaustive inventory of the trees in the Edouard Montpetit woodland would be necessary to quantify exactly what is sequestered by this forest area. Only the carbon sequestration of trees located in maintained forest areas can be accounted for. The Édouard Montpetit woodland is considered maintained because of the above activities that are carried out by the University's teams:

- Invasive species control
- Protection of vulnerable plant species
- Expansion of the canopy
- Reforestation with native species
- Trail Protection

I. References

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