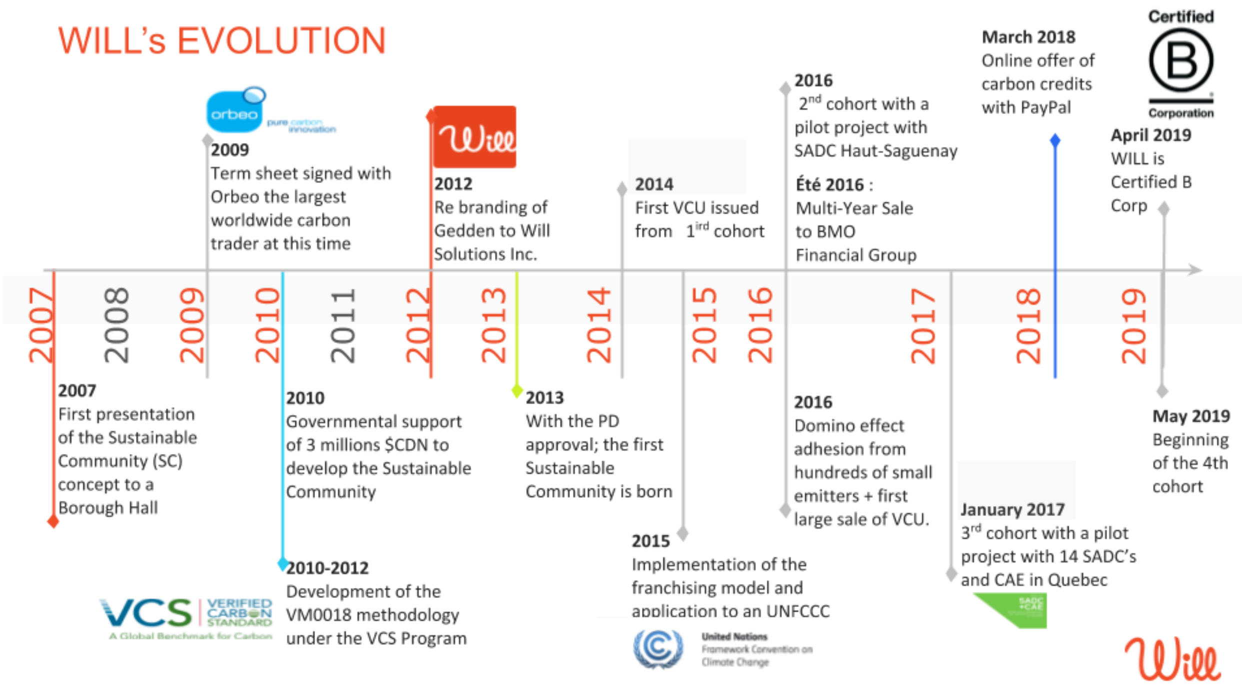
APPENDIX

APPENDIX 1

KPI of the result for the period 2010-2019 history of the first period 2020 up to 2019 and the anteriority from 2007

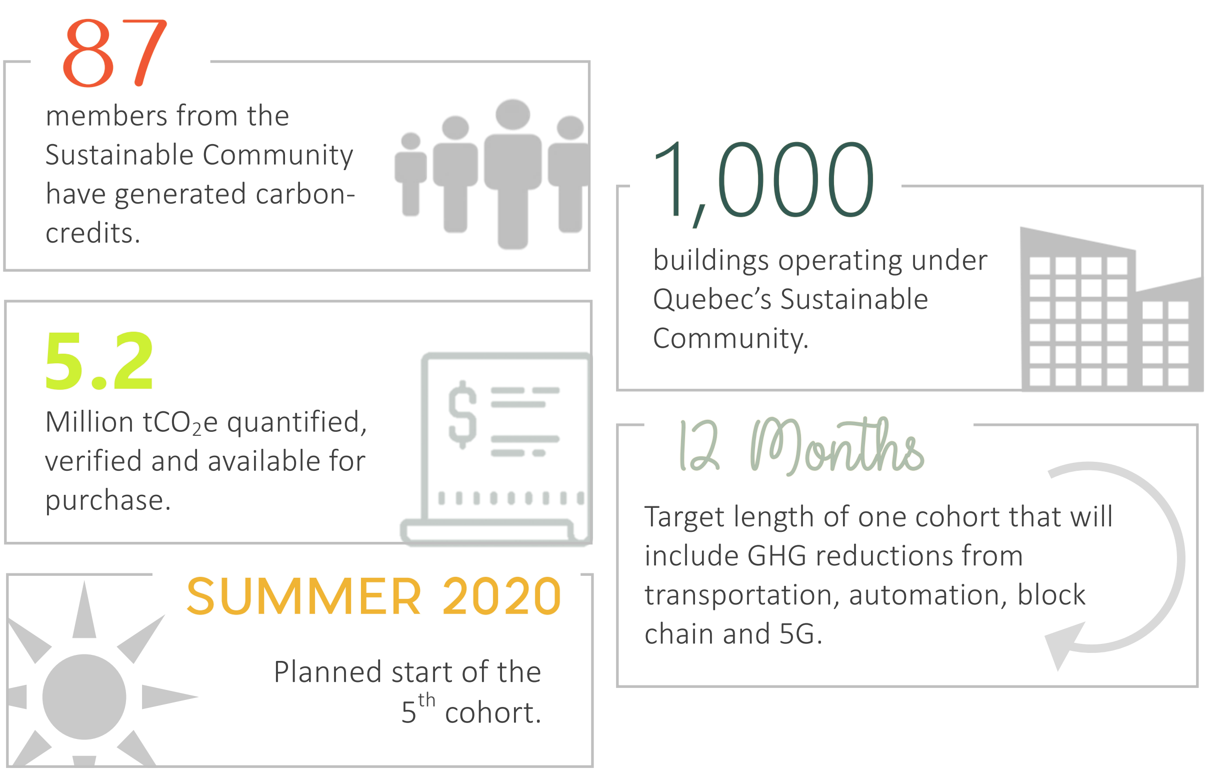


https://www.solutionswill.com/en/blog_post/wills-social-innovation-model/

The project's major steps carried out so far:

1. **May 2007**: Interest from Mr. DeSousa, mayor of the Saint-Laurent borough.
2. **Autumn 2008**: Presentation of the project at the Agence de l'efficacité énergétique du Québec (AEEQ), within the scope of the "Technoclimat" Program.
3. **April 2010**: Selection of VCS standard, development of the technology supporting our project, online-release on VCS's web site (Dec 2010) and double validation process (Sept. 2011).
4. **June 2010**: Signature and implementation of a contribution from AEEQ (Technoclimat Prorgram).
5. **October 2010**: Signature of the 1st industrial park (DEL) with a financial contribution from RecycQuébec.
6. **March 2011**: First private financing from C3E.

7. **April 2011**: First pre-sale of carbon credits.
8. **June 2011**: Contribution from Emploi-Québec in the scope of "Projets d'envergure économique".
9. **January 2012**: Deposit of the 1st technological patent for the American market at USPTO.
10. **Winter 2012**: Deployment of commercial and operational activities in the Quebec territory.
11. **Winter 2012**: Completion of the first audits ex-antes.
12. **February 2012**: VCS final acceptance in February 2012 (VM0018).
13. **March 2012**: Press release and Webinar from VCS.
14. **July 2013:** First validated cluster project under the VM0018.
15. **February 2014:** First Monitoring Report (quantification GES reduction) verified by a third recognized party under the Quebec cluster project.
16. **November 2017**: Second Monitoring Report (quantification GES reduction) verified by a third recognized party under the Quebec cluster project.
17. **July 2019**: Third Monitoring Report (quantification GES reduction) verified by a third recognized party under the Quebec cluster project.
18. **August 2020**: Fourth Monitoring Report (quantification GES reduction) verified by a third recognized party under the Quebec cluster project.
19. **March-October 2020**: up to now; internal preparation for the renewal of the PD.



APPENDIX 2

Standard Contract between Will and the client Facility version June 2020

Example of the contract can be found in the following pages.

Membership Contract to the Sustainable Community of Will Solutions Inc.

Will Solutions Inc.'s Sustainable Community solution ("**SC-solution**") is used to reward a community member who subscribes to its program for its Green House Gas ("**GHG**") reduction efforts in order to stimulate sustainable actions. The SC-solution is based on a new and unique methodology, VM0018 that allows for the quantification and verification of GHG reduction efforts in order to aggregate and to sell the GHG reductions on the voluntary carbon market (the "**Methodology**"). This Methodology is the cornerstone of the SC-solution. It has been developed by Will Solutions Inc. under the Verified Carbon Standard ("**VCS**") and gives small final and not regulated GHG emitters access to the voluntary carbon market. This project features several small final GHG emitters that reduce their GHG emissions through energy efficiency and waste diversion management activities (the "**Eligible GHG Reductions**"). For each jurisdiction identified by Will Solutions Inc., a Project Description ("**PD**") is developed in accordance with the Methodology and validated by a third party, a Validator Verificator Body ("**VVB**") recognized by the VCS.

For the province of Quebec (a Canadian province), Will Solutions Inc. has developed, submitted and obtained certification for its first PD entitled "Energy Efficiency and Solid Waste Diversion Activities within the Quebec Sustainable Community". Consequently, Will Solutions Inc. obtained its first verification done by a VVB recognized by the VCS and converted GHG reductions into Verified Carbon Units ("**VCU**") from which a first batch was issued into a VCS recognized registry.

Will Solutions Inc. is presently working on the deployment of its SC-solution and intends to operate its SC-solution in a franchise mode, by granting a franchise license to at least one franchisee (the "**Franchisee**") for a defined territory (the "**Franchise's Territory**") which will be responsible, amongst others, to complete recruitment of the subscribers on the Franchise's Territory, of data collection and of offering support to the Subscriber (as defined below) inside the Franchise's Territory.

The subscriber, on its behalf and on behalf of its affiliates, its agents and subcontractors (collectively the "**Subscriber**"), hereby agrees to be bound by the present agreement (the "**Agreement**") which will come into force upon the completion of the selection, execution and implementation of a Franchisee by Will located in the province, state or territory of at least one Subscriber's Site.

This Agreement shall become null and void with respect to each Site for which Will Solutions Inc. will not have completed the selection, execution and implementation of a franchise agreement with a Franchisee in the Subscriber's Territory of each such Sites (as defined below) within three (3) years of the date of the signature of the Agreement by the Subscriber, without any recourse from the Subscriber against Will Solutions Inc. or penalty. Under the present Agreement, any right or obligation of Will Solutions Inc. hereunder can, at Will Solutions Inc.'s discretion, be exercised by Will Solutions Inc. or its authorized Franchisee (hereinafter collectively designated as "**Will**").

Subscriber Number :	
Name of the Subscriber :	
Address :	
City :	
Postal Code:	
Phone Number :	
Email :	
Name of subscriber's Representative :	
Title of Subscriber's Representative :	
Name of Will Solutions Inc.'s Representative :	

The Subscriber hereby confirms that the following sites are subject to this Agreement ("**Sites**") (the location where the Sites are established being the "**Subscriber's Territory**"). The Subscriber represents to Will (collectively the "**Parties**" and individually the "**Party**") that these Sites are all of the sites owned or leased by the Subscriber in the Franchise's Territory for which reduction efforts are made by the Subscriber. Any additional site owned or leased by the Subscriber from time to time in the Franchise's Territory for which reduction efforts will be made by the Subscriber shall be included on this list and shall automatically be part of the Sites covered by the definition herein. The definition of Sites shall exclude any Site disposed of or which the Subscriber ceases to lease from time to time.

Number of Sites	Description	
	All Sites to be part of the Agreement across the Subscribers' Territory *[List to be provided by the subscriber].*	**No fees**

Signature Date :

Subscriber's Representative (dd-mm-yyyy)

Signature Date :

Representative of Will Solutions Inc. (dd-mm-yyyy)

Terms and Conditions for Subscribing to the Sustainable Community Solution

1. Subscriber's Obligations

1.1 There are no fees payable by the Subscriber for its subscription and participation to the SC-Solution.

1.2 The Subscriber shall, for the whole Term and Renewal Period (as defined under Section 6.1), make commercially reasonable efforts to reduce its GHG emissions for the purpose of allowing their conversion into VCUs under this Agreement and, upon request of Will and at least once a year, provide truthful and detailed evidence of such reductions.

1.3 The Subscriber agrees to supply the information required by Will to allow the identification of all Sites, the creation and maintenance of an electronic account for each Site and the determination of the baseline reference GHG emission scenario per Site;

1.4 The Subscriber shall also supply Will upon request and at least once a year, detailed Eligible GHG Reductions information and evidence for each Site to the satisfaction of Will and a VVB.

1.5 The Subscriber agrees to provide Will and a VVB access to the Subscriber's place of business and Sites, following a seventy-two (72) hours' prior notice, during normal business hours, to allow for the verification of the SC-solution process and the information provided to Will and a VVB;

1.6 The Subscriber agrees to participate, upon Will's reasonable request, to the promotion of the SC-solution and the Subscriber's own GHG reductions' projects, including without limitation, the Subscriber's participation to various media communications, interviews, testimonies, videos and events.

1.7 The Subscriber also agrees to assign and transfer all its rights title and interest to all benefits arising from any GHG reductions arising from the Sites and identified as Eligible GHG Reductions by Will:

1.7.1 The Subscriber undertakes to do everything and sign any document or form required by Will from time to time, in order to give effect to this Agreement;

1.7.2 Upon assignment of the Eligible GHG Reductions, the Subscriber acknowledges and confirms that it will be at all times from the date hereof the sole owner of the Eligible GHG Reductions arising from the Sites, free of any liens, mortgages or other charges.

1.8 If Will were to avail himself of the provisions of Article 6.2.3 of this Agreement, the eligible GHG Reductions would then be remitted to the members to which they belong.

1.9 The Subscriber agrees and undertakes that all Eligible GHG Reductions shall be additional to any reduction made in the Subscriber's normal course of business if the Eligible GHG Reductions had not been carried out and that the GHG reduction efforts shall be maintained for the Term and the Renewal Period, if any.

2. Will's obligations

2.1 Will agrees to use commercially reasonable efforts to convert the Subscriber's Eligible GHG Reductions into VCUs, using the VCS, and to agglomerate these VCUs in order to sell them;

2.2 Will agrees to define the baseline reference GHG emission scenario for each Site;

2.3 At least once a year, Will will collect and validate the information and evidence provided by the Subscriber in order to determine the Eligible GHG Reductions for each Site in accordance with this Agreement. Will will create an electronic account for each Site which will be maintained on Will's information technology communication platform (the "ITC Platform") in order to trace, collect from the Subscriber and document the Eligible GHG Reductions information and evidence required by a VVB;

2.4 Will, will convert the Eligible GHG Reductions into VCUs, provided a VCS' authorization to issue them into a VCS recognized registry and/or a Will registry. Will is currently negotiating with a Quebec lawyer so that VCUs can be held in the trust account of a lawyer in good standing with the Barreau du Québec. Will is also in discussion with a financial institution offering the service of a trust account. Will plans to create an independent trust that will hold and administer these VCUs. The Member hereby agrees that VCUs may be held in the trust account of a lawyer and may be transferred to a trust account or an independent trust to be created. If Will were to avail himself of the provisions of Article 6.2.3 of this Agreement, the VCUs held in trust or in trust would be returned to the members to whom they belong.

2.5 Will agrees to use commercially reasonable efforts to sell the VCUs during the year following their date of conversion, provided that the price and market conditions are satisfactory to Will. In the event that Will is not satisfied with the price and market conditions, Will will sell the VCUs when the price and market conditions will be satisfactory to Will;

2.6 Will agrees to share with the Subscriber the gross sale of the VCUs as follows: (i) 40% to the Subscriber; and (ii) 60% to Will;

2.7 Will shall deposit the Subscriber's portion of the proceeds from the gross sale of the VCUs in a separate trust account; Will is currently negotiating with a Quebec lawyer so that VCUs can be held in the trust account of a lawyer in good standing with the Barreau du Québec. Will is also in discussion with a financial institution offering the service of a trust account. Will plans to create an independent trust that will hold and administer these VCUs. The Member hereby agrees that VCUs may be held in the trust account of a lawyer and may be transferred to a trust account or an independent trust to be created. If Will were to avail himself of the provisions of Article 6.2.3 of this Agreement, the VCUs held in trust or in trust would be returned to the members to whom they belong.

2.8 Will agrees to provide support (accompaniment) to the Subscriber for the collection and validation of its Eligible GHG Reductions.

2.9 Will convient de fournir un soutien (accompagnement) au Membre pour la collecte et la validation de ses Réductions de GES admissibles.

3. Payment

Will will pay the Subscriber its share, if any, of the yearly gross sale proceeds of the VCUs generated by the Subscriber (as set forth under Section 2.7) no later than December 31st of each year, commencing on December 31st following the first anniversary date of the signing of the Agreement. However, no payment will be made to the Subscriber before the VCUs generated by the Subscriber are sold and payment is received by Will. The Subscriber will be paid in Canadian dollars by direct deposit if it provides all relevant bank information. In the event that no bank information is provided, a cheque will be mailed to the Subscriber's address provided under this Agreement. . The Payment will be made out of the trust account of a solicitor, the trust account of a financial institution or the trust to be created by Will, as the case may be. Within ninety (90) days of each payment to the Subscriber, Will will provide a statement report to the Subscriber describing the Eligible GHG Reductions and VCUs generated through the use of the SC-solution by the Subscriber;**Interdiction de cession**

4. Assignment Prohibited

The Subscriber cannot assign its rights or obligations under this Agreement without Will's prior written consent. Will may assign its rights or obligations under this Agreement without the Subscriber's consent.

5. Representations

5.1 Will represents that it owns the SC-Solution and that it has the authority to grant the Subscriber the right to participate to the SC-solution. Will does not guarantee to the Subscriber in any way the results obtained from participating to the SC-solution nor the quality or scope of such results. The Subscriber is solely responsible for the data that is supplied by the Subscriber to Will to be used in the SC-solution and of the results obtained. The Subscriber assumes all risks related to the use of the data and the results obtained;

5.2 These representations replace all other representations, conditions, verbal or written warranties, express or implicit, concerning the participation to the SC-solution. Will does not warrant the accuracy, the integrity, the timeliness or the fair market value of the information or results obtained from the Subscriber's participation to the SC-solution, nor the fact that these information or results are conceived or used for a particular goal. It is the Subscriber's responsibility to verify and provide all necessary data to Will to be used in its SC-solution account.

5.2.1 In no event shall Will be liable for any expense, liability, claims, demands, taxes, damages, losses or penalties relating to the execution of its obligations under this Agreement (including, without limitation, services such as supply, compilation, interpretation, transcription, reproduction or delivery of any information obtained by means of the SC-solution or participation to the SC-solution), unless it was judicially determined to be caused by fraud, intentional fault or gross fault by Will, its officers, employees or agents.

5.2.2 All investments made in the carbon voluntary market are subject to market risks, including, without limitation, risks related to the territory, the nature and the origin of the VCUs, or the year they were created. Will does not in any way guarantee the outcome and is not liable for any diminution in the value of the VCUs, which may go up or down based on market conditions. Past performance should not be taken as an indication or guarantee of future performance and no representation or warranty, express or implied, is made regarding future performance.

5.3 The Parties shall not be liable for delays or default under this Agreement as a result of an event of force majeure, including without limitation, fire or other casualty, act of God, strike or labour dispute, war or other violence, political instability, or any law, order or requirement of any governmental agency or authority

6. Term and Termination

6.1 This Agreement will end on December 31st, ten (10) years after the earlier of the following dates (the “Term”): (i) the installation date specified in the PD and its final validation by a VVB; (ii) the date of the implementation of a Franchise in the Subscriber’s Territory;

6.1.1 The Agreement will be automatically renewed for one (1) term of three (3) years (the “Renewal Period”), unless either Party sends a non-renewal written notice to the other Party, no less than twelve (12) months prior to the end of the Term.

6.2 The Agreement can be terminated as follows:

6.2.1 By Will upon ninety (90) days prior written notice, for convenience without obligation;

6.2.2 By a Party, at the expiration of a ninety (90) days prior written notice, if the other Party fails to remedy or cure a breach of any provision of this Agreement;

6.2.3 By a Party, forthwith and without notice, if (i) the other Party voluntarily enters into proceedings in bankruptcy or insolvency, (ii) the Subscriber makes an assignment for the benefit of creditors, (iii) a petition is filed against the other Party under a bankruptcy law, a corporate reorganization law, or any other law for relief of debtors or similar law and such petition is not discharged within thirty (30) days after such filing, (iv) the other Party ceases to actively conduct business or enters into liquidation or dissolution proceedings; or (v) the other Party is subject to criminal charges.

6.3 Will reserves all rights and recourses as to any damages that can result from any default by the Subscriber under this Agreement.

6.4 Upon expiration or termination of this Agreement, unverified Eligible GHG reductions shall be returned by Will to the Subscriber. The remaining VCUs will be sold by Will in accordance with the terms and conditions of this Agreement and the proceeds will be shared in accordance with article 2.7. However, if the Agreement has been terminated by Will in accordance with sections 6.2.2 and 6.2.3, Will shall, notwithstanding section 2.7, keep the full proceeds from the sale of the remaining VCUs.

6.5 Section 6.4 and articles 7, 8 and 9 shall survive the termination of the Agreement.

7. Indemnification

Should a legal proceeding or claim arising out of the Subscriber’s conduct or negligence or the execution of its obligations herein be brought against Will, the Subscriber agrees to indemnify, defend and hold Will and its respective directors, officers and personnel harmless from and against all losses, costs, damages, expenses, penalties and liabilities whatsoever (including reasonable legal fees) which may be suffered or incurred by Will arising out of or as a result of or relating in any manner whatsoever to this Agreement. Will shall advise the Subscriber of such claim within thirty (30) days of knowledge of the event.

8. Ownership’s Right on SC Solution

8.1 The Parties agree that (i) the Will trade-mark, including the logos depicted in Schedule A, (the “Trade-Mark”), the SC-solution and its content, Will’s business model, the ITC Platform as well as all intellectual property rights relating thereto, including copyright and rights in patent applications and patents, are owned or controlled by Will, and (ii) no right, title or interest in and to the SC-solution, the Methodology and the ITC Platform as well as in all intellectual property rights relating thereto, including copyright and rights in patent applications and patents, is transferred to the Subscriber, except for the limited right to participate, use and access as specifically mentioned herein.

8.2 The Subscriber is granted a limited, personal, non-transferable and revocable right to reproduce the Trade-Mark in promotional material preapproved in writing by Will at its sole and entire discretion. It is understood and agreed that such promotional material (i) shall include a legend stating that WILL is a registered trade-mark of Will, and (ii) shall only be used in the Subscriber's Territory for the purposes contemplated in this Agreement.

8.3 Without limiting the foregoing, the Subscriber is allowed to use the Trade-Mark in the form of the certificate(s) attached under Schedule B. Confidentialité

9. Confidentiality

9.1 Each Party expressly undertakes to retain in confidence all information supplied by one Party (the "Disclosing Party") to the other Party (the "Receiving Party"), including, but not limited to, (i) all technical or commercial information disclosed orally or in writing by Will to the Subscriber; (ii) the data supplied by the Subscriber to Will; and (iii) any information that by its nature or by the nature of the circumstances surrounding the disclosure, ought in good faith to be treated as proprietary and/or confidential by one Party or both (hereinafter referred to as "Confidential Information");

9.1.1 Each Party shall, and shall ensure that it and its affiliates, franchisees, subcontractors, agents and their respective officers, directors, employees and agents shall keep and maintain completely confidential and not publish, distribute, disseminate or otherwise disclose and not use for any purpose, except as expressly permitted hereunder, any Confidential Information disclosed to it by the other Party or its affiliates, franchisees, subcontractors, agents or their respective officers, directors, employees or agents pursuant to this Agreement;

9.1.2 Each Party shall ensure that it and its affiliates, franchisees, subcontractors, agents and their respective officers, directors, employees and agents have access to such Confidential Information only for the purpose of performing their duties under this Agreement;

9.1.3 Confidential Information shall not include any information: (i) that becomes generally available to the public other than as a result of unauthorized disclosure by the Party receiving the Confidential Information; (ii) that was available to the Receiving Party on a non-confidential basis prior to receipt from the Party disclosing Confidential Information or is received thereafter from a third Party without restriction and without breach of any duty of confidentiality; (iii) that is independently developed by the Receiving Party without the use of or reference to any Confidential Information from the Disclosing Party, as demonstrated by documented evidence prepared contemporaneously with such independent development; or

9.1.4 The Receiving Party shall be permitted to disclose Confidential Information if forced to do so pursuant to an order of a court or government agency, provided that, prior to such disclosure, the Receiving Party notifies the Disclosing Party of such order or upcoming order and cooperates with the Disclosing Party in seeking an appropriate protective order for such Confidential Information. The Receiving Party shall limit disclosure of such Confidential Information to the minimum disclosure permitted under the applicable order.

9.2 Upon the request of a Party, upon termination or expiration of this Agreement, each Party shall promptly cease use of and return to the other Party or destroy and certify destruction of all of the other Party's Confidential Information, including all copies, excerpts or summaries thereof, in whatever form or medium, and thereafter shall not make any use of any such Confidential Information of the other Party, in each case except as expressly permitted hereunder; provided that no Party shall be obligated to return or destroy Confidential Information that has become integrated with other business records of such Party; provided, further, that such Party shall continue to be bound by the confidentiality obligations under this Agreement with respect to any such Confidential Information that is not so returned or destroyed.

9.3 Notwithstanding all of the above, the Subscriber expressly agrees that the data supplied to Will pursuant to this Agreement, and the results of any calculation executed through the SC-solution, may be compiled, used and made available by Will for statistical and analytical or research purposes, provided that the Subscriber is not identified or personally associated with such data in any manner. In addition, the Subscriber also acknowledges and recognizes that Will is authorized to use the Confidential Information in order to comply with its obligations set forth herein.

9.4 In the event that a Party or its affiliates, franchisees, subcontractors, agents or their respective officers, directors, employees or agents breaches such terms, such Party shall be jointly and severally liable to the other Party for any damage incurred by the other Party and resulting from such breach.

10. Miscellaneous

10.1 Will may change the conditions, the fees and the methods used to allow the Subscriber to participate to the SC-solution by giving the Subscriber a reasonable written notice with respect to the nature of the modifications and the date they come into force;

10.2 The provisions of this Agreement and their interpretation shall be governed by the laws applicable in the Province of Quebec, including the laws of Canada applicable therein. If any provision of this Agreement is declared invalid by a Court of law or is unenforceable under any applicable statute or rule of law, it is so only to that extent to be deemed non-essential and omitted from this Agreement, which will continue to bind the Parties in all its other provisions;

10.3 This Agreement, including its schedules which are incorporated and made a part hereof, sets forth the entire understanding between the Parties and replaces any other agreement, verbal or written;

10.4 The Parties agree in the district of Montreal, Quebec, Canada.

11. Notices

11.1 All notices in connection with this Agreement must be in writing and shall be given by registered mail, courier service, or other means offering a proof of delivery to the addresses mentioned below, or at any other address notified in writing by a Party;

11.2 Notices shall be given at the following addresses:

For :	**Will Solutions Inc.**	**For :**	
Attention :	M. Martin Clermont	Attention :	
Phone :	514-990-2124 ext. 1	Phone :	
Email :	mclermont@solutionswill.com	Email :	

ANNEX A

ANNEX B


Will
WILL - QUEBEC
SUSTAINABLE
COMMUNITY
MEMBER
Certificate of reduction of greenhouse gases
Awarded on December 31st, 2018 to
Name of the member
Is hereby recognized for its efforts in reducing greenhouse gas emissions as a *Sustainable Community* member as of January 1st 2009 to December 31st 2017 of
X tons
This contribution enabled Name of the account, operating in City to reduce its carbon footprint and participate to Quebec's sustainable development.
S/N: CWS-R0001
Martin Clermont,
Président-directeur général, Les Solutions Will
VERRA
Realized under the VM0018 methodology of the Verified Carbon Standard program.
Project No.929 validated and registered under the VCS program.

APPENDIX 3

The list and common practice analysis of the 15 generic PAI

1. PAI Summary - Common Practices and Regulations Analysis
2. Common Practice Analysis Methodology
3. Emission factor (EF) to be used for the renewal period of 2020-2029
4. PAI Common Practice Analysis

1. PAI Summary - Common Practice (CP) and Regulation Analysis

PAI	Description	Scope	Renewal	New generic PAI	CP and Regulation analysis
I	Thermal conversion process using heat as the dominant mechanism to convert biomass into energy.	3	X		Updated
II	Waste management approaches that avoid landfilling and reduces emissions through the recovery of residual waste (e.g. recycling and composting)	13	X		Updated
III	The recovery, transformation and reuse of urban biomass, sawdust, bark and wood residues, by diverting them from landfill and making wood pellets.	3	X		Updated
IV	Energy savings made through recycling activities of materials that are not currently recycled, or recycled in small quantities.	3	X		Updated
V	The recovery and reuse of thermal discharge to fulfill other energetic purposes.	3	X		Updated
VI	-	-	-	-	-
VII	Reduction in energy demand and consumption in new and existing ICI buildings	3	X		Updated
VIII	Switching fossil fuels to a cleaner form of energy that emits less GHG emissions.	3	X		Updated
IX	Recovery and reuse of hydrocarbon products to avoid their disposal. This also includes all projects that replace Natural Gas (NG) by Renewable Natural Gas (RNG)	3	X		Updated
X	Sustainable design for new buildings and major renovation projects resulting in improved energy efficiency.	3	X		Updated
XI	Clean transportation business models that result in significant GHG emission reductions	7		X	New analysis available
XII	Changes in behaviour in sustainable mobility, sustainable living and lifestyle, as well as flexibility in work organization.	7		X	New analysis available
XIII	New transportation technologies that enable significant GHG emission reduction.	7		X	New analysis available
XIV	All measures that a company with transport activities can implement to reduce GHG emissions (excluding technological transformation).	7		X	New analysis available
XV	Waste management approaches that avoid landfilling through the recovery of residual materials such as residues and sludge, dry biomass residues, and biochar.	13		X	New analysis available

2. Common Practice Analysis Methodology

An estimation of the number of ICI buildings eligible to the Sustainable Community project inside the Quebec territory.

The main objective of this analysis is to estimate for each of our initial project activity instances (PAI) what may be or may not be “common practice” within the Quebec project territory and apply our findings to all eligible buildings to our project, as described in our Project Document (PD). Considering a large number of expected buildings, it would be non-productive and unreasonable to try for each of our initial PAI, to identify and evaluate precisely if these projects activity instances were exactly duplicated (at technologies or practices level) in other buildings.

After reviewing the CDM’s methodological tool, we have concluded through a conservative analysis that a PAI is considered a ‘common practice’ when more than 40% of potential buildings have implemented such practices since 2007, which may be associated with similar technologies or practices.

To complete this analysis, we identified the total number of eligible buildings associated with the Industrial, Commercial and Institutions (ICI) classification within the Quebec territory. After thorough research, the exact number was not found; therefore we proceeded to an estimation based on the following points.

1. The number of ICI buildings is recorded in annual property assessment reports made available by the *Ministère des Affaires municipales et de l’Habitation (see section 2.1 in Appendix 3)*. The most recent data available was selected: **320,000 ICI buildings in 2019.**
2. Will’s audit observations and internal statistics indicate that most often audited sites have more than one building. Therefore, the **multiplication factor of 2** was used.

320,000 x 2 = 640,000 buildings

Based on our research, analysis and assumptions, we feel confident to estimate the number of non-residential buildings eligible to our Quebec project at **640,000 buildings** for the calculations of common practices.

Evidence: https://www.mamh.gouv.qc.ca/evaluation-fonciere/donnees-statistiques/

2.1 Number of ICI Building References

According to the data collected from the *Ministère des Affaires municipales* on the Property Assessment of 2019. This includes the types of buildings as indicated in the table below:

Categories	Nbr of buildings
Manufacturing industries	10,988
Transport, Comm. and Public services	46,938
Parking lots and garages	3,018
Commercial	51,748
Shopping centers and buildings	16,901
Wholesale sales	1,969
Retail sales	23,282
Hotels, motels, and tourist homes	9,296
Services	34,645
Office buildings	3,996
Cultural, recreational and leisure	5,035
Golf fields	416
Parks	690
Production and extraction of natural resources	
Agriculture	110,761
Total:	**319,983**
Rounded total:	**320,000**

2.2 Additional data found from other sources:

A. Statistics Canada

Canadian Business Counts with Employees
December 2019

Province	Number of businesses with employees
Quebec	268,797

Source: Statistics Canada. Table 33-10-0222-01 Canadian Business Counts, with employees, December 2019. Retrieved from https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3310022201

"The counts are compiled from the Business Register, Statistics Canada's central listing of Canadian businesses. They are based on the statistical concept of "location". Each operating location is counted separately, including cases where one business comprises multiple locations. For example, a retail business with 10 stores represents 10 businesses in the Canadian business counts. Generally, among all Canadian businesses, 95% are single-location enterprises."

Source: Statistics Canada. Canadian Business Counts, December 2019. Retrieved from
https://www150.statcan.gc.ca/n1/daily-quotidien/200206/dq200206c-eng.htm

B. Ministère des Affaires Municipales : ÉVAStat

Building Inventory
Year 2016

Number of non-residential buildings:	**268,797**
Industries	13,036
Commercial	157,785
Services and culture	65,636

Source:
https://www.mamh.gouv.qc.ca/fileadmin/publications/evaluation_fonciere/renseignements_donnees/EVAstat2016.pdf

2.3 Common Practice Analysis

Assessment of practices in relation to current usage for updating PAI

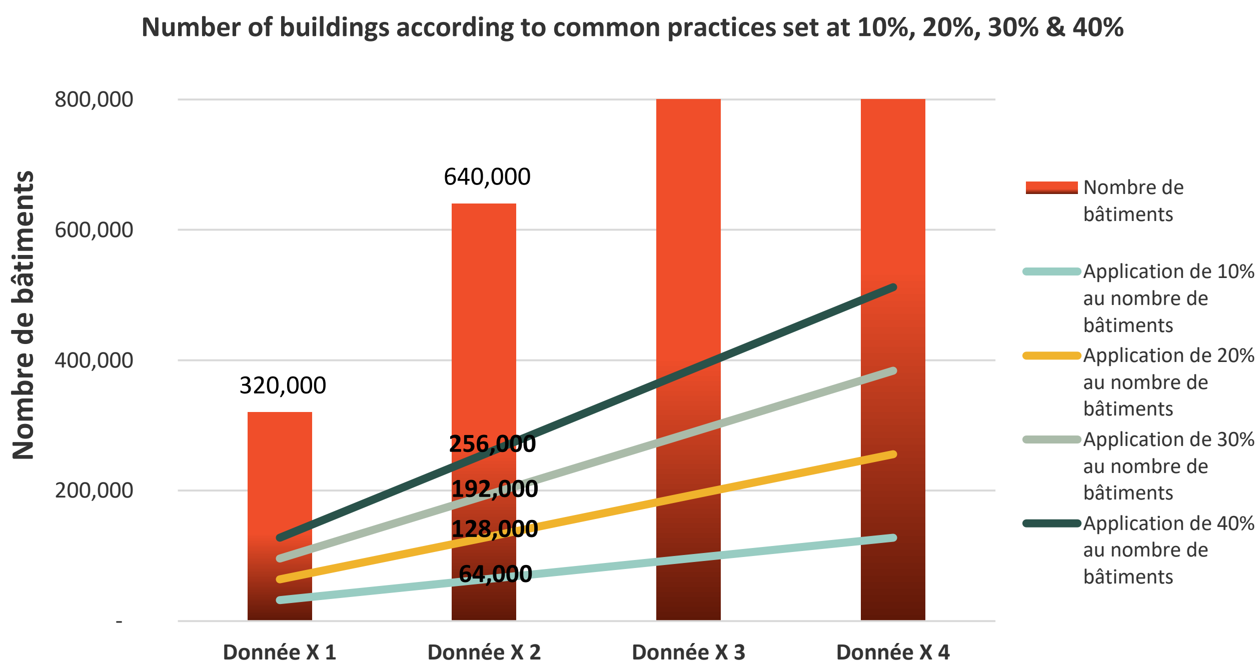
	Innovative (0-10)	Non-Common (10-20)	Non-Common (20-30)	Non-Common (30-40)	Threshold	Generalized
Percentage	10	20	30	40	50	100

Assessment of the number of buildings for updating PAI

	Data X 1	Data X 2	Data X 3	Data X 4	Data X 5
Applying a multiplier coefficient to the data from the **Ministry of Municipal Affairs**	320,000	640,000	960,000	1,280,000	1,600,000

Number of buildings according to common practices at 10%, 20%, 30% and 40%

	Number of buildings	Applying 10%	Applying 20%	Applying 30%	Applying 40%
Data x 1	320,000	32,000	64,000	96,000	128,000
Data x 2	640,000	64,000	128,000	192,000	256,000
Data x 3	960,000	96,000	192,000	288,000	384,000
Data x 4	1,280,000	128,000	256,000	384,000	512,000



3. Emission factor (EF) to be used for the renewal period of 2020-2029

Sectoral Scope 3 Emission Factors

	Baseline Scenario	Source, date issued	Energy type	Unit	Value tCO_2/unit
1	Fossil fuel consumption	MERN, October 4th, 2018	Butane	L	0.001764
2	Fossil fuel consumption	MERN, October 4th, 2018	Biomass and bark residue	Mt	0.000036
3	Fossil fuel consumption	MERN, October 4th, 2018	Diesel	L	0.002790
4	Fossil fuel consumption	MERN, October 4th, 2018	Electricity	KWh	0.000002
5	Fossil fuel consumption	MERN, October 4th, 2018	Gasoline	L	0.002361
6	Fossil fuel consumption	MERN, October 4th, 2018	Coke (Coal)	Mt	0.002487
7	Fossil fuel consumption	MERN, October 4th, 2018	Natural gas	M^3	0.001889
8	Fossil fuel consumption	MERN, October 4th, 2018	Fuel oil #2	L	0.002735
9	Fossil fuel consumption	MERN, October 4th, 2018	Fuel Oil #6	L	0.003146
10	Fossil fuel consumption	Life Cycle Carbon Benefits of Aerospace Alloy Recycling	Recycled Material (FeTi)	Mt	0.000061
11	Fossil fuel consumption	MERN, October 4th, 2018	Propane	L	0.001544

Source: http://www.efficaciteenergetique.gouv.qc.ca/fileadmin/medias/pdf/Facteurs_emissions.pdf

Sectoral Scope 13 Emission Factors

	Baseline scenario	Source, date issued	Waste stream	Unit	Value tCO_2/unit
1	Landfilling waste	USEPA, WARM version 2018	Food/organic wastes	Mt	0.63
2	Landfilling waste	USEPA, WARM version 2018	Corrugated container cardboard	Mt	0.46
3	Landfilling waste	USEPA, WARM version 2018	Mixed paper primarily residential	Mt	0.22
4	Landfilling waste	CDM scope 13, AMS-III-E	Sewage & septic sludges	Mt	2.08
5	Landfilling waste	USEPA, WARM version 2018	Asphalt shingles	Mt	0.02
6	Landfilling waste	USEPA, WARM version 2018	Medium density fiberboard	Mt	-0.97
7	Landfilling waste	USEPA, WARM version 2018	Dimensional lumber	Mt	-1.11

Source: https://www.epa.gov/warm/versions-waste-reduction-model-warm#WARM%20Tool%20V14

Sectoral Scope 7 Emission Factors

	Baseline scenario	Source, date issued	Waste stream	Unit	Value tCO_2/unit
1	Kilometers traveled	T.b.d.	Automobile	Km	T.b.a.
2	Kilometers traveled	T.b.d.	SUV	Km	T.b.a.
3	Kilometers traveled	T.b.d.	Heavy truck	Km	T.b.a.
4	Kilometers traveled	T.b.d.	Other general vehicles	Km	T.b.a.
5	Kilometers traveled	T.b.d.	Train	Kg/km	T.b.a.
6	Kilometers traveled	T.b.d.	Boat	Kg/km	T.b.a.
7	Kilometers traveled	T.b.d	Plane	Kg/km	T.b.a.

4. PAI Common Practice Analysis

Generic Project Activity Instance I

Biomass Project

Table of Contents

1. Description of the generic PAI I

The PAI I is defined as a thermal conversion process using heat as the dominant mechanism to convert biomass into energy from forest biomass, urban residual biomass and postproduction biomass.

2. Looking back on the generic PAI I in previous cohorts

The third cohort of the Sustainable Community project in Quebec (*VCS id project # 929*) counted 141 biomass projects covering 9 of the 17 administrative regions of Quebec. Three regions were characterized by their large number of projects, with more than 3/4 of the projects as shown in the table below. In the first two cohorts, generic PAI I was estimated at 3 PAIs for the first cohort and 5 PAIs for the second cohort.

		PAI I
	Quebec Administrative Region	**Biomass project**
1	Abitibi-Témiscamingue (région 08)	**1**
2	Bas-Saint-Laurent (région 01)	**9**
3	Chaudière-Appalaches (région 12)	**8**
4	Côte-Nord (région 09)	**3**
5	Laurentides (région 15)	**19**
6	Mauricie (région 04)	**2**
7	Montérégie (région 16)	**76**
8	Outaouais (région 07)	**22**
9	Saguenay–Lac-Saint-Jean (région 02)	**1**
	Total	**141**

Most biomass projects refer to the energy conversion from fossil fuels (propane and fuel oil) to biomass (wood residue, wood pallets, urban biomass residues etc.).

3. Research methodology on generic PAI I

The literature review conducted for the PAI I mainly examined governmental and para-governmental documents as well as reports from associations and scientific research, such as the *État de l'énergie au Québec 2020* by the HEC Montréal energy sector management chair.

4. Analysis of existing government policies, regulations and law

Currently, there are no provincial, federal or municipal regulations or law requiring energy conversion (switch fuel) from any fossil fuel to biomass project. However, in 2016, the Quebec government published the document *Politique énergétique 2030* whose objective is to increase by 25% the production of renewable energy, in particular through a 50% increase in the production of bioenergy (biomethane, renewable fuels, energy pellets, etc.). It is by the same logic that subsidy programmes also exist to support the development of bioenergy. In the case of PAI I, the related program refers to residual forest biomass.

However, it should be noted that laws or regulations have constraints, while policies do not. Consequently, companies are not required to convert their fossil fuel systems to biomass.

5. Results

5.1. Quebec's potential biomass energy

Biomass (forest, agri-food and urban) is the second most important source of renewable energy after hydroelectricity, due to the high availability of the resource, good management philosophy and good supervision of harvesting processes. It should be noted that wood residues from forest biomass, agricultural biomass and urban biomass categories remain virtually unexploited, thus showing a high potential for exploitation (see Table 1 in the Appendices).

In 2017, Quebec had 2,362 PJ of energy, where 163 PJ came from biomass, representing 7% of the total primary energy share. Table 2 in the Appendices provides details on the availability of primary energy sources in Quebec. Also in 2017, Quebec had 824 megawatts (MW) of installed biomass capacity on its transmission system, representing 1.8 % of Quebec's electricity system infrastructure (see Table 3 in the Appendices).

In 2019, the province of Quebec generated 214 TWh of electricity, from which 0.05% came from industrial biomass and 0.02% from other biomass. Also in 2019, of the 129 private power plants connected to the Hydro-Québec grid and supplying 5,476.67 MW, only about 17 plants (13.18%) are biomass-fired, producing 434.75 MW (7.94%) of energy. Table 4 (see Appendices) lists the generating stations by type of production.

5.2. Biomass energy consumption in Quebec

In 2017, total energy consumption in all forms and sectors amounted to 1,749 PJ, of which 127 PJ (8%) was biofuels. Biofuel is defined here as woodstove pellets, biogas, ethanol and biodiesel.

In 2012, biomass consumption in the industrial sector outside Montreal was already 19.5% and the commercial and institutional sector outside Montreal accounted for 1.3% of total energy consumption.

However, in 2017, of the 8% biofuel, 15% is consumed by industries, 13% by the residential sector, and 1% by the commercial and institutional sector.

A comparison between biomass energy consumption for the entire Province of Quebec and the total primary biomass energy available shows, on the one hand, that the trend in biomass consumption is even lower and that there is enormous potential to be tapped. On the other hand, Quebec has a large number of potential biomass users.

5.3. The potential users of biomass energy

5.3.1. According to the literature

Although the majority of information sources consulted mentioned a lack of availability and accessibility to data, several documents and even the above data implicitly identify institutions, businesses and industries as the most important potential market for the use of biomass as an energy source (by direct combustion). In fact, approximately two-thirds of the energy consumed in Quebec is devoted to industrial, commercial and institutional uses.

Of the 1,749 PJ of energy consumed in Quebec in 2017, nearly 66% was attributable to the industrial, residential, commercial and institutional building and industrial sectors, as well as the agricultural sector. The industrial and agricultural sectors consumed 621 PJ (35%) of this energy, where 85 PJ (15%) came from biomass and the residential building sector consumed 333 PJ where 42 PJ (13%) came from biomass. Concerning the commercial and institutional building sector, a very small portion, almost nil, is attributed to biomass out of the 198 PJ of energy consumed. Furthermore, taking into account only the industrial and agricultural sector, of which 71% are manufacturing, aluminum and pulp and paper, only 11% (70 PJ) came from biomass.

As well, based on the collected data, we estimate that there are 320,000 commercial and institutional industrial enterprises in Quebec. For an average of 2 buildings per company, there will be approximately 640,000 buildings with heating, lighting and air conditioning needs, etc. This means that 640,000 buildings use about **819 PJ** (621 PJ+198 PJ) of energy, of which just **85 PJ** (**10%**) comes from biomass.

On the other hand, the high investment cost of biomass boilers may prove to be a barrier to the deployment of such projects. To this end, the Quebec government has put in place several measures and subsidy programs to promote the use of biomass as an energy source and to help businesses in the replacement of fossil fuels or any other non-renewable energy that emits CO_2. That is why we seek data on the number of subsidized projects as additional information for our estimate.

5.3.2. According to successful biomass projects accepted into the Fonds Vert program from 2013 to 2019 (Conseil de gestion du Fonds vert, October 2019)

In order to support the development of bioenergy to reduce short-term GHG emissions by use of residual forest biomass, Transition Énergétique Québec (TEQ), through the Fonds vert, has awarded grants to municipalities and municipal organizations, non-profit organizations, large, small and medium-sized businesses and research institutions. Quantity details are provided in the table below.

Number of funded projects	Number of set up projects		Number of analyzed projects	
187	**148**		**39**	
	75 completed	73 in progress	33 completed	6 in progress

Source : Compiled from a document from the Conseil de gestion du Fonds vert (October 2019).

As of October 31, 2019, a total of 187 projects have been subsidized, which includes 148 set-up projects and 39 projects analyzed. This means that there are 148 functional projects, corresponding to 148 companies, using biomass as an energy source and another 39 companies that will be able to use the same energy source in the near future.

6. Common practice analysis on generic PAI I

Even considering the 148 companies or the 187 companies (148+39), the total biomass energy consumption does not change significantly from the 10 % mentioned as the total biomass energy consumption of the companies. Moreover, considering WILL Solutions 2012 estimation, which noted that approximately 200 biomass projects have been carried out in Quebec since 2007, the current total would be around 387 biomass projects (200+187).

If we look at these data, without taking into account Will Solutions biomass projects[6], there would be 387 biomass projects, approximating 400 biomass projects for 320,000 existing companies. This is amounts approximately to 0.12% of companies using biomass as an energy source.

7. Conclusion

Although there is not enough data on the number of companies using biomass, all the above information leads to the conclusion that **the use of biomass as an energy source in the industrial, commercial and institutional sector, including the agricultural sector, is not a common practice**. However, our research leads us to consider a strong possibility that biomass projects will become more important in the coming years. We conclude that biomass conversion projects are not a current practice with an approximately 0.12% of companies and their buildings using biomass as an energy source.

[6] The biomass projects of Will Solutions sustainable community cannot be differentiated from projects that have received grants and even other biomass projects in the literature. Thus, no reference is made to them in order to avoid double accounting.

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9. Appendices

Table 1: Quebec's Biomass Potential - 2011

BIOMASSE	POTENTIEL TOTAL BRUT		POTENTIEL DÉJÀ EXPLOITÉ	
	QUANTITÉ (tms/an)	ÉNERGIE (PJ_{th}/an)	QUANTITÉ (tms/an)	ÉNERGIE[1] (PJ_{th}/an)
Biomasse forestière				
Bois de chauffage (résidentiel)	2 771 850	52,00	2 771 850	52,00 (100 %)
Résidus de transformation du bois	2 380 000	44,96	2 107 000	39,84 (89 %)
Résidus de coupe	4 430 000	83,95	0	0 (0 %)
Résidus de pâtes et papiers	915 172	15,63	560 910	9,93 (63 %)
Liqueur résiduaire	3 018 750	37,10	3 018 750	37,10 (100 %)
Biomasse agroalimentaire				
Résidus de culture céréalière	1 835 940	30,77	0	0 (0 %)
Cultures énergétiques de plantes pérennes[2]	868 000	14,79	0	0 (0 %)
Lisiers d'animaux d'élevage	2 069 659	32,12	0	0 (0 %)
Cadavres d'animaux	7 803	0,20	0	0 (0 %)
Résidus d'abattoirs	160 935	3,88	0	0 (0 %)
Huiles de friture	60 000	2,21	29 500	1,09 (15 %)
Lactosérum	81 600	1,10	820	0,011 (1 %)
Biomasse urbaine				
Boues de stations d'épuration des eaux usées municipales	223 796	2,66	n. d.	n. d. n. d.
Résidus domestiques putrescibles	669 665	12,24	0	0 (0 %)
Total	**19 493 177**	**333,63**	**8 468 050**	**139,63 (42 %)**

Note : tms/an : tonne métrique sèche par année – tma/an (aussi utilisé) : tonne métrique anhydre par année. Dans l'industrie forestière, les expressions « séché au four » (anhydre) et « séché à l'air » (± 8 % d'humidité) sont également employées. Indice th : énergie ou puissance thermique.

1. Les pourcentages entre parenthèses indiquent la proportion de la biomasse déjà exploitée par rapport au potentiel d'utilisation.
2. Cultivées sur les bandes riveraines et des terres marginales.

Source: Hydro-Québec (2014), page7

Table 2: Availability of primary energy sources in Quebec for 2017

	Sources	Pétajoules	Part du total	Équivalence
Importations = 53 %	Pétrole	815	35 %	135 millions de barils
	Gaz naturel	323	14 %	8,4 milliards de m³
	Hydro*	95	4 %	26 TWh
	Charbon	19	0,8 %	1,0 millions de tonnes
	Électricité (sources variables)**	3	0,1 %	0,8 TWh
Sources locales = 47 %	Hydro	801	34 %	223 TWh
	Biomasse	163	7 %	
	Éolienne	140	6 %	39 TWh
	Gaz naturel renouvelable	3	0,1 %	0,08 milliards de m³
	Total	**2362**	**100 %**	

Sources : Voir graphique 1 ; EIA, 2019.

Note : *Cette importation d'électricité correspond à l'achat d'électricité produite par la centrale hydroélectrique de Churchill Falls à Terre-Neuve-et-Labrador.
** Ces importations d'électricité proviennent de l'Ontario, de New York, de la Nouvelle-Angleterre et du Nouveau-Brunswick, où elles sont issues de sources variables.

Source: **Whitmore and Pineau (**2020), page 8

Table 3: Electricity grid infrastructure in Quebec in 2018

Puissance installée des centrales	(MW)	(%)
Hydroélectricité	40 438	89,0 %
Éolienne*	3 510	7,7 %
Biomasse	824	1,8 %
Combustion (gaz naturel, mazout)	483	1,1 %
Combustion interne (diesel)	192	0,4 %
Solaire	n.d.	–
Total	**45 447**	

Source: **Whitmore and Pineau (**2020), page 19

Table 4: Inventory by type of private power plants connected to the Hydro-Québec grid in 2019

Types de production	Centrales raccordées au réseau de transport (1)				Centrales raccordées au réseau de distribution (2)				Total	
	Nombre de centrales	Puissance installée (MW)	% Nombre	% puissance installée	Nombre de centrales	Puissance installée (MW)	% Nombre	% puissance installée	Nombre de centrales	Puissance installée (MW)
Éolien	38	3,797.4	55.9	76.3	6	119	9.83		**44**	**3,916.4**
Biogaz	0	0	0	0	2	17.5	8.2		**2**	**17.5**
Biomasse	12	377.2	17.65	7.57	5	57.55	3.28		**17 (13.18 %)**	**434.75 (7.94 %)**
Hydraulique	16	247.3	23.53	4.97	47	301.62	77.05		**63**	**548.92**
Turbine à gaz	1	547	1.47	11	0	0	0		**1**	**547**
Thermique	1	7.5	1.47	0.15	1	4.6	1.64		**2**	**12.1**
Total	**68**	**4976.4**			**61**	**500.27**			**129**	**5,476.67**
67 centrales sont opérationnelles et 2 en développement					**55 centrales sont opérationnelles, 2 en construction et 4 en développement**				**122 opérationnelles, 2 en construction et 6 en développement**	

Source: Compiled from the list of private power plants connected to the Hydro-Québec 2019 grid (Hydro-Québec, 2019).

Generic Project Activity Instance II

Methane Emission Avoidance

Table of Contents

1. Description of the generic PAI II

The PAI II covers waste management approaches that avoid landfilling and consequently reduces methane emissions through the recovery of residual materials. This project involves the recovery, reuse, recycling and composting of organic matter. Organic matter can be diverted from landfill through composting or biomethanization (anaerobic digestion).

2. Looking back on the generic PAI II in previous cohorts

The third cohort of Sustainable Community project in Quebec (*VCS id project # 929*) counted 438 methane emission avoidance projects covering 10 of the 17 administrative regions of Quebec. Three out of those 10 administrative regions have more than half of the PAI II, with one region, the Saguenay, representing nearly 1/3 of the total of PAI II, as shown in the table below. In the first two cohorts, the number of generic PAI II was estimated at 3 PAIs for the first cohort and 51 PAIs for the second cohort.

		PAI II			Total of PAI II
	Quebec Administrative Region	**Reduction/ Reuse**	**Composting**	**Recycling**	
1	Abitibi-Témiscamingue (région 08)	**0**	**2**	**1**	**3**
2	Bas-Saint-Laurent (région 01)	**7**	**21**	**2**	**30**
3	Chaudière-Appalaches (région 12)	**1**	**0**	**0**	**1**
4	Côte-Nord (région 09)	**55**	**0**	**0**	**55**
5	Lanaudière (région 14)	**1**	**0**	**2**	**3**
6	Laurentides (région 15)	**9**	**42**	**16**	**67**
7	Mauricie (région 04)	**29**	**40**	**0**	**69**
8	Montérégie (région 16)	**12**	**0**	**0**	**12**
9	Outaouais (région 07)	**17**	**38**	**4**	**59**
10	Saguenay–Lac-Saint-Jean (région 02)	**86**	**49**	**4**	**139**
	Total	**217**	**192**	**29**	**438**

Most methane emission avoidance projects registered in WILL's Sustainable Community relate to the reuse of materials (urban biomass residues, wood and bark residues).

3. Research methodology

The literature review conducted for the PAI II mainly examined governmental documents from Recyc-Québec and the MELCC (Ministère de l'Environnement et de la Lutte Contre les Changements Climatiques), as well as a few press reports.

4. Analysis of government policies, regulations and laws

Several official documents, including policies, laws and regulations related to waste management have been adopted at the provincial and federal levels. On the federal government side, there is, for example, the Canadian Environmental Protection Act of 1999. In Quebec, related legislation and regulations include, among others, the following:

- Q-2 Environment Quality Act of 2011, which has been amended. The new version became effective on March 23, 2018;
- S-22.01 Act respecting the *Société québécoise de récupération et de recyclage*.

Several regulations are linked to the following Environment Quality Act, such as:

- Q-2, r.19 **Regulation respecting the landfilling and incineration of residual materials**

The purpose of this Regulation is to prescribe the residual materials that may be accepted in the dedicated facilities (various authorized landfill sites), the conditions under which the facilities must be established and operated, and the conditions that apply to their closure and post-closure management;

- Q-2, r.40.1 **Regulation respecting the recovery and reclamation of products by enterprises**

The purpose of this Regulation is to reduce the quantities of residual materials to be disposed of by assigning to enterprises the responsibility for the recovery and reclamation of the products covered and marketed by them, and by promoting the design of products more respectful of the environment.

- Q-2, r. 43 **Regulation respecting the charges payable for the disposal of residual materials**

The purpose of this Regulation is to fix the charges to be paid for the disposal of residual materials in disposal sites.

In 2011, a Residual Materials Management (RMM) policy, whose fundamental objective is that the only residual material disposed of in Quebec is the ultimate waste, was adopted in accordance with the 2011 Environment Quality Act. The associated 2011-2015 action plan was updated for a new period: from 2019-2024. Among the targets to be achieved in 2023 by the new action plan are the recycling of **60% of organic materials** and the recycling of **75% of paper, cardboard, glass, plastic and metal**, as shown in Table 1, which provides a comparative overview of the quantitative aims of the two action plans.

Table 1: Goals and targets of the action plans of RMM 2011-2015 and 2019-2024

Entitled	2011-2015	2019-2024
Deadline	***2015***	***2023***
Reduce to **X kg** or less the amount of material disposed per capita	X= **700 kg**	X= **525 kg**
Recycle **Y %** of residual putrescible organic mater	Y= **60%**	Y= **60%**
Recycle **Z %** of residual paper, cardboard, glass, plastic and metal[7]	Z= **70%**	Z= **75%**
Recycle and valorize **R %** of cement, brick and asphalt residues/ Construction, renovation and demolition residues	R= **80%**	R= **70%**
Sort at source or send to a disposal center **S %** of construction, renovation and demolition residues from the building segment	S= **70%**	**/**

Sources: MELCC (2011) & MELCC (2020a, February)

Furthermore, always in line with government actions related to RMM policy aimed at reducing the ultimate residue through recycling activities, Quebec announced in February 2020 a reform of the curbside collection system. This involves the modernization of the curbside collection system. To this end, a budget has been established for five programmes that could now support the sorting centers and collection actors. That reform follows the management of the recycling crisis of 2018-2019, due to the tightening of product quality by Asian countries. In fact, the vast majority of sorting centers and RMM facilities in Quebec has difficulty meeting the established standards, due to lack of financial and logistical resources. The reform is based on the principle of Extended Producer Responsibility (EPR), which previously applied only to electronic products, mercury lamps and batteries. This curbside collection will come into force in autumn 2022 and will be fully operational in summer 2025.

In addition, as part of the implementation of the RMM policy, a new strategy for the valorisation of organic matter was launched on July 3, 2020. Its aim is to provide brown bins to all Quebecers by 2025 so that green food waste can be better recovered and recycled. In the same vein, an increase in the charges payable for the landfilling of organic matter from $23 to $30 per tonne is announced to encourage the recovery, reuse and revalorization of materials.

[7] Does not apply to materials constituting products or classes of products for which recuperation and development goals are prescribed by regulation.

Thus, until the new reform is adopted by the National Assembly in autumn 2022 in order for the new EPR to take effect, companies that were not subject to EPR have no regulatory obligation to reuse, recycle and compost waste.

5. Results: Status of recycling in Quebec – Trends in materials from 2012 to 2018

5.1. Organic materials

In 2018, a total of **5,183,000 MT** of organic materials for all activity sectors were generated, 2,916,000 MT were landfilled and incinerated, and **2,267,000 MT** were recycled, giving a global recycling rate of 44% of the organic waste produced. These numbers seem high, but they hide very large disparities in the data. Indeed, when excluding agri-food residues, the total quantity of putrescible organic materials generated in 2018 is **3,933,000 MT**, of which **1,057,000 MT** have been recycled, representing **27%** of the total. Despite the fact that the quantity recycled in 2018 is increasing (from **22%** in 2012 to **27%** in 2018), it remains very low compared to the total quantity of generated putrescible organic materials.

However, our main focus is on the industrial, commercial and institutional (ICI) sectors. The quantity of organic matter generated by ICI is **997,000 TM** in 2015 and **1,019,000 TM** in 2018, while the quantities recycled in the same years are respectively **29,000 TM** and **51,000 TM** (i.e. **3%** and **5%**). The details of these data are provided in Table 2 in the appendices. In sum, the data collected shows us that the proportions of recycled organic materials from the ICI sector are **2%** in 2012, **3%** in 2015 and **5%** in 2018. Although the quantity recycled is increasing, it still remains very low compared to generated quantities.

Our secondary focus is on the municipal sector, where some of our members manage domestic waste through the grouping of municipalities, in remote areas far from urban large cities and into Inter-municipal management board for residual materials, such as “Régie Intermunicipale des Déchets de la Lièvre” (RIDL), and “Régie Intermunicipale des Déchets de la Rouge” (RIMR) and the MRC Témiscamingue.

Moreover, we know that organic matter can be diverted from landfill through composting or anaerobic digestion. Thus, the part of composting in the recycled organic matter quantity in 2018 (2,267,000 MT) 499,000 MT corresponds to 22.01% of the recycled part. For the ICI, this proportion is 37,000 MT out of 51,000 MT of recycled materials (i.e. 72.55%); see Table 2 in the Appendices. Indeed, composting is done with organic matter from municipal and ICI collections as well as with municipal sludge. This organic matter is constituted of food and green residues collected by the third way (brown bins). In 2015, more than 300 municipalities in Quebec were providing services to citizens across the province through brown bins for the recovery of food and green waste. In 2018, more than 500 municipalities in Quebec were doing so. This represents, for 2018, slightly less than half of the municipalities offering this service; 43.6% for about 1,140 municipalities. On the other hand, organic materials also come from ecocenters to sorting facilities. In 2015, there were 260 ecocenters for 405,000 MT of materials, of which 9% was organic matter. In 2018, there were 332 ecocenters for 509,000 MT of materials with 8% of green residues (i.e. 42,000 MT).

On another side, materials sent to landfill and incineration are also increasing. Despite a slight decrease in the number of landfill sites from 82 in 2015 to 79 in 2018, the quantity of disposed waste, excluding sludge, increased from **5,140,000 MT** in 2015 to **5,361,000 MT** in 2018, which represents an increase of **4.3%**. The compiled data used are provided in Table 3 (see Appendices).

5.2. Paper, cardboard and plastic

The overall recovery rate for the residential sector from 2015 to 2017 was 63.6%, and was composed of 71.4% for paperboard, 78.8% for glass, 52.7% for metal and 34.8% for plastic; see Table 4 in the Appendices. In addition to this information, from 2017 to 2018, the materials recovered by municipal curbside collection trucks (residences, ICI, ecocenters and out-of-home collections) that arrived at the material recovery facilities (MRFs) were composed of 63% cardboard, 13% plastic, 13% glass, 8% organic matter and 4% metal.

Looking at the data, the recycling situation in Quebec does not seem to be too desperate. However, the data conceals a number of dissimilarities relating to materials characterization, notably the proportion of untargeted materials representing **12.9%**, in addition to contaminated materials at the origin of the recycling crisis. In the same way, it would be relevant to emphasize here that both the untargeted and contaminated materials are destined for landfill.

Furthermore, 926,000 MT of recyclable materials were collected in the blue bins of residences in 2018, precisely from 2015 to 2017; 36% were discarded and 64% were recovered. Of the 64% recovered, 82% (485,000 MT) was sent for conditioning or recycling and 18% were not recycled. This means that out of **926,000 MT**, **485,000 MT** were recycled, representing **52%** of recyclable materials generated. This included **511,000 MT** of paper and cardboard of which **363,000 MT** (**71%**) were recycled and **201,000 MT** of plastics of which **51,000 MT** (**25%**) were recycled.

On the other hand, looking at the evolution of overall recyclable materials from 2012 to 2018, as Table 5 in the Appendices shows, it can be seen that the quantity of materials received to MRFs gradually decreases from **1,095,000 MT** in 2012, **996,000 MT** in 2015 to **993,000 MT** in 2018. Quantities effectively recycled (i.e. sold) follow the same trend and the recycled proportions dropped from **970,000 MT** in 2012, **808,000 MT** in 2015 to **786,000 MT** in 2018. Concerning the ICI sector, the quantities of material arriving at MRFs from 2012 to 2018 are **290,000 MT** in 2012, **222,000 MT** in 2015 and **221,000 MT** in 2018. However, it is difficult to make real comparisons between the quantities of waste generated and those actually recycled because many data, in this case those specific to ICI, are not available. Nevertheless, the quantities of paper and cardboard recycled from 2012 to 2018 are **810,000 MT** in 2012, **707,000 MT** in 2015 and **642,000 MT** in 2018, while those of plastic are respectively **41,000 MT**, **46,000 TM** and **59,000 TM**.

Carrying on the analysis with the data on recycling brokers, it appears that in 2012, 48% of the recycled materials were purchased by local businesses for the manufacture of new products, 39% in 2015 and 55% in 2018 (see Table 6 in the Appendices). Even though local purchases have increased, they are not yet enough to absorb all of the recycling output. This remains a major challenge given that Asian markets have severely tightened.

6. Common practice analysis on generic PAI II

6.1. Organic materials

This research has shown that the recycling rates for organic matter (green waste and municipal food) on the whole territory of Quebec are **17%** in **2015** and **31%** in **2018**. In addition, the recycling rates of putrescible organic materials from ICI are **3%** in **2015** and **5%** in **2018**. This leads us to the partial conclusion that landfilling is still a common practice while composting is uncommon, although the distribution of brown bins and ecocenters is increasing and inter-municipal boards are starting to compost organic materials. This is also justified by the fact that at WILL, most of our members are part of the ICIs that take the initiative to compost and recycle organic materials, paper and cardboard without it being imposed by regulations. This is the case of "Lanoraie Pharma" which benefits from support and waste management services of EBI, manager of four ecocenters in the Lanaudière region; this type of commitment by ICIs are not common. So, for the remote area, far from large urban cities, it is the same conclusion that composting is an uncommon practice.

Furthermore, WILL estimated that there were 320,000 ICI for about 640,000 buildings in Quebec. If ICIs produced 1,019,000 TM in 2018 with 51,000 TM recycled, this means that 320,000 ICIs produced the same amount. This is equivalent to the production of approximately 3.2 TM of waste per ICI of which only 5% was recycled. This value being far below 40%, we conclude that composting of organic matter is not yet a common practice in Quebec.

This finding about the recycling of organic materials being an uncommon practice is reinforced by Susan Antler[8]'s comments in a magazine commentary on recycling products on August 6, 2020. She argues that only about a third of the annual potential of organic materials is recycled, and that kudos should be given to those who are already making an annual collective impact, without much help, by diverting millions of tonnes of organic wastes from landfill to be turned into compost, "digestat" and renewable energy. In conclusion, she adds that much remains to be done in terms of infrastructure implementation, participation and local market development. Ms. Antler's comments show that the potential for recycling organic materials is far from being reached, both in Canada and in Quebec. As a result, recycling of organic materials is not a common practice.

However, while congratulating the Quebec government's initiatives in favour of composting organic residues, Antler (2020) believes that the MELCC reform is on the right track and that, with time and the development of recycling infrastructures, "encouraging" the recycling of organic materials will become an "obligation". This is justified, according to her, by the fact that the government's targets are accompanied by financial commitments of $1.2 billion over the next decade and by increased landfill taxes.

6.2. Paper, cardboard and plastic

According to the Recyc-Québec report, only 52% of the materials generated are received in the MRFs. So, out of 926,000 TM generated, 485,000 TM from curbside collection were sent to the MRFs. Of the quantities sent to the MRFs, 11.4% are discarded (i.e. they will be sent to landfill or incineration). This means that approximately 46% of the materials initially generated are recycled. However, as noted above, it was difficult to have all the data on the ICI generated and recycling materials in order to draw enlightened conclusions. Moreover, it must also be taken into account that sorting could be incorrectly done at source, sending to the waste what should go into the recycling bin.

[8] *Susan Antler is the executive director of the Compost Council of Canada.*

In addition, the years 2018 and 2019 were marked by severe recycling crises, a repeat of the situation in 2008 and 2009, which had a heavy impact on sorting centers and broker's activities in this field. The known causes of this crisis are the poor treatment of waste in sorting centers and the contamination of certain types of products such as paper which, up to the end of 2017 and in 2018, were mainly shipped to Asia. Based on this element, could it be said that 46% of the materials generated are actually recycled? Probably not, since materials that are recycled (sorted) and identified as contaminated or of poor quality and that cannot find a buyer will eventually end up being disposed of by landfill or incineration. Only, this proportion remains unknown until now. Also, this crisis has raised awareness on the fact that recovery does not guarantee that the material is properly recycled.

Lastly, in its final report on the identification of financing mechanisms for Quebec companies ,TEQ (2018) states that only 4.3% of companies in Quebec have adopted waste management technologies. So, of the 320,000 ICI identified by WILL in Quebec, only 4.3%, 13,760 ICI, have adopted waste management technologies. This is relatively much less than 40%. This demonstrates that there is still a long way for recycling to become a generalized practice. Consequently, the practice of recycling is not common in Quebec ICIs and even in Quebec to a large extent.

That's why there remains recycling challenges such as raising public awareness and attention on what goes into recycling, innovation and market adaptation. It is with this same logic that we think that there is still a great need to raise awareness about recycling and about what is put in the bins, due to the fact that recovery is a constant challenge in public education. This is illustrated by many examples, notably Tricentris, which spends about $600,000 a year on advertising; Recyc-Québec, which recently implemented an awareness application, " Ça va où" (Where's it going?); Quebec Government with his five programs under curbside collection system reform of February 2020 as well as his increase of payable charges for organic matter landfilling from $23 to $30 per tonne and his new strategy for the valorisation of organic matter, launched on July 3, 2020.

7. Conclusion

Despite a number of missing data mentioned in most of the 2017 and 2019 Recyc-Québec reports consulted, and considering the Recyc-Québec and Statistics Canada reports explored in addition to all the information collected, we believe that some major steps in recycling should be different from what is currently practiced. With 5% of recycled organic materials in 2018 and 4.3% of companies which have waste management technologies, percentages are much less than 40%. In other words, **recycling,**

composting and other practices to avoid methane emissions are not yet ready to be considered as common practices. That is why there is even more emphasis on them.

However, these percentages of recycling of organic matter, paper and cardboard as well as other materials may increase in the future, given government efforts and the various community and local initiatives that are emerging.

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9. Appendices

Table 2: Trends in organic materials (OM) management from 2012 to 2018

Title	Generated quantities (in Metric Tons)		Disposed quantities (Landfill + Incineration) (in Metric Tons)		Recycled quantities (in Metric Tons)			Composted component in the recycled quantity
	2015	2018	2015	2018	2012	2015	2018	2018
OM from municipal sector including sludge	2,348,000	1,937,000	1,661,000	1,262,000	20 %	687,000 (29 %)	675,000 (35 %)	443,000 (65.6 %)
Sludge and putrescible OM from pulp and paper mills	1,066,000	977,000	699,000	646,000	39 %	367,000 (34 %)	331,000 (34 %)	4,000 (1.21 %)
OM from ICI sector	997,000	1,019,000	968,000	968,000	2 %	29,000 (3 %)	51,000 (5 %)	37,000 (72.55 %)
Total putrescible OM (excluding agri-food wastes)	**4,411,000**	**3,933,000**	**3,328,000**	**2,877,000**	**22 %**	**1,083,000 (25 %)**	**1,057,000 (27 %)**	**484,000 (45.79 %)**
Agri-food sludge and OM	/	1,249,000	/	39,000	927,678 (96 %)	1,047,000 (97 %)	1,210,000 (97 %)	15,000 (1.24 %)
Total putrescible OM	**/**	**5,183,000**	**/**	**2,916,000**	**40 %**	**2,130,000 (38 %)**	**2,267,000 (44 %)**	**499,000 (22.01 %)**

Sources: Compiled using Recyc-Québec (2017) and Recyc-Québec (2019b)

Table 3: Trends in the quantities of disposed materials from 2015 to 2018 (Incineration and landfill)

	2015	2016	2017	2018	Variation rate between 2015 and 2018 (%)
Disposal sites	82	82	82	79	-3.7
Quantities of disposed waste, excluding sludge (in Mt)	**5,140,000**	**5,004,000**	**5,417,000**	**5,361,000**	**4.3**
Municipal sludge incinerated	323,000	297,000	328,000	338,000	4.8
Municipal sludge landfilled	160,000	142,000	142,000	123,000	-23
Other landfilled sludge (agri-food, industrial, etc.)	5,000	7,000	7,000	26,000	458.8
Total Boues éliminées	**487,000**	**446,000**	**477,000**	**487,000**	**0.1**
Total disposal materials	**5,627,000**	**5,450,000**	**5,894,000**	**5,848,000**	**3.9**

Source: Compiled using Recyc-Québec (2019c)

Table 4: Recovery rate material by category for the residential sector (in %)

Material Category	2012-2013	2015-2017
Paperboard	70.6	71.4
Glass	77.2	78.8
Metal	43.3	52.7
Plastic	31.7	34.8
Overall Materials	**62.5**	**63.6**

Source: Recyc-Québec (2019d)

Table 5: Quantity of received and outgoing materials (in Metric tons)

		2012		2015		2018	
		Received materials	**Output or sold materials**	**Received materials**	**Output or sold materials**	**Received materials**	**Output or sold materials**
Overall materials	MC	805,000	703,000 (87 %)	774,000	614,000 (79 %)	772,000	590,000 (76 %)
	ICI	290,000	/	222,000	194,000 **87.398 %**	221,000	196,000 **88.69 %**
	T	**1,095,000**	**970,000**	**996,000**	**808,000**	**993,000**	**786,000**
Paper and cardboard	T	**/**	**810,000**	**/**	**707,000**	**/**	**642,000**
Plastic	T	**/**	**41,000**	**/**	**46,000**	**/**	**59,000**

Source: Compiled using Recyc-Québec (2017) and Recyc-Québec (2019a)

Table 6: Destination of sold materials for recycling (in %)

Material Category		2012	2015	2018
Quebec processors or recyclers	Paper and cardboard	/	36	48
	Plastic	/	47	66
	Overall outgoing Materials	**48**	**39**	**55**
Brokers or shipped outside Quebec	Paper and cardboard	/	64	50
	Plastic	/	48	4
	Overall outgoing Materials	**52**	**60**	41

Source: compiled using Recyc-Québec (2019a)

Generic Project Activity Instance III

Torrefied Biomass Project

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1. Description of generic PAI III

The PAI III is defined as the recovery, transformation and reuse of urban biomass, sawdust, bark and wood residues, by diverting them from landfill and making wood pellets.

2. Looking back on the generic PAI III in previous cohorts

The third cohort of the Sustainable Community project in Quebec (*VCS id project # 929*) had 83 torrefied biomass projects covering 3 of the 17 administrative regions of Quebec, corresponding notably to 3 members:

- *Granulco*: a division of *Boisaco* that uses bark residues to produce wood pellets and redistribute them to its clients;
- *Lauzon bois énergétique* of Papineau and St-Paulin: transform post production wood residues into wood pellets.

3. Research methodology

The literature review conducted for the PAI III is the same as for PAI I. It focused primarily on governmental and para-governmental documents as well as reports from associations and scientific research, such as the *État de l'énergie au Québec 2020* by the HEC Montréal energy sector management chair.

4. Analysis of government policies, regulations and law

Just as there are no provincial, federal or municipal regulations or legislation requiring energy conversion (switch fuel) from any fossil fuel to biomass project, there is similarly no such requirement for torrefied biomass projects. However, related to the PAI III, there is the Energy Policy 2030, which aims to increase bioenergy production (biomethane, renewable fuels, energy pellets, etc.) by 50%. On the other hand, the Québec Residual Materials Management Policy sets objectives to eliminate the waste of resources and to transfer accountability to all the actors involved in the management of residual materials. Referring to it, there is no mention, either in laws or regulations, of the mandatory nature of the actions to be adopted with regard to the recovery of bark, wood and urban biomass residues. Rather, timelines to accelerate the implementation of the necessary collection systems and treatment facilities to prohibit the disposal of these materials in the future are included. In addition, the Government expresses a preference for the return of recyclable materials to a production cycle.

This indicates that companies are not required to recover, reuse or send for recycling their biomass and wood bark residues.

5. Research results

The statistical results are the same as those found in the PAI I research.

6. Common practice analysis on generic PAI III

In the Generic PAI I, the literature review and statistics found lead to the conclusion that approximately 0.12% of companies use biomass as an energy source. Not having been able to separate the statistics for biomass projects from those for torrefied biomass, the analysis took into account all types of biomass. Thus, we can extend this conclusion to the use of torrefied biomass. As a result, the recovery, transformation and reuse of urban biomass as well as sawdust, bark and wood residues to make wood pellets is not a common practice in Quebec.

7. Conclusion

As in PAI I, **we conclude that the recovery, transformation and reuse of urban biomass as well as sawdust, bark and wood residues to make wood pellets in the industrial, commercial and institutional sector is not a common practice**. However, our research leads us to consider the possibility that biomass projects will become more important in the coming years due to government incentives related to the use of residual biomass.

We conclude that biomass conversion projects, including torrefied biomass, are not a common practice, with approximately 0.12% of companies and their buildings using biomass as an energy source.

8. References

Documents and references consulted are the same as in PAI I.

Generic Project Activity Instance IV

Saving Energy on Recycling Activity

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1. Description of the generic PAI IV

Here, the term "recycling activity" refers to all material output that can first be recovered, and then transformed and re-used in order to avoid energy and virgin material consumption. This PAI aims to assess energy savings that can be made through recycling activities of materials that are not currently recycled, or recycled in very small quantities.

The 4th cohort of the Sustainable Community counted 34 projects (4%) associated with the PAI IV, which were all led by a company working on the recycling of aircraft alloy. Another type of project involved in the recycling of plastic materials such as HDPE and PVC from domestic post-consumption waste were also quantified. The project performed approximately 1,300 tCO_2e of GHG reductions in 2015 and 2014.

2. Research methodology

The analysis is based on a governmental study made by **EDDEC Institute**, specialized in circular economy and sustainable development, which provides a global inventory on recycling activities in Quebec, with a focus on metals and material recovery and reuse.

3. Analysis of government policies, regulations and laws

No specific legislation has been implemented in Quebec to fulfill recovery, recycling and reuse of metals or other materials. However, some products are targeted by a specific regulation act within the frame of the “extended responsibility of producers”. This act is the “*Regulation respecting the recovery and reclamation of products by enterprises”* (LégisQuébec, 2020). This act makes it mandatory for companies to plan measures and actions to recover and process specific products at the end of their lifecycle. In the case of material/metals recovery, the main products concerned in this generic PAI are residential post-consumption goods such as computers, printers, screens, mobile phone, cameras, etc., which represent a significant amount of recovery opportunities. Besides, the recycling of metals is not yet a critical issue for the Quebec government and neither a strong economic sector.

4. Results

Overall, the recycling of some metals like copper, aluminum, iron and steel is well developed in Quebec, however capacities and opportunities have not yet reached their best potential (EDDEC, 2017). The chain of recovery, sorting, and recycling is quite dynamic in Quebec for some metals like copper and iron (EDDEC, 2017). Steel industries, mining companies, and recovery and recycling facilities have developed a dynamic local market, since these metals are easy to gather or extract from waste byproducts or from finished products (cars, appliances etc.). Extraction of metal from finished products is the principal source for recycling. Also, some industrial outputs, like slag and anode slimes from primary metallurgy of copper, steel and iron find great recycling opportunities in Quebec. As for lithium batteries from electric cars, the recycling process is more complex and faces cost-effective issues.

According to the EDDEC Institute, in 2012, **30,000 tons of metals** were recovered, representing a recovery rate of **52%**. In 2015, the Horne Foundry recycled 26,500 tons of copper and 1.6 million oz of precious metals from 106,000 tons of recovered materials (EDDEC, 2016). This information was crosschecked with data available on the Horne Foundry’s website; in 2016, the same amount of metals was recovered by the company (Fonderie Horne, 2016). Regarding copper, about 50% of waste products are recycled in Quebec, 50% is sent abroad and 0.5% is sent to landfill. As for iron, 2.6 million tons reach end of life each year: 38% are recycled, 54% are sent out of Quebec and around 8% (0.2 Mt) are sent to landfill (EDDEC, 2018). The EDDEC Institute also reports on other private recovery initiatives such as ArcelorMittal and AIM Canada, which have declared using recycled metals, sometimes from their own waste material. Caterpillar is also recovering metals from its mechanical extraction equipment in order to reuse them (EDDEC, 2016). In 2018, foundries have recycled 833,000 tons of metal, from which 87% came from Quebec recycling facilities (Recyc-Québec, 2020).

Regarding other metals like **lithium or rare-earth elements**, **the recovery rate in Quebec falls under 1%**: one half is sent out of Quebec, and the other half is sent to landfill (EDDEC, 2018, pp. 17-18). However, some recycling projects have emerged in Quebec. A first example is the company Lithion who has developed an efficient technological process to recycle lithium-ion batteries found in electric vehicles[9]. This process enables 95 % of metal components to be recovered and purified in order to be re-used by manufacturers. The second example is GEOMEGA, a company that specializes in the recycling of rare-earth elements found in permanent magnets which are an essential part of electric vehicles and wind turbines[10]. GEOMEGA's ISR technology enables the recycling of four highly-valued chemical components: Neodymium, Praseodymium, Dysprosium and Terbium (GEOMEGA, 2019). These two examples show that industrial infrastructures are emerging in Quebec for rare-earth element recycling, but are not yet common practices. However, because the number of electric vehicles is increasing, the recycling of core chemical elements found in batteries can be expected to become a more significant issue.

According to the EDDEC, two promising but underdeveloped sectors for metal recycling in Quebec are "urban mining" and selective deconstruction of buildings and infrastructures. **Urban mining** is a recent activity consisting in recovering metals present in cities. It is still a research field that faces some operational difficulties and economic uncertainties, especially in regards to targeting potential sources of recycling material. **Deconstruction of buildings and infrastructures** consists in recovering the metal structure of the envelope or foundation. Though some construction companies are involved in these recovery practices, it is not a common practice due to the operational cost and difficulties.

Additionally, some companies are manufacturing building elements from recycled material such as plastic, glass and textile. Here, isolation is the most concerned element. Generally, insulation products are fossil-based; however, natural insulation is becoming increasingly more attractive. The production of recycled insulation requires less intensive energy and water consumption.

During the 2008-2018 period, the **sector of recycled plastics, like others materials,** has faced a severe crisis. Efforts to recover plastics have drastically increased the supply of recycled plastic materials which

[9] https://www.lithionrecycling.com/fr/
[10] https://ressourcesgeomega.ca/

vastly exceeded the demand for these products. Consequently, sorting centers could hardly find buyers in Quebec to recycle these materials, which resulted in an important volume of recovered plastic to be buried or sent outside Quebec (Léveillé, 2019). These events led some of the most dynamic plastic recycling facilities to close during 2010-2020 (e.g. Recyc RPM)[11]. Furthermore, there are no public regulations or incentives that help promote recycled products rather than new products; in other words, industrial and individual consumers still favor products made of new materials. For industries, it is often more profitable (Léveillé, 2019). As a result, recyclers in Quebec face strong difficulties to sell their recycled-plastic based products (Robillard, 2019).

If we focus on recovery and recycling rates, in 2018 and 2019, 55% of all recovered domestic wastes in sorting centers were sold to recyclers in Quebec, compared to 35% in 2015 (Léveillé, 2019). Concerning plastic products only, **66% of recovered plastics have been sent to Quebecois recyclers, which represent about 38,000 tons** (Recyc-Québec, 2020). In 2018, 21 plastic recyclers have been reported in Quebec (Recyc-Québec, 2020). The types of material concerned here are the most commonly used plastics for domestic and industrial purposes: PET, HDPE, PVC, LDPE, PP, PS and HMW. Finally, about 86% of total plastic recovered were from domestic wastes from cities and municipalities.

For fiber materials, mainly paper and cardboard, **642,000 tons of fibers** were sold by sorting centers in 2018, which represent the most recovered and recycled material in Quebec. About 48% (or 308,000 tons), have been processed in Quebec, and 52% abroad (Recyc-Québec, 2020). In Quebec, 36 companies are currently in activity in fibers recycling.

In addition, a new industrial sector is emerging in Quebec for plastic recycling: chemical recycling (Lebel, 2019). Three companies are leading this innovation in Quebec, and more broadly, in North America: Polystyvert[12], Pyrowave[13] and Loop industry[14]. The process consists in dissolving plastic products in chemical solutions in order to break long polymers chain and recover plastic monomers in order to form new polymers chain (depolymerization process). Globally, the companies claim high rate of plastic recovery (about 95% for some of them). According to Pyrowave, its technology consumes three times less energy than virgin material production. Furthermore, whereas mechanical process can't recycle plastic over a limited number of times, chemical technologies can recycle infinitely the plastic

[11] https://www.journaldemontreal.com/2014/10/06/les-metivier-mettent-recyc-rpm-en-faillite
[12] http://www.polystyvert.com/fr/
[13] https://www.pyrowave.com/fr/la-technologie-pyrowave
[14] https://www.loopindustries.com/en/

monomers. This new recycling activity qualifies with the PAI IV, since it enables interesting energy savings.

5. Comparison with the previous Project Document (PD)

The previous PD provided some examples on glass and plastic recycling which were not common practices in 2012.

6. Conclusion

To conclude, we can say that the recycling of rare metals is going to have more importance for metal criticality reasons (Bihouix & Guillebon, 2010)**.** But still, materials are not recovered, recycled and reused at their best potential in Quebec due to a lack of public regulations and economic incentives. We have seen that recovery and recycling of plastic and fibers wastes, despite cyclical market difficulties, is active in Quebec.

Consequently, we can say that **the following types of projects are not common practices in Quebec and should be admissible to WILL's Sustainable Community**:

- Recovery and recycling of lithium and rare-earth elements: this activity currently represents **less than 1% in Quebec**.
- Some exotic residual material such as an **aircraft alloy (Fer-Ti)**
- Urban mining: recycling materials present in cities infrastructures, old or in renovation - represents less than 1%.
- Recycling of plastics through chemical and thermal processes - less than 1% of plastic products are recycled through chemical process.

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Generic Project Activity Instance V

Heat Recovery

Table of Contents

1. Description of the generic PAI V

Every energy system or industrial process releases heat. This energy can be recovered and used for other purposes, such as producing electricity and heating buildings, which can help reduce the energy consumption of a system. According to a study from the Chair in Energy sector management of HEC Montréal, 54% of the total energy consumption in Quebec is wasted because of energy inefficiency (Whitmore & Pineau, 2020); a majority of the energy being lost through thermal discharge.

In this PAI, we assess every non-common practices that involve the recovery and reuse of thermal discharge to fulfill other energetic purposes.

The focus is on two sectors: ICI buildings (industrial, commercial and institutional) and the industrial sector, which is where the greatest heat recovery potential exists. For the industrial sector, heat can be recovered from a process. For ICI buildings, heat recovery technologies are used to pre-heat incoming air from outside.

2. Research methodology

Academic studies and scientific articles were reviewed in order to assess if heat recovery is a common practice in the industrial sector and ICI buildings.

3. Analysis of Governmental Regulations and Policies

For the ICI sector, the **Act respecting the conservation of energy in buildings** imposes the installation of a recovery system when the sensible heat in the exhaust air system is superior to 300 kW (LégisQuébec, 2020). In this case, the recovery system has to recover at least 40% of the total sensible heat. In the same way, every building with a cooling system has to recover the sensible heat that would be rejected to a condenser, if the heat that can be recovered exceeds 600 kW (LégisQuébec, 2020). However, the lack of regulations is the reason why, according to experts, heat recovery is not widely adopted by entrepreneurs (Garon, 2020).

4. Results

According to a study from HEC Montréal, 1,116 PJ (54%) are lost through the transformation and the consumption of energy in Quebec (Whitmore & Pineau, 2020). Energy waste mainly consists in thermal discharge. The table below details the amount of energy wasted for the principal sectors, as presented in the HEC's study:

	Energy wastes (PJ)	Energy waste (%)
Building (commercial, institutional)	60	30 %
Industries	211	34 %
Transportation (vehicles and goods)	391	77 %

This shows that energy saving through heat recovery is not widely use in Quebec, and largely inefficient. The next table shows the various energy sources by sector:

	Coal	Natural gas	Electricity	Biofuel	Liquefied natural gas	Oil
Building (commercial, institutional)	0%	38%	42 %	1%	4%	15 %
Industries	3 %	24 %	50 %	15%	0.3%	8 %
Transportation (vehicles and goods)	0%	1%	0,3%	2%	0.1%	97%

In the above table, we can see that fossil fuels are significantly present in the building and industrial sectors. Consequently, an important volume of GHG reductions can be made by implementing heat recovery systems, especially if they reduce natural gas and oil demand and consumption.

Very little data is available to estimate the amount of heat recovery projects installed in Quebec. Stephan Gagnon, scientific expert of the public program Transition Énergétique Québec[15], underlines the fact that heat recovery technologies are still under-implemented in Quebec's buildings[16]. Below are listed several projects that are globally recommended by official energy efficiency programs or green building certifications for both buildings and industrial sectors:

- Water heat exchanger pre-heating the incoming water by outcoming water.
- Air heat exchanger: pre-heating incoming air from hot outcoming air.
- Heat accumulator: store heat for subsequent uses (recommended for IT centers)[17].
- Heat pump and mechanical vapor compressor.
- High induction pipes[18].
- Heat wheels.
- Urban heating network.

However, these technologies are commonly implemented for new or retrofitted ICI buildings seeking green certification (commercial, industrial, office, library, university, hospital). In order to achieve green certification, energy efficiency and heat recovery are essential considerations for many certification scoring systems. In Quebec, 848 buildings have been certified LEED where energy optimization is necessary (Canada Green Building, 2018). Furthermore, these technologies are now broadly integrated in new conceptions since energy efficiency is an important element of contemporary constructions. Heat recovery technologies, like air heat exchangers or heat pumps, are modern, cost-effective and sometimes imposed for new commercial, offices or industrial buildings.

Moreover, other specific heat recovery projects have emerged in Quebec such as **urban heating networks** (Garon, 2020). The few heating networks currently operating in Quebec produce their heat from fossil fuels. According to Stéphane Gagnon, recovering the heat from industrial plants could be a

[15] https://transitionenergetique.gouv.qc.ca/a-propos
[16] https://transitionenergetique.gouv.qc.ca/en/nouvelles/actualites/detail/blogue-dexpert-la-recuperation-de-chaleur-sur-les-equipements-de-refroidissement
[17] https://www.rncan.gc.ca/energie/publications/efficacite/industrie/peeic/6012
[18] https://energiemc2.com/services/recuperation-de-chaleur/

solution to supply such heating networks in replacement to fossil fuels, and lead to GHG emission reductions (Garon, 2020). These GHG reduction projects could be admissible to WILL's Community.

Several companies are currently offering heat recovery solutions for industrial processes and transportation[19]. Almost 70 companies are currently leading technical innovation on energy efficiency in Quebec for these two sectors[20]. However, considering the energy efficiency of industries, we can say that optimization through heat recovery is not generally adopted by industrial plants. The cost and the yield of such investments are not always profitable. Since fossil fuel prices are still low, energy efficiency is not a priority for industries, even more when it implies important re-organization and renovation.

5. Comparison with the previous Project Document (PD)

The previous PD focused on CO_2 heat recovery systems in arenas. New systems are based on CO_2 refrigeration systems with heat recovery, allowing an increase of 30-40% in energy efficiency. Between 1960 and 1970, 318 arenas (75%) were built using old refrigeration systems that operated with R717 refrigerant or R22 refrigerants, a gas now banned following the recommendations of the Montreal Protocol (RCAN, 2013). However, since 2008, 80% of arenas have implemented mechanical systems to improve energy efficiency: most of them can recover the same amount of energy the system is able to supply (RCAN, 2013, p. 18). Heat recovery is usually a common project to reach such goals.

6. Conclusion

We conclude that heat recovery projects from both industrial processes and urban heating networks **are not a common practice in Quebec.** Therefore, these types of projects are admissible to WILL's Sustainable Community since they can result in significant GHG reductions. Moreover, since buildings, industrial and transportation sectors are still largely fossil-fuel dependent and energy inefficient, there is a great potential for eligible GHG reductions from to the expansion of heat recovery projects.

[19] https://www.economie.gouv.qc.ca/fr/bibliotheques/secteurs/environnement/apercu-de-lindustrie-de-lenvironnement/efficacite-energetique/
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Generic Project Activity Instance VII

Energy Efficiency - Buildings

Table of Contents

1. Description of the generic PAI VII

The PAI VII is related to all projects involving reduction in energy demand and consumption in new and existing ICI buildings (institutional, commercial and industrial). The energy demand consists of the energetic needs like heating, cooling, appliances, industrial processes and other technological devices.

The table below resumes the main projects admissible to this PAI. They correspond to the type of projects that public programs and green building certifications usually identify as energy efficiency.

Industrial buildings	• High efficiency processes • Energy efficient equipment • Optimization measures
Commercial and Institutional buildings	• Mechanical system efficiency (HVAC) • High efficiency appliances and lighting (fridge, microwave, heaters, etc.) • Smart energy tools (softwares, sensors) • Insulation materials (windows, doors, walls) • Optimization measures

In the 3rd cohort of WILL's Sustainable Community, 19 projects have been identified with this PAI, which represents around 2% of total projects.

Two typical examples in our Sustainable Community illustrate the type of project under PAI VII. The first one is the **printing company Marquis**. In 2013, the company implemented two new **cold drying processes** that helped reduce significantly the consumption of natural gas (225 tCO_2 in 2016). The second one is **Honda's building** in Sainte-Agathe who implemented energy efficiency measures to reduce its heating energy consumption in 2016.

2. Research methodology

Because of the very little data available, an overall estimation of the implementation of energy efficiency measures in Quebec remains difficult. However, an analysis on green buildings from **Clean Energy Canada**, using key indicators like GDP, growth and investments for the entire country provides precious information on the dynamism of the sector through aggregated data, with respect to the entire clean energy sector. We have also reviewed studies and reports from institutional organization in Quebec like **HEC Montreal** and **Transition Énergétique Québec (TEQ) and Dunsky Energy Consulting Office**. These data should help us determine more accurately if this PAI is a common practice or not.

3. Analysis of government policies, regulations and laws

Currently, there are no provincial, federal or municipal regulations or laws requiring energy conversion (switch fuel) from fossil fuels to biomass in existing buildings. If these projects occur, they are voluntary initiatives.

However, two main regulations are currently framing energy efficiency projects for new construction or renovation in Quebec: **The National Energy Code of Canada for Buildings** (NECB) (Government of Canada, 2015) and **the Building Code of Québec (BCQ)**, which is an adaptation of NECB with some specificities of Quebec. The Building Code of Quebec is part of the **Building Act** (LégisQuébec, 2020), who has force of law (Gouvernement du Québec, 2020).

The NECB and the BCQ provide laws, standards and measures that have to be respected by all entrepreneurs. They focus on five building elements**: building envelope, lighting, HVAC systems (heating, ventilating and air conditioning), water heating and electrical power systems and motors** (Government of Canada, 2015)**.** For instance, they set minimal threshold for thermal resistance (window, door, wall), indicate the best material specifications for isolation and air tightness, give construction measures for low energy load, efficient equipment, etc. They also encourage acting beyond these recommendations. Apart from these codes some acts have been added for specific purposes such as the **Chapter N-1.01** of the law act *"Act respecting energy efficiency and energy conservation standards for certain electrical or hydrocarbon-fueled appliances"* (LégisQuébec, 2020). This act makes it mandatory for all electrical equipment to be compliant to energy efficiency standards and verified by official certifications.

An act has been recently added to Quebec's Building Code **specifically for ICI** building's energy efficiency: **Chapter I.1- Energy efficiency for buildings** (Régie du Bâtiment, 2020). It came into effect on June 27, 2020 and applies to every new construction with a **floor area exceeding 600 m^2**, or **more than three floors high** (Régie du Bâtiment, 2020). After December 27, 2021, new buildings will have to be compliant to all its requirements. The Government of Quebec forecasts that the requirements of this law act will improve by 27.9% the energy efficiency of ICI Buildings (Régie du Bâtiment, 2020). Similarly to other energy efficiency acts, it provides measures, technics, material, minimal threshold (e.g. thermal resistance), calculation, formula, etc. (Gazette officielle du Québec, 2020).

In terms of policy, the government of Quebec has created a **Master Plan for 2030** in order to transform the real estate of Quebec in a more ecological way. Transition énergétique Québec (TEQ) has set important guidelines for 2030 (Transition Énergétique Québec, 2016):

- Implement energy efficiency measures for 5% of the total public buildings area.
- Reduce by 15% the energy consumption for public buildings.
- Increase the use of renewable energy
- Upgrade the efficiency of appliances, mechanical equipment and technologies.
- Support innovation and private initiatives through public subsidies.

Though the **goals included in the Master Plan are only general recommendations** and do not have the force of law of previously mentioned acts and codes, their framing of regulation strategies and future measures are similar to the Chapter I.1.

4. Results

Clean energy Canada has estimated for 2017, the Canadian GDP and the investments level in all clean energy projects such as renewable energy production, buildings and transportation. For clean buildings, **including new buildings and retrofits/recommissioning**, the results are resumed in the following table:

	Canadian GDP (2017)		Canadian investments (2017)	
HVAC	$366 million	12 %	$1.4 billions	12 %
Energy-saving building materials (without isolation)	$150 million	5 %	-	-
High Efficiency appliances and lighting	$160 million	6 %	$5.1 billion	43 %
Architecture	$2.2 billion	76 %	$5.3 billion	45%
Total	**$2.9 billion**	**100 %**	**$11.8 billion**	**100%**

Focusing on investments, we can see that $11.8 billion was spent in 2017 for clean building projects, which account for **21% of the total clean energy investment in Canada ($35 billion)**. It is the most important annual investment compared to other categories such as grid infrastructure, transport and renewable energy. Thus, between 2010 and 2017, the average annual investment soared at $9.1 billion (Navius Research, 2019).

Only considering HVAC, energy-saving buildings and high efficiency appliances altogether, we can see that they represent 23% of green building GDP (US$ 0.6 billion), and 55 % of total investment in 2017 (US$ 6.5 billion). Moreover, between 2010 and 2017, energy demand projects had an annual growth rate of 8.7% (Navius Research, 2019). This shows that energy efficiency in buildings is an increasingly important economic sector in the clean energy economy.

In Quebec, in 2019, **848 projects** received a **LEED certification** among the 4,000 buildings certified in Canada, and **1,643 registrations** were reported (Canada Green Building Council, 2019). According to TEQ, new public buildings are constructed with respect to official energy efficiency measures, while existing buildings are getting retrofitted for energetic purposes.

However, according to the last report of HEC Montreal regarding Quebec's energy system, **commercial and institutional buildings** (CI) and the **industrial sector** represented, in 2017, **11 % of the total energy consumption** (Whitmore & Pineau, 2020).

Within the commercial and institutional building category, **office buildings** including educational, health and administrative spaces represent 50% of the CI's total floor area (78 million m^2 with respect to 143.7 million m^2). This corresponds to **2/3 of the total energetic consumption of the sector** (Whitmore & Pineau, 2020). Electricity (47%) and natural gas (43%) are the main energy sources, with 5% of propane and coal consumption. The most important needs are heating (53%), secondary equipment (17%) and lighting (14%). Therefore, the study reports also that, since 1990, the energy intensity (energy consumption vs floor area in GJ/m^2) of CI buildings declined by 2.8% because of the expansion of the total floor area. Consequently, **the energy intensity gains are not due to energy efficiency measures.**

Moreover, the majority of these buildings are quite old: for example, the median age is 27.1 for health institutions, with 78.5% of them aged between 10 and 50 years old (92 buildings between 25 - 50 years and 73 between 10 – 25 years)[21]. This means that energy efficiency is an issue for most of them.

Thus, the Master Plan for efficient buildings of *Transition Énergétique Québec* (see section 3) expects the implementation of energy efficiency measures for 5% of public building's total floor area, and improve by 15% the energy efficiency (Efficiency Canada, 2019). We can conclude that, in 2020, **less than 5% of the total public buildings floor area can be called energy efficient**.

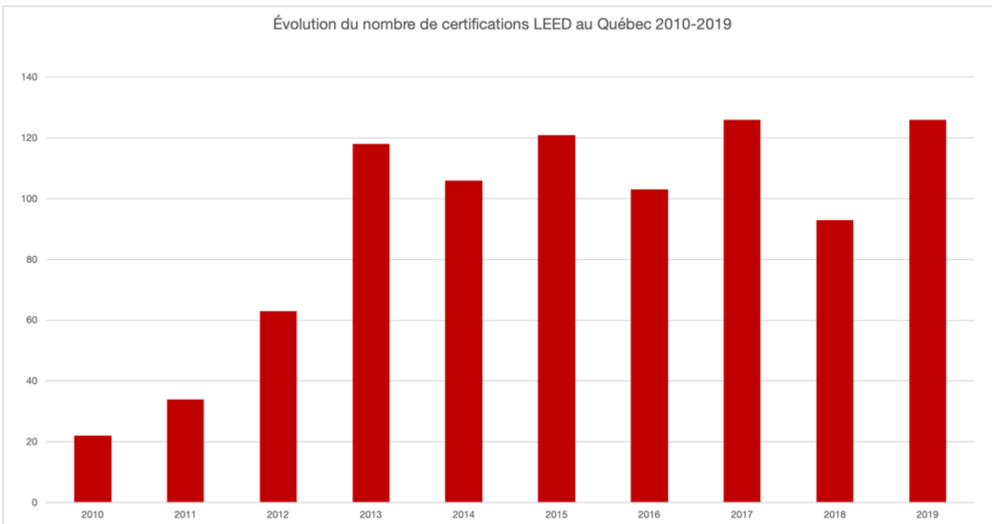
Concerning the industrial sector, it is responsible for **35 % of total energy consumption** and 25 % of the total emissions in Quebec (Whitmore & Pineau, 2020). Since 1990, emission reductions of this sector are essentially due to the efforts of pulp and paper industries and the closure of big industrial sites. The emission intensity (CO_2 emissions vs energy consumption) has slowly decreased by 4% since 1990. Furthermore, the energy losses are still very important in this sector: 57% of the total energy consumption is lost through industrial processes (Whitmore & Pineau, 2020).

To resume, the data shows that ICI buildings remain a significant source of CO_2 emissions and energy consumption in Quebec in 2020. Huge efforts need to be taken to improve its energy efficiency.

[21] https://www.rncan.gc.ca/energie/publications/efficacite/batiments/5986

5. Comparison with the previous Project Document (PD)

The previous PD only focused on LEED certification registered in CaGBC. It reported 268 LEED registrations during 2007-2012. 580 new projects have been certified for 2012-2020. Even if it is a promising evolution, it is still quite slow considering the energy efficiency needs to achieve energy efficiency objectives. The graph below illustrates the evolution of LEED certifications in Quebec for the period of 2010-2019:



6. Conclusion

Renewed codes, new standards, public subsidies, regulations and plans might certainly increase green building projects in Quebec, improving energy demand side efficiency and conservation. High level of public and private investments, high annual growth rate (9%), increasing green certifications, and strong regulatory framework might show the growing dynamism of this sector.

However, for now, considering the data available on this sector**, we conclude that this PAI is not yet a common practice in Canada in general, and in Quebec particularly,** since most of the buildings still don't respect green building standards**.** For the industrial sector, we can see no real progress in energy efficiency processes since 1990. **We can presume that energy efficiency measures concern 0% to 5% of ICI buildings in Québec**.

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Generic Project Activity Instance VIII

Energy Conversion

Table of Contents

1. Description of the generic PAI VIII

The PAI VIII refers to energy conversion projects. Energy conversion covers activities that consist in switching fossil fuels for the same energy need, to a cleaner form of energy that emits less greenhouse gas emissions. For example, a SME, a municipality or a service institution that eliminates an oil furnace by converting its heating system to a renewable energy source such as hydroelectricity, geothermal, wind, solar, etc., may be eligible for this type of conversion. This may also involve replacing fuel oil with propane or natural gas.

2. Looking back on PAI VIII in previous cohorts

The third cohort of Sustainable Community project in Quebec (*VCS id project # 929*) counted 130 energy conversion projects covering 8 of 17 administrative regions of Quebec. Of this total, two of 8 administrative regions were characterized by their large number of projects, with approximately 3/4 of the projects as shown in the table below. The Bas-Saint-Laurent represents nearly 48.5% of the total PAI VIII and the Laurentides 26%. In the first two cohorts, the number of generic PAI VIII was estimated at 2 PAIs for the first cohort and 4 PAIs for the second cohort.

		PAI VIII
	Quebec Administrative Region	**Energy Conversion**
1	Abitibi-Témiscamingue (région 08)	**4**
2	Bas-Saint-Laurent (région 01)	**63**
3	Chaudière-Appalaches (région 12)	**7**
4	Lanaudière (région 14)	**10**
5	Laurentides (région 15)	**34**
6	Mauricie (région 04)	**1**
7	Outaouais (région 07)	**5**
8	Saguenay–Lac-Saint-Jean (région 02)	**6**
	Total	**130**

Most energy conversion projects relate to the energy conversion from fossil fuels (propane and fuel oil) to the use of electricity or geothermal energy.

3. Research methodology

For this research, we reviewed several reports from research chairs and associations as well as government and para-governmental documents, such as *Hydro-Québec* and *Transition Énergétique* Québec 2018 and 2019.

4. Analysis of government policies, regulations and laws

There are currently no provincial, federal or municipal regulations or legislation requiring energy conversion (fuel switching) of any fossil fuel to green energy (electricity, geothermal, solar, etc.).

However, various measures taken by the Quebec government in recent years have been gradually influencing the way companies do business and their consumption habits, notably through the 2030 energy policy and Transition Énergétique Québec (TEQ).

In fact, in 2016, the Quebec government published the document Politique énergétique 2030. Some of its objectives are to increase renewable energy production by 25% and to reduce the quantity of petroleum products consumed by 40%. In line with this objective of reducing the use of petroleum products, the Government of Quebec established the TEQ organization in April 2017 to pursue related initiatives. The two main targets of the TEQ 2018-2023 Master Plan are: to annually improve Quebec society's average energy efficiency by 1%, and to reduce the total consumption of petroleum products by at least 5% compared to 2013.

Under the energy conversion programs of TEQ's Master Plan, measures to assist industries, small and medium-sized enterprises as well as municipalities have been planned through the following actions:

- Implementing energy conservation and conversion projects through the EcoPerformance program. This program is in effect until 31 December 2020 and includes energy efficiency and conversion projects, as well as process improvement projects. It is financed by the *Fonds vert* and is designed to encourage the conversion of corporate and industrial energy systems to low-carbon energy sources, with an emphasis on energy efficiency and conversion to cleaner energy projects and on the reduction of fugitive emissions. Eligible companies are those operating in the industrial, commercial and institutional (ICI) sector, and includes both small and large energy users;
- Implementing conversion and energy efficiency subsidy programs designed for small commercial and institutional (CI) building customers through the « Chauffez vert CII[22]» program. This program offers financial support for the replacement of light oil and propane heating with an efficient and less polluting system (electricity or other renewable energy).

However, it is interesting to note that these incentive programs for the use of renewable energy (electricity, geothermal and biomass) exclude solar energy. There are currently no incentive programs for solar energy use.

[22] https://transitionenergetique.gouv.qc.ca/affaires/programmes/chauffez-vert-cii

The fact remains that energy policy, like any policy, and all measures taken to accompany energy conversion do not carry constraints such as laws or regulations. Therefore, the conversion of companies' fossil fuel systems to energy sources that emit less GHGs is a voluntary initiative.

5. Results

5.1. Quebec's renewable energy potential (electricity, wind, geothermal, and solar)

In 2019, the province of Quebec generated 214 terawatt hours (TWh) of electricity; of which 95% came from hydroelectricity; 4.7% from wind power; and 1% from biomass, solar power and diesel, of which 0.5% was industrial biomass, 0.2% other biomass, 0.2% diesel and 0.001% solar power. Quebec is Canada's largest electricity producer and has the largest power plants in the country with a generating capacity of 46,176 megawatts (MW). Its installed hydroelectric capacity is 40,853 MW.

For wind power, the second largest source of electricity in Quebec, its generating capacity in 2018 was 4,096 MW, representing 4% of the province's generating capacity. Hydro-Québec's current total installed capacity is approximately 40,000 MW (AQPER[23], n.d.). Since the construction of the first farm in 1998, the province has increased the share of wind in its renewable electricity generation through a series of calls for tenders, with current capacity reaching approximately 3,878.9 MW out of a target of 4,000 MW. Estimates of uncaptured energy potential for the province in 2005 ranged from 3,600 MW to 100,000 MW. Excluding the proximity of power lines, the potential quadruples to 400,000 MW, which is Quebec's gross wind energy potential; a potential that may never be reached without new investments in transmission infrastructures.

Concerning geothermal energy, a green energy that is not yet widely used in Quebec by both companies and individuals, Quebec has limited geothermal resources. Although Hydro-Québec provides information to customers on the installation of geothermal heating and cooling systems, no power generation facilities currently exist or are planned. A deep geothermal potential has been studied in the south-eastern part of the province, with a water temperature of about 150°C, theoretically allowing the production of electricity estimated at 2-5 MW per installation. However, there are no statistics available for geothermal systems in ICI buildings in terms of potential, production and consumption.

[23] Association Québécoise de la Production d'Énergie Renouvelable

As for solar energy, the daily average insolation in Quebec's most inhabited part of the province is between 4.2 and 5 kWh/m^2 over a year, the average insolation varying from 1,000 kWh/m^2 to 1,350 kWh/m^2. Large-scale generation, connected to the Hydro-Québec transmission system, is gradually being introduced in Quebec. However, solar systems are proving to be less profitable in Quebec, especially residential solar systems, due to the low price of electricity.

5.2. Quebec's energy profile from 2012 to 2017

The Quebec Energy Policy 2030 document points out that in 2013, hydrocarbons accounted for more than half of Quebec's energy supply, approximately **56%**, while 44% was renewable energy. These are nearly **40% petroleum products**, 14.9% natural gas and 0.7% coal, as well as 37.3% hydroelectricity and 7.4% bioenergy. During the same year, the two sectors that consumed the most energy were transportation and industry, with 29% and 37% respectively.

In 2012, the industrial sector consumed 48% electricity, 22% natural gas and **15% petroleum products** (diesel, kerosene, light fuel oil, heavy fuel oil, etc.). The CI sector consumed 63% electricity, 32% natural gas, **2.2% petroleum products** and 2% coal and propane (see Table 1 in the Appendix). Also in 2012, the industrial sector outside Montreal consumed 65.1% natural gas, **8.5% light fuel oil**, **3.8% heavy fuel oil** and 3.2% propane. The CI sector outside Montréal consumed 64.2% natural gas, **24.8% light fuel oil**, **5.9% heavy fuel oil** and 3.8% propane.

In 2017, Quebec's energy demand was 1,770 Petajoules (PJ), of which 39% was for the industrial sector, 30% for transportation, 20% for the residential sector and 10% for the commercial sector. **Refined petroleum products were the main fuel used** in Quebec with **710 PJ (40%)**, followed by electricity 627 PJ (35%) and natural gas 252 PJ (14%). Thus, **56%** of the Quebec's energy consumed in 2017 came from hydrocarbons (40% petroleum products, 14% natural gas, 1% liquid natural gas and 1% coal) and 44% from renewable energy (36% electricity and 8% bioenergy). In terms of electricity consumption, the industrial sector was the largest consumer with 84.1 TWh, followed by the residential sector with 66.6 TWh and the commercial sector with 23 TWh. Transportation and industry remain the two largest energy consumers (30% for the transportation sector, 33% for the industrial sector and 2% for the agricultural sector). In 2017, the industrial sector consumed 48% electricity, 23% natural gas, and **13% petroleum products** (diesel, kerosene, light fuel oil, heavy fuel oil, etc.). The CI sector consumed 47% electricity, 43% natural gas, 5.2% petroleum products and 4% coal and propane (see Table 1 in the Appendix).

These statistics show that, generally, the situation has not changed significantly since 2013. However, Whitmore and Pineau's (2020) conclusion in the State of Energy in Quebec 2020 indicates that, there is a 10% increase in petroleum product consumption from 2013 to 2018. And even though the energy consumption of all ICIs, including the agriculture sector, appears to have decreased since 2012, they represent 51% in 2012 and 46% in 2017 of total energy consumption (see Table 2). In fact, from 2012 to 2017, as shown in Tables 3 and 4 in the Appendix, hydroelectricity accounts for about one-third of the energy consumed in Quebec, varying from 38% in 2012, 35% in 2013 and 36% in 2017 (see Table 4 in the Appendix). While petroleum products, always as the main source, constitute nearly 40% of the energy profile, varying from 37% in 2012 to 40% in 2013, and 40% in 2017. These two types of energy are followed by natural gas, varying between 13% and 16%, with the industrial sector proving to be a major consumer of natural gas in both 2013 and 2017.

If we consider natural gas as a fossil fuel, even though it is a low CO_2 emitter compared to other hydrocarbons, it appears that **more than half of Quebec's energy consumption is of fossil origin**. Thus, according to Table 4, refined petroleum products and natural gas accounted for 50% of energy consumption in 2012, 54% in 2013, and 54% in 2017; this consumption remained constant from 2013 to 2017. Finally, bioenergy constituted 10% in 2012 and 8% in 2013, remaining stable at 8% until 2017.

Quebec's dependence on hydrocarbons is still visible through energy consumption in several sectors of the economy, particularly in two sectors, industry and transportation, which will account for 35% and 30% respectively of the total energy share in 2017; see Tables 1 and 4 for more details. A study conducted by IISD[24] in 2018 concluded that the Quebec government continued to provide an average of $300 million annually to various hydrocarbon consumers, including companies, through the reduction of fuel tax. IISD (2018) considers that this reduction in tax, while being an incentive for hydrocarbon consumption, slows down the process and potential investment of conversion to renewable energy in these economic sectors.

5.3. Estimated number of energy conversion projects completed

First of all, it is important to mention that energy efficiency projects could not be dissociated from energy conversion projects because the collected data combine energy efficiency and energy conversion information. Therefore, we will consider the number of companies in energy conversion as the potential

[24] International Institute for Sustainable Development

number of companies that have opted for energy efficiency and conversion based on information from TEQ, Hydro-Québec and Gaz Métro-Énergir.

On the one hand, TEQ (2019b) and Gril (2019) reveal that since the creation of TEQ, **1,007 participants** have benefited from the EcoPerformance program, which includes energy efficiency and conversion projects as well as fugitive emission reduction and process improvement projects (**Cumulative results 2013-2018**).

On the other hand, TEQ (2018b) estimates that between 2014 and 2018, **3,500 companies** adopted energy management measures and that this number will tend to increase in the coming years, and could reach 7,000 companies in the middle of the next decade. Although the data is incomplete, the three managers of energy efficiency and transition programs, TEQ, Hydro-Québec and Gaz Métro-Énergir, recorded **3,982 interventions** by companies and institutions in 2016, including small and very large projects.

These same sources of information emphasize that it is more difficult for SMEs to engage in energy efficiency and conversion projects and to apply for funds, including the grant, due to the complexity of project development. On the other hand, business leaders have a poor understanding and perception of the strategic value of these projects. In this regard, TEQ (2018b), in its final report on the Industrial Workshop, indicate that only a small minority of Quebec companies carry out energy efficiency or conversion to cleaner energy sources projects. Only 15% of companies use Quebec government programs. The majority of the demand, estimated at approximately **3,000** companies and institutions for 2016, would be financed by internal resources (for 85% of companies) and 35% by banking-type private financing.

In addition, although not part of the ICI sector, 25 geothermal projects were in place in 2016 in the Greater Montreal area and 3 solar energy projects between 2013 and 2016. The source indicates that the number of projects could be higher, but not exponentially, and concludes that geothermal energy seems to be little exploited in the agglomeration's territory and solar energy is even less exploited. This shows the extent to which these renewable energies, apart from hydroelectricity, are not yet the prerogative of everyone. Thus, given the small proportion of the population and the ICIs that carry out these conversion projects, it can be said that this is not a common practice.

Furthermore, a market study by TEQ (2018 b), based on studies by the *Institut de la statistique du Québec* (ISQ) dating from 2015 and 2016, shows that all advanced technologies adopted by Quebec companies, namely green technologies, including energy management technologies, have the lowest adoption rate. Only **6.0%** on average of companies with 10 or more employees adopted advanced green technologies between 2012 and 2014, while the provincial average for all technologies combined is 64.2%. During the same period, **1.1%** of Quebec companies adopted a green advanced technology known as energy management technology. TEQ (2018b) estimates that approximately **3,500** companies have adopted energy management values, of which 2,241 companies and institutions through Gaz Métro-Énergir's programs and 1,275 companies and institutions through Hydro-Québec's programs.

These low statistics can be explained by the fact that the majority of Quebec companies are still reluctant to significantly change their business practices, and even less inclined to invest in this direction. Five industries show a significantly high rate of adoption of advanced energy management technologies : petroleum and coal products manufacturing (10.7%), primary metal manufacturing (7.4%), transportation equipment manufacturing (7.1%), and public services (5.3%). It is clear that SMEs are not included. Moreover, Quebec would be looking for a strategy to attract fossil fuel consumer conversions and increase corporate demand for renewable energy.

6. Common practice analysis on generic PAI VIII

Based on collected data, WILL Solutions estimates that there are 320,000 ICI companies in Quebec. For an average of 2 buildings per company, there are approximately 640,000 buildings with heating, lighting, air conditioning and even process needs. And, TEQ's estimation model tends to identify approximately 3,982 interventions[25] for nearly 3,000 companies, which, with a favourable environment, could triple in five years. Thus, multiplying 3,000 businesses in 2016 by 3 for 2021 gives **9,000 businesses**. So, even if we consider 2021 instead of 2020 as the year of the estimate, the fact remains that it is a minority of Quebec companies that carry out energy efficiency or conversion to cleaner energy sources projects. If we consider that 9,000 out of 320,000 companies (i. e. 2.81%) carry out energy efficiency and conversion projects by 2021, this remains an uncommon practice, since this percentage is well below 40%.

In addition, several observations supporting our conclusion of non-common practice were identified through the literature, including the following:

[25] The number of interventions includes many small projects and very large investments.

- The federal and provincial governments continue to provide permits for oil and gas transportation, exploration and development projects, such as the Saguenay natural gas project. These projects perpetuate a culture of dependence on hydrocarbons;
- The Quebec Government provides subsidies for hydrocarbon consumption and continues to subsidize the expansion of the gas network. To this end, nearly $27 million has been granted, over the three fiscal years 2015-2018, to at least thirteen initiatives that use hydrocarbons as an energy source. Since 2011, the Quebec government has spent approximately $1.7 billion to support fossil fuels through various programs offering a reduction, exemption or reimbursement of the fuel tax;
- The number of subsidized energy conversion projects is low compared to the number of companies in Quebec in the ICI sector. Energy conversion costs for SMEs tend to be higher and this would be a barrier to the implementation of such projects;
- According to Whitmore and Pineau (2016), the majority of Quebec firms, with the exception of large energy consumers, do not assign a high priority to energy in their decision-making process. Their planning is more often operational than strategic, because they do not consider that energy expenses are high enough in their cost structure to justify investments.

7. Conclusion

Energy conversion from fossil fuel systems to renewable energy in ICIs is not a common practice considering that about 9,000 out of 320,000 companies (i.e. 2.81%), will have implemented energy conversion projects by 2021 for the period 2016-2021.

Moreover, data presented in official balances are often aggregated and not very detailed. This can limit the perception of reality, because a very large number of companies have not yet undertaken energy conversion projects.

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9. Appendices

Table 1: Quebec energy consumption for ICI sectors from 2012 to 2017 (%)

	2011	2012	2013	2014	2016	2017
Industrial sector						
Electricity	51	48	46	45*	48*	48*
Naturel Gas	21	22	20	20*	23*	23*
Propane	/	/	/	/	/	/
Petroleum products (diesel, kerosene, light fuel oil, heavy fuel oil, etc.)	13	15	14	17	14*	13*
Biomass/biofuels	**12**	**12**	**10**	**11***	**12***	**11***
Coal	3	4	2	1	1	1
Others	/	1	1	0.5	0.4	1
Undefined sources	/	/	7	/	/	/
Petroleum products and/or coal	/	/	/	6	3	4
Total of Industrial Sector* **	**100**	**100**	**100**	**100**	**100**	**100**
Commercial and institutional sector						
Electricity	57	63	51	49	47	47
Naturel Gas	37	32	41	42	45	43
Coal and Propane	/	2	3	3	4	4
Propane	2	/	/	/	/	/
Petroleum products (diesel, kerosene, light fuel oil, heavy fuel oil, etc.)	3.4	2.2	5	6.3	3.2	5.2
Biomass/biofuels	**/**	**/**	**/**	**/**	**/**	**/**
Total of Commercial and institutional sector* **	**100**	**100**	**100**	**100**	**100**	**100**
*Including the agricultural industry						

Source : State of energy in Quebec from 2015 to 2020 (Whitmore and Pineau, 2015, 2016, 2017, 2018, 2019, 2020)

Table 2: Energy consumption by sector in Quebec from 2012 to 2017 (%)

	2012	2013	2014	2015	2016	2017
Industrial sector	33	34	35	34	34	33
Agriculture	2	2	2	2	2	2
Commercial and institutional sector	16	11	11	12	11	11
Residential sector	18	19	19	19	19	19
Transport	32	29	28	29	30	30
Non-energetic use	/	5	5	4	4	5
Total of Energy Consumption* **	**100**	**100**	**100**	**100**	**100**	**100**
Industrial sector+ Agriculture	35	36	37	36	36	35
ICI Sectors + Agriculture	51	47	48	48	47	46

Source : State of energy in Quebec from 2015 to 2020 (Whitmore and Pineau, 2015, 2016, 2017, 2018, 2019, 2020)

*** Some amounts are equal to 100% ± 1 due to data aggregation.

Tableau 3: Distribution of primary energy sources in Quebec from 2012 to 2017 (in PJ)

	2012	2013	2014	2015	2016	2017
Imports						
Petroleum	839 (40 %)	772 (36 %)	837 (38 %)	848 (37 %)	826 (36 %)	815 (35 %)
Natural Gas	296 (14 %)	317 (15 %)	311 (14 %)	338 (15 %)	325 (14 %)	323 (14 %)
Coal	23 (1%)	20 (1%)	17 (1%)	12 (<1%)	13 (<1%)	19 (0.8%)
Uranium*	55 (3%)	/	/	/	/	/
Hydro**	/	/	/	/	/	95 (4%)
Electricity (Variable Sources)	/	/	/	/	/	3 (0.1%)
Total Hydrocarbon Energy	**58%**	**52%**	**53%**	**53%**	**51%**	**53%**
Local Productions						
Hydroelectricity	691 (33 %)	814 (38 %)	793 (36 %)	789 (35 %)	818 (36 %)	801 (34 %)
Biomass	168 (8%)	178 (8%)	156 (7%)	162 (7%)	170 (7.5)	163 (7%)
Wind Power	23 (1 %)	68 (3 %)	97 (4 %)	124 (5 %)	126 (6 %)	140 (6 %)
Renewable natural gas	/	/	/	/	/	3 (0.1%)
Total Renewable Energy	**42%**	**49%**	**47%**	**47%**	**49%**	**47%**
Total Energy* **	**2,095 (100%)**	**2,169 (100%)**	**2,211 (100%)**	**2,273 (100%)**	**2,278 (100%)**	**2,362 (100%)**

* Quebec no longer imports uranium since the Gentilly-2 nuclear power plant stopped producing electricity in Dec. 2012.

** This electricity import corresponds to the purchase of electricity generated by the Churchill Falls hydroelectric plant located in Newfoundland and Labrador.

Source : State of energy in Quebec from 2015 to 2020 (Whitmore and Pineau, 2015, 2016, 2017, 2018, 2019, 2020)

Tableau 4: Consumption by different types of energy in Quebec from 2012 to 2017 (%)

	2012	2013	2014	2015	2016	2017
Refined Petroleum Products	37	40	39	39	40	40
Natural Gas	13	14	15	16	15	14
Liquid Natural Gas	/	1	1	1	1	1
Coal	1	1	1	1	1	1
Electricity	38	35	36	36	36	36
Biofuels	10	8	7	8	8	8
Total of Energy Consumption	**100**	**100**	**100**	**100**	**100**	**100**

Source : State of energy in Quebec from 2015 to 2020 (Whitmore and Pineau, 2015, 2016, 2017, 2018, 2019, 2020)

*** Some amounts are equal to 100% ± 1 due

Generic Project Activity Instance IX

Energy Conservation

Table of Contents

1. Description of the generic PAI IX

This generic PAI consists in projects that **recover and reuse hydrocarbon products**, such as waste oil for mechanical equipment, motor lubricants, antifreeze, and fossil fuels in order to avoid their disposal. This also includes the filters and containers of these liquids. We also include **all projects that replace Natural Gas (NG) fuel by Renewable Natural Gas (RNG)** that result in a significant reduction of GHG emissions. In the second part of this analysis, we try to assess RNG emissions calculation compared to NG projects through a life cycle assessment of RNG production, and landfill avoidance.

In the 3rd cohort of WILL's Sustainable Community, 17 projects were quantified under this PAI, representing 2% of all PAI's projects.

2. Part I: Recovery and reuse of hydrocarbon products

2.1 Research methodology

This study aims to understand the recycling process of hydrocarbon products, from the client deposit to the recycling facilities. The methodology is based on the analysis of public regulations, companies' actions, and public/private partnerships, in order to define how both public and private sectors interact to manage the recycling of hydrocarbon products.

2.2 Analysis of government policies, regulations and laws

Since 2011, the recycling of hydrocarbon products **is highly regulated and planned** as a result of public laws and strong public/private partnerships (Recyc-Québec, 2019). Current legislations are generally based on the **principle of "extended responsibility of producers"**, which aims to go beyond the sale and service of specific products that involve environmental concerns. In other words, this principle compels companies to act in ways that benefit the environment and a circular economy (Recyc-Québec, 2019). Two major provincial regulations frame this activity:

- **Q-2, r. 40.1** - Regulation respecting the recovery and reclamation of products by enterprises (LégisQuébec, 2020).
- **Q-2, r. 32** - Regulation respecting hazardous materials (LégisQuébec, 2020).

The first regulation (i.e. Q-2, r. 40.1) targets all companies that market these products and assign them "responsibility for [their] recovery and reclamation". It also sets recovery rates at **75% for 2020 and 80% for 2024** (Recyc-Québec, 2019). The **SOGHU** (*Société de Gestion des Huiles Usagée*), a private organization made of a group of companies subject to the regulation act, is responsible for ensuring that established recovery rates are achieved. The organization operates **1,750 deposit stations** to recover hydrocarbon products in Quebec (Recyc-Québec, 2019). On the other hand, some companies have decided to launch their own recovery program, independently from the SOGHU, such as Canadian Tire (Canadian Tire, s.d.), Crevier (Crevier, s.d.), and Paquet et Fils (Paquet et Fils, s.d.), which are the most significant initiatives. Once these companies have recovered the products, they are sent to **certified industrial plants** that provide evidence of the recycling of the products into new and marketable ones (SOGHU, s.d.).

The second regulation (i.e. Q-2, r. 32) puts hydrocarbon products under the general regulation of "hazardous materials" in order to commit specific requirements for their distribution in the community and assert that these products need special care.

2.3 Results

In 2015, **76.6%** of waste oil[26] "available for recovery" has been recovered by the SOGHU and **82% in 2018**, which represents approximately 62 million liters (UOMA, 2019). In addition, 95.7% filters, 92.5% oil and aerosol containers, 24.6% antifreeze and 51% of antifreeze containers were recovered. Once liquid products are recovered, they are recycled through **regeneration and re-refining processes**. First, almost **60 million liters** are redirected to **Veolia's regeneration plant** of Sainte-Hyacinthe who produces asphalt, fuel and lubricant oil (Recyc-Québec, 2019; Véolia, n.d.). Also **7.6 million liters** of waste oil are sent to **Safety-Kleen re-refining plant** where they are then transformed into fuel (EcoPower, s.d.), tar diluent (for reconstruction of roof and pavement) and oil for lubricants (Safety-Kleen, s.d.). The Napierville refinery recycles about **4 million liters of engine coolant** into new coolant (Recochem Inc, s.d.).

Quebec's "Regulation respecting hazardous materials" allows the combustion of waste oil for energy purposes only through equipment **with a power superior to 3 MW,** and for very specific cases (LégisQuébec, 2020). Consequently, only big industries like cement plant, paper plant and greenhouses can use waste oil as fuel. In this case, the use of waste oil as fuel, under regulations, is negligible and is not a common practice.

While there is a very high proportion of hydrocarbon products recovered and reused each year as a result of the regulations and private measures in place, it remains **the responsibility of manufacturing**

[26] Classified as hazardous materials article 4, see http://legisquebec.gouv.qc.ca/en/showdoc/cr/Q-2,%20r.%2032

companies to implement recovery programs for their products in compliance with the law. Consequently, we can conclude that **energy conservation projects have to be solely undertaken by the companies themselves**. In other words, the “ownership” of hydrocarbon products is still held by the companies since the end-of-life management is under their legal responsibility.

2.4 Comparisons with the previous Project Document (PD)

In the previous PD, only one project was related to the PAI IX. For the 3rd cohort of WILL’s Sustainable Community, 17 projects - or 2% of the total projects - are attributed to the PAI IX.

2.5 Conclusion

This analysis of the available data demonstrates that only a marginal percentage (0-25%) of virgin hydrocarbon products are collected, recuperated and processed through recycling activity, which indicates that energy conservation is **not a common practice in Quebec.** In fact, any volume that exceeds current regulatory targets (i.e. 75%) is considered a non-current practice, since more than 75% of fossil products distributed must be recovered and transformed. Therefore, in this last sector, anything below 75% of the volume is highly regulated: **the recovery is legally the responsibility of companies who market these products**. The industrial recycling facilities have to be certified and are usually realized by bigger companies such as Veolia and Safety-Kleen. The opportunity for these projects appears to be limited.

3. Part II: Renewable natural gas assessment

3.1 Methodology

To analyze RNG practices in Quebec, we reviewed one institutional energy analysis from the well-known Chair in Energy Sector management from HEC Montréal University and several studies from private and public actors in RNG production like Energir and Deloitte. These analyses give us a detailed portrait of the current situation of RNG production and consumption in Quebec as well as the forecasts for the next decade.

3.2 Analysis of government policies, regulations and laws

Supply, transmission and distribution of RNG, like every energy source in Quebec, is regulated by the “*Act from the Régie de l’énergie*” which is the institutional energy regulating authority in Quebec (Gouvernement du Québec, 2020). The *Régie de l’énergie* provides requirements and laws concerning tariff regulation, distribution rights, supply plan, and delivers authorizations for project development (Energir, 2018).

RNG integration in the energy mix is an important element of energy policy in Quebec. The Government of Quebec has legally decreed[27] a progressive integration of RNG in the public gas grid: **in 2020, 1% of total gas volume has to be RNG, and at least 5% in 2025** (MERN, 2019). The gas distributor Energir has to be compliant to this regulation.

Thus, the *Régie de l'Énergie* has fixed a tariff for RNG purchase, called the "TRG" (Energir, 2018). This act fixes the market price of RNG and the level of additional purchasing fees. The TRG, making RNG more expensive than natural gas (15 $/GJ versus 6.67 $/GJ), enables RNG producers to cover the expensive cost of RNG production (CAPEX and OPEX), and secure their investments for a long-term development (Energir, 2018). The RNG tariff (15 $/GJ) is a determinant factor in technical potential forecasts (RECYC-Québec, 2018).

In accordance with the article 22 of the "Environment quality act", a certified authorization is required for any RNG production project that involves biomethanization processes (Gouvernement du Québec, 2020). Because RNG is mainly produced through the methanization of organic biomass, the management of organic wastes is highly regulated to avoid any environmental contamination such as methane leaks, water and soil pollution (Gouvernement du Québec, 2018). In Quebec, any private companies or individuals can develop methanization, except in the Magdalen Islands, where the municipality controls all organic wastes including those from the ICI sectors (Industrial, commercial, institutional) (Solinov, 2009, p. 9). **Self-production and decentralized production** are authorized by the *Régie de l'énergie* in order to drive innovation and technology development (Régie de l'énergie, 2017, p. 21). This represents the segment of RNG production that is of interest to WILL since **these sites of production are independent from Energir's grid and additional to Quebec energy policies.**

3.3 Results

A recent study from Deloitte regrouping HEC Montréal University, public gas distributor Energir, RECYC-Québec and al. has recently demonstrated the great potential of RNG in Quebec and the advantages to developing this sector.

[27] http://legisquebec.gouv.qc.ca/en/showdoc/cr/Q-2,%20r.%2032

There are currently 60 RNG producers reported in Quebec that produce 222 million m^3 of RNG (Whitmore & Pineau, 2020). It represents around **3% of the total natural gas consumption in Quebec** (Whitmore & Pineau, 2020). However, only three industrial sites can currently market their RNG production to local and American actors: two landfills sites and one biomethanization municipal site (MERN, 2018). These 3 sites produce annually around 120 million m^3 of RNG.

Municipalities are the most indicated sites to develop RNG production due to residential organic wastes, followed by the ICI sector, particularly food industry, farming, wood industry, pulp and paper (Solinov, 2009). The most advanced and developed RNG production site is the biomethanization plant of Sainte-Hyacinthe, which has the capacity to process 200,000 tons of organic wastes annually. The municipality of Sainte-Hyacinthe currently uses RNG for residential heating and public vehicles (Regroupement , 2019, p. 12), which may significantly improve the city's CO_2 emissions. However, except for a few cases like Sainte-Hyacinthe, most landfills in Quebec burn their biogas from waste decomposition, which releases significant CO_2 emissions and methane (CH_4) leaks that are estimated at 25%[28].

In 2017, 58.9% of RNG was consumed by the industrial sector, 30.3% by the commercial and institutional sector, and 10.7% by residential buyers (MERN, 2018). Deloitte and Energir forecast that in 2030, 2/3 of the current NG consumption could be replaced by RNG, representing approximately 144.6 million GJ (Deloitte, 2018). They also predict a growing importance of technologies in the production of RNG: in fact, in 2030, 82% of RNG could be generated by second generation technologies (e.g. pyrolysis and gasification processes), versus 13% by biomethanization and 5% by landfill gas extraction (Deloitte, 2018). The study states that **the substitution of NG by RNG could reduce GHG emissions by 7.2 $MtCO_2e$** (Regroupement , 2019, p. 18).

WILL's methodology makes it possible to assess GHG reductions from RNG self-production and consumption, at individual scale, in substitution of fossil fuels, for heating, electricity generation or cogeneration purposes (heating and electricity). In WILL's Sustainable Community, one cheese dairy is currently producing its own RNG from dairy wastes and consuming it for its own energetic needs. For such self-production cases with local RNG consumption, GHG reductions calculations consist in the landfill emissions avoided from the diversion of organic wastes thanks to their transformation in RNG,

[28] https://www.recyc-quebec.gouv.qc.ca/municipalites/matieres-organiques/recyclage-residus-verts-alimentaires/implanter-optimiser-collecte/bilan-emissions-ges

plus, eventually, the reduction of combustion emissions respect to more emissive fuels. The “baseline scenario” would consist in the current fossil fuels consumption; the “project scenario” would be the new fuel consumption, with or without fossil fuels, after the integration of RNG.

A life cycle analysis (LCA) methodology seems leading to important issues. In fact, the GHG emissions for RNG production have not been estimated yet, because of the complexity of the process. New methanization processes are emerging, such as pyrolysis which could replace current technologies. This is limiting an LCA comparison between RNG and other fossil fuel production, like natural gas for example.

We have to note that RETscreen energetic software[29] offers the possibility to calculate an RNG volume production from various organic inputs. This gives us an interesting opportunity to verify client data for RNG production and eventually calculate GHG reductions by implementing specific emission factors.

All biomethanization processes induce liquid or bio solids digestate that can be spread as fertilizer for agriculture or even be composted. However, for the moment, it seems difficult to assess GHG reductions through this practice. In fact, digestate fertilizers are regulated by the Environment Quality Act because its spreading can cause soil and water contamination, especially acidification and eutrophication. Consequently, official certifications and authorizations must be required for any digestate spreading project for environmental reasons. Therefore, we hardly found a study that could assess GHG reductions from the substitution of fertilizers by methanization digestate.

3.4 Conclusion

Due to the available data, we can say that **RNG self-production and consumption is not a common practice in Quebec at the individual scale, e.g. food producers and farmers that are not connected to the gas distribution network**. We estimate than less than 1% of farmers are currently producing RNG from their organic wastes. For WILL’s community, we think that self-production and consumption is not a current practice where significant and calculable GHG reductions can be achieved since, at this scale, production volume, process control and reduction’s property are easily determinable. Thus, RNG’s production project connected with a gas distributor grid (distribution of the produced RNG into its pipeline), **are also not yet a common practice**. The challenge will be to clearly assess a potential issue from the interface of two economic incentives programs: monetization of GHG’s reduction (with WILL Solutions) and the sales of RNG at a fixed regulated extra pricing.

[29] https://www.rncan.gc.ca/cartes-outils-publications/outils/logiciels-danalyse-de-donnees-ou/retscreen/7466

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5. ANNEXE 1: Methodologies and calculation for RNG emission factor.

The goal here is to determine the emission factor of renewable natural gas (RNG), in comparison with the emission factor of natural gas (NG). It aims to explore possibilities for the implementation of RNG in WILL's protocol. As previously mentioned, RNG has a great technical and economic potential in Quebec and is receiving significant support from the government of Quebec in replacing NG by RNG. Two different methodologies have been tested depending on two different ways to deem RNG emission factor calculation.

First, the different methodologies and their respective emission factor calculations are presented below. Then, differences in buildings are compared by using the RETScreen simulation tool.

5.1 Methodology 1: Landfills methane avoidance

The first methodology for RNG emission factor calculation focuses on landfills methane avoidance which is the basic way to consider RNG environmental benefits (Gouvernement du Québec, 2019). In fact, the advantage of RNG production is to divert organic wastes from landfills and transform them into biogas. Consequently, the global emission statement of the combustion of a given volume of RNG has to take into account GHG emissions that RNG production avoids by diverting organic wastes from landfills. **We voluntarily ignore respective emissions occurring during the production of NG and RNG since no data can provide a precise estimate.**

So, we can say that RNG emission factor is the difference between emissions occurring during combustion of RNG and methane emission avoidance, or:

RNG emission factor = emission factor at combustion – landfills emission avoidance

The "emission factor at combustion" is the same as NG emission factor: **0.00188932 tCO2e/m3 (E.F Recycling)**.

WARM version 14 gives **0.63 tCO2e/tons of organic waste**. As a first approximation, we consider all organic wastes as equivalent in terms of landfills emissions. For our methodology, we have to link this data directly to a volume of RNG in order to estimate emission avoidance per volume of RNG consumed (in tCO2e/m3 of RNG).

The difficulty here is that each type of organic wastes has its specific **Biochemical Methane potential (BMP)** which corresponds to the volume of biogas that can be extracted from 1 ton of organic waste. The table below resumes several methanogenic powers for the main organic wastes used for biomethanization (Collectif Scientifique National Méthanisation, 2018)[30]:

Type of organic waste	Biochemical Methane Potential (m3 CH4/ton of raw organic waste input)
Food oil	784
Rape residue	355
Corn straw	331
Grain residue	300
Used grease	250-261
Sludge of water treatment plant	245-250
Drying grain	245
Flotation grease	244
Drying corn, silos wastes	220-225
Poultry wastes	160
Alcohol distillery	152
Lawn and green wastes	80-125
Corn silage	100
Porcine manure	47-70
Bovine manure	40

Consequently, we can define a landfill emission factor for each type of organic wastes by applying this formula:

Landfills emission factor = 0.63 [tCO_2e/ton of raw organic waste input] / BMP [m^3 CH4/ton of raw organic waste input] = X [tCO_2e / m^3 CH4]

The units are coherent because in the two terms of the equation, organic waste inputs are the same.

Type of organic waste	Landfill emission factor (tCO_2e / m^3 CH4)
Food oil	0.00080357
Rape residue	0.00177465
Corn straw	0.00190332
Grain residue	0.0021

[30] Two other sources have been used for verification: (ADEME, 2013) and (Wikipedia, 2020)

Used grease	0.00241379
Sludge of water treatment plant	0.00252
Drying grain	0.00257143
Flotation grease	0.00258197
Drying corn, silos wastes	0.0028
Poultry wastes	0.0039375
Alcohol distillery	0.00414474
Lawn and green wastes	0.00504
Corn silage	0.0063
Porcine manure	0.009
Bovine manure	0.01575

We now calculate the total RNG emission factor for each type of organic waste, thanks to the following operation:

RNG project emission factor = 0.00188932 [tCO_2e/m^3] – Landfill emission factor [tCO_2e/m^3 CH4]

Type of organic waste	RNG emission factor (tCO2e / m3 CH4)	Reduction compared to natural gas (%)
Food oil	0.001085749	43%
Rape residue	0.000114672	94%
Corn straw	-1.40033E-05	101%
Grain residue	-0.00021068	111%
Used grease	-0.000524473	128%
Sewage plant sludge	-0.00063068	133%
Drying grain	-0.000682109	136%
Flotation grease	-0.000692647	137%
Drying corn, silos wastes	-0.00091068	148%
Poultry wastes	-0.00204818	208%
Alcohol distillery	-0.002255417	219%
Lawn and green wastes	-0.00315068	267%
Corn silage	-0.00441068	333%
Porcine manure	-0.00711068	476%
Bovine manure	-0.01386068	834%

Note:

Most emission factors are negative. The emission factors for the first two types of organic waste (i.e. food oil and rape residue) listed in the table above seems coherent since their methanogenic power is significant, which means that more biogas can be extracted from 1 ton of organic waste, resulting in less quantity of organic waste being diverted from landfills. This means that the emissive impact of landfills is greater than the combustion of RNG. This can be an interesting reason to encourage the use of RNG.

5.2 Methodology 2: RETscreen

RETscreen energy simulation software doesn't apply any CO_2 emission factor for RNG. The methodology here considers that RNG combustion releases CO_2 that was captured during the organic phase of the process. It also ignores emission reductions through the diversion of organic wastes to landfills. However, RETscreen does apply some small emission factors for N_2O and CH_4, so that's RNG's impact at combustion is not null. Here a screenshot of RETscreen emission factors for biogas/RNG.

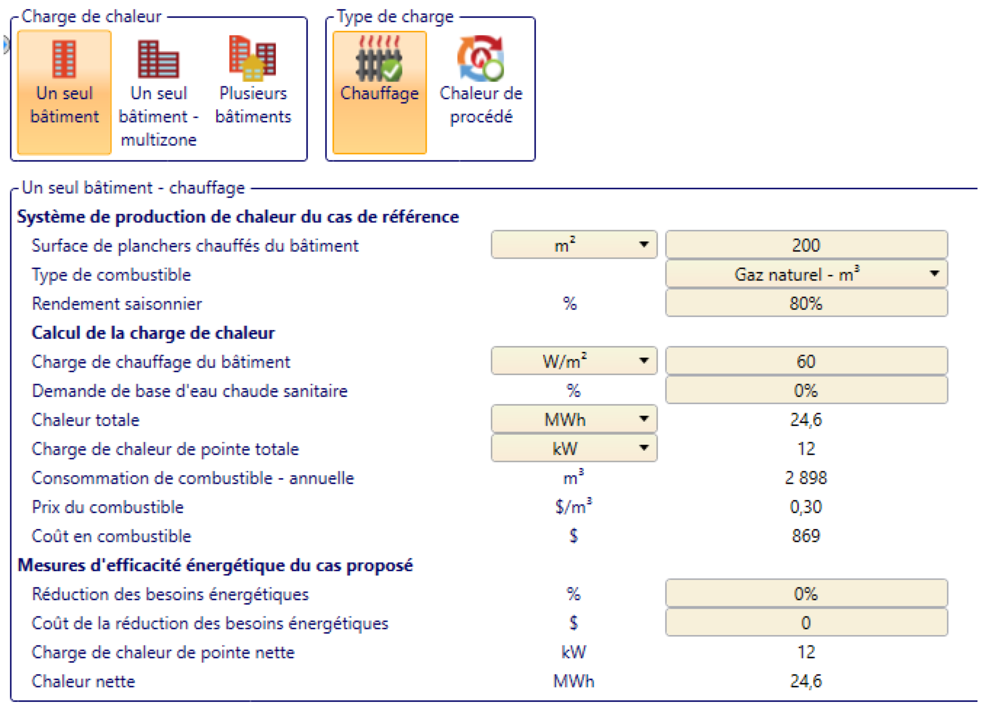
Sommaire des GES du cas proposé				
Type de combustible	Proportion de combustible %	Facteur d'émissions de CO_2 kg/GJ	Facteur d'émissions de CH_4 kg/GJ	Facteur d'émissions de N_2O kg/GJ
Biogaz	100,0%	0,0	0,0299	0,0037
Total	100,0%	0,0	0,0299	0,0037

5.3 Methodology 3

A third methodology could be possible based on official data on RNG production.

5.4 Case study: Building simulation on RETscreen

We propose here a fictive case study in order to illustrate the differences between the two methodologies for GHG emission reductions of GNR utilization. We have simulated on RETscreen the heating energy needs of a given building with the following characteristics:



Système de production de chaleur du cas de référence		
Surface de planchers chauffés du bâtiment	m^2	200
Type de combustible		Gaz naturel - m^3
Rendement saisonnier	%	80%
Calcul de la charge de chaleur		
Charge de chauffage du bâtiment	W/m^2	60
Demande de base d'eau chaude sanitaire	%	0%
Chaleur totale	MWh	24,6
Charge de chaleur de pointe totale	kW	12
Consommation de combustible - annuelle	m^3	2 898
Prix du combustible	$\$/m^3$	0,30
Coût en combustible	$	869
Mesures d'efficacité énergétique du cas proposé		
Réduction des besoins énergétiques	%	0%
Coût de la réduction des besoins énergétiques	$	0
Charge de chaleur de pointe nette	kW	12
Chaleur nette	MWh	24,6

In the baseline scenario, the heating system is fueled by natural gas (NG). The project scenario uses the same building but with a heating system using renewable natural gas (RNG). For comparison purposes, two different organic inputs will be calculated for the RNG project emission. We resume here the most important data for the calculation:

Natural gas volume needed	2 898 m^3
Heating energy needs	24.6 MWh

Methodology 1: To calculate CO_2 emissions, we need the following data:

NG emission factor	0.00188932 tCO_2/m^3
RNG emission factor	Depending on the type of organic waste
Caloric value	10.64 kWh/m^3
% of methane in $1m^3$ of RNG (average)	40%

For the baseline scenario, the calculation is:

Baseline emissions = NG emission factor * Natural gas volume needed

= 0.00188932 [tCO_2/m^3] * 2,898 [m^3]

= 5.48 tCO_2e

For the project scenario, we have, according to the previous emission factors table:

Case 1: if project scenario biogas is produced from **food oil**, we have

Project emissions = (Heating energy needs / Calorific value) * RNG emission factor

= 24.6*1,000 [kWh] / 10.64 [kWh/m^3] * (0.001085749) [tCO_2/m^3]

= 2.5 tCO_2e

Case 2: if project biogas is produced from **bovine manure**, we have

Project emissions = (Heating energy needs / Calorific value) * RNG emission factor

= 24.6*1,000 [kWh] / 10.64 [kWh/m^3] * (-0.01386068) [tCO_2/m^3]

= -32 tCO_2e

To resume, we obtain:

	Total emission	GHG emission reductions from baseline
Baseline scenario emissions	5.48 tCO_2e	x
Project scenario emissions (food oil biogas)	2.5 tCO^2e	2.98 tCO^2e
Project scenario emissions (bovine manure)	-32 tCO^2e	37.48 tCO^2

Note:

We see that with bovine manure, GHG emission reductions are important. A more detailed life cycle analysis could rectify this result by including emissions of bovine breeding activity.

Methodology 2: With RETscreen methodology we obtain the following emissions statement for both for baseline and project scenarios:

Émissions de GES		
Cas de référence	tCO_2	5,5
Cas proposé	tCO_2	0,2
Réduction annuelle brute d'émissions de GES	tCO_2	5,3

5.5 Comments

We think that, to assess RNG benefits in replacement of fossil fuels, we must include a life cycle analysis of the RNG production. It is the only way to enhance GHG emission reductions that RNG consumption can offer, like methane landfills avoidance, as we could see in methodology 1. According to our analysis, RETscreen methodology does not reflect the real impact of RNG production and consumption, since the assumption of neutral emissions during the entire production and consumption cycle of RNG is a large simplification of the problem. It also minimizes the positive impact of RNG and the necessity to encourage its consumption in replacement of fossil fuels. The first methodology gives more possibilities, depending on the type of organic wastes, to calculate RNG GHG emissions. A more detailed life cycle assessment will certainly generate improvement. Finally, we should find or calculate an appropriate EF that could assess GHG reductions from the substitution of fertilizers by methanization digestate.

Generic Project Activity Instance X

Energy Efficiency - New Building or Major Renovation

Table of Contents

1. Description of the generic PAI X

This category of projects (generic PAI) focuses on **sustainable design for new buildings and major renovation projects** that can reduce GHG emissions significantly through the improvement of energy efficiency (LEED, 2019, p. 159). For several years, a new architectural movement has proposed new plans to conceive buildings in a way that improve space integration for minimal environmental impact. Moreover, renovation of existing buildings using efficient materials or improving space utilization can also significantly improve energy efficiency. All these actions can be considered, in this generic PAI, as relevant sources of GHG emission reductions.

In WILL's Sustainable Community, only 5 projects were quantified in this PAI for the 3rd cohort, which represents less than 1% of total projects. One typical example is the thermal station "Éternel Spa" which achieved, since 2011, significant GHG emission reductions through sustainable design.

2. Research methodology

In order to define technically the projects admissible, we reviewed green building certifications analyses and methodologies, such as LEED and PassivHaus, as well as specialized media on building construction and innovation, like Écohabitation. For the common practice analysis, we searched for global studies to estimate the level of occurrences, the dynamism and the trends of these construction projects as it was done for the PAI VII.

3. Analysis of government policies, regulations and laws

Since they concern building construction, all admissible projects described here are compliant with the building codes of Canada and Quebec such as the National building Code of Canada (NBC), National Energy Code of Canada (NECB) and the Building Code of Québec (BCQ). These codes impose security and construction standards and establish some important requirements such as minimal thermal resistance, air quality, energetic load etc. However, the objective of this PAI is to go beyond these national requirements in order to reach additional energy gain, or GHG emission reductions. Theses codes do authorize any designs that exceed their requirements since they respect the basic recommendations, allowing further energy efficiency gains.

4. Results

Briefly, **sustainable design** refers generally to the smart **integration of the building into the environment** and **high energy efficiency** in order to **minimize the impacts on the environment by reducing the use of resources**. The LEED organization estimates that its certified buildings reduce by 30%-40% their electricity consumption (LEED, 2019, p. 159). We aim here to sketch the most common practices that could define the project admissibility to this PAI.

These new conceptions require an accurate focus on **facade orientation**, **room positioning**, **fenestration area and material**. For the first two elements, the goal is to maximize the exposition to energy and light from sunlight in order to satisfy building needs without using energy from another source, especially fossil fuels (Écohabitation, 2012). This can significantly reduce the energy consumption of the building and drastically improve the global energy efficiency. This practice is usually a core element of passive houses or net-zero projects.

For example, in houses, bedrooms and living rooms usually require more light and heat than other rooms. In the northern hemisphere, a sustainable design will place these rooms against the southern facade in order to maximize sunlight exposure and heating gains during the day; whereas kitchens and bathrooms, because they are less used and have less energy needs, will be placed to the northern side of the building (Écohabitation, 2012). This can also apply to ICI buildings (industrial, commercial, institutional).

Special attention is also put on materials, particularly for the **envelope building** and **the insulation**. In fact, sustainable designs favor **high thermal inertia material** for walls **like concrete, cast iron and brick** (Écohabitation, 2013). These materials have the capacity to capture heat during the day and release it during the night, eventually **avoiding heat intakes from the energy mechanical system.** Thus, high quality insulation techniques and materials are searched to lower heating loads. For example, thermal resistance often arises to R80 for these constructions (Écohabitation, 2013), while the minimum recommended by National Code is R24 (APCHQ, 2012, p. 17). The **fenestration material** is also usually highly efficient in terms of emissivity (very low) in order to prevent heat transmission by radiation. Apart from the high efficiency criteria, materials will be chosen depending on their recyclability and their origin (recycled materials or derived from sustainable production).

Those are the main concepts of sustainable design currently realized under the best certifications worldwide, such as LEED and PassivHaus. We do think that if projects have implemented these actions, which are easily verifiable, they are admissible to this PAI.

We now analyze if this practice is common or not in Quebec. The results from a study on the economic level of clean energy in Canada for 2017 by Clean Energy Canada are used, in which was analyzed. It offers a broad and detailed view of the dynamism of this sector through several indicators such as GDP, investment, growth etc. For clean buildings, **including new buildings and retrofits/recommissioning**, the global economic indicators are resumed in the following table:

	Canadian GDP		Canadian investments	
HVAC	$366 million	12 %	$1.4 billions	12 %
Energy-saving building materials (without isolation)	$150 million	5 %	-	-
High Efficiency appliances and lighting	$160 million	6 %	$5.1 billion	43 %
Architecture	$2.2 billion	76 %	$5.3 billion	45%
Total	**$2.9 billion**	**100 %**	**$11.8 billion**	**100%**

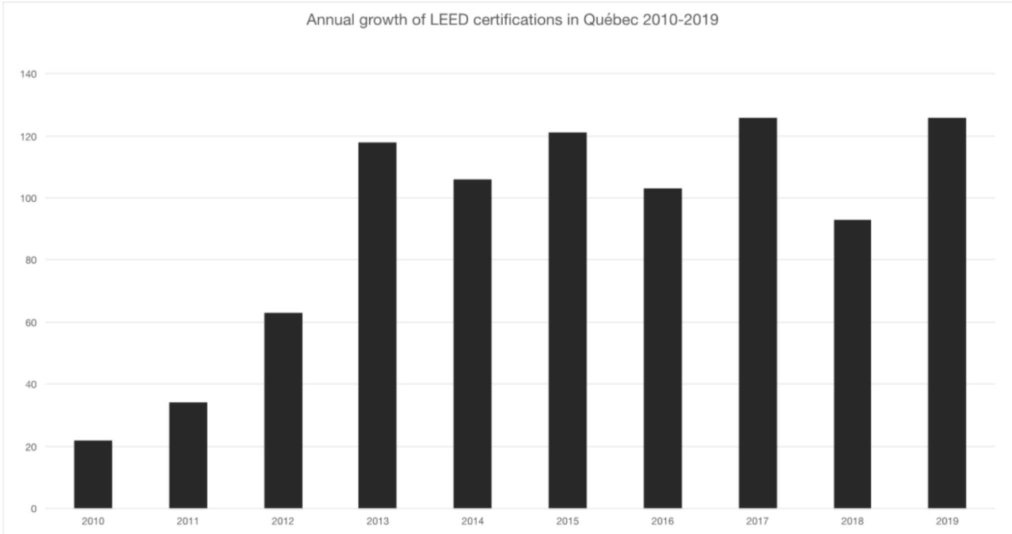
Investments in clean building achieved $11.8 billion in 2017 representing **21% of the total clean energy investment in Canada which arises at $35 billion** (Navius Research, 2019). We can note that architecture projects account for 76% of Canadian GDP and 45% of the total investments. These indicators show that the architectural part plays a significant role in clean building projects.

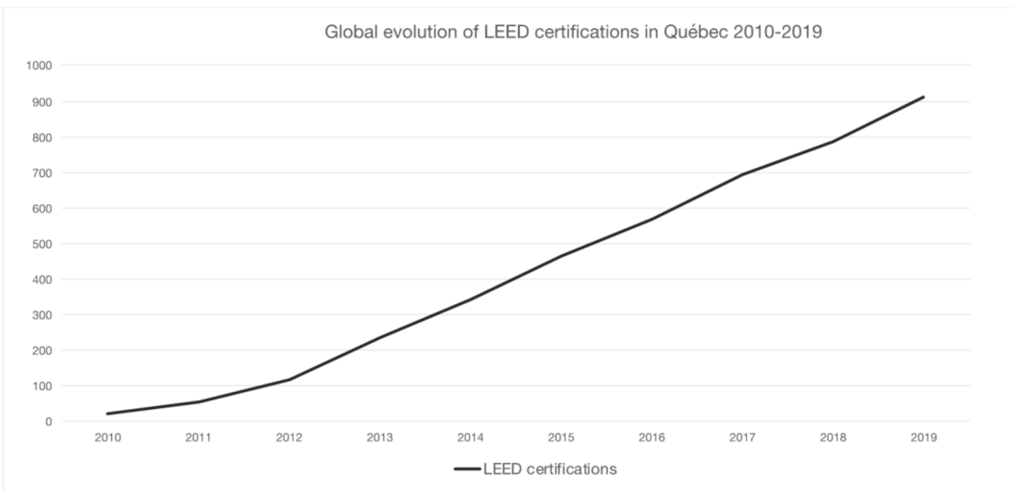
The main occasions where sustainable architecture projects can be reported are through green building certifications. The most common one is LEED, which gives an important role for sustainable design in its rating system. In Quebec, **848 projects** are certified **LEED** among the 4,000 buildings certified in Canada, plus **1,643 registrations** (Canada Green Building Council, 2019).

Thus, two organizations are currently active for **passive house certifications** in Quebec. The first one is the American certification Passive House Institute US (PHIUS, 2020). The second one is the well-known German PassivHaus certification (Maison Passive, 2020). The main difference with LEED is that passive house certifications have drastic goals in terms of construction techniques, impacts and energy efficiency. The energetic load is around 15 kWh/m2, leading from 80% to 90 % energy consumption reduction versus usual building (Pott, 2018). There are no **passive commercial buildings** currently certified in Quebec (IndexDesign, 2017). For individuals, very few examples are available. In 2018, Quebec inaugurated its second passive certified house (Écohabitation, 2018). One reason often given to explain the very low number of passive houses in Quebec is the low price of hydroelectricity which is limiting the profitability of energy efficiency projects.

5. Comparison with the previous Project Document (PD)

The previous PD considered only LEED certifications in 2012 and concluded that it was not a common practice. Since 2012, more buildings have been LEED certified and new certifications, like PassivHaus, has emerged in Quebec, providing new guidelines and practices for high energy efficiency. The two graphs below show the evolution of LEED certifications between 2010 and 2019, the most popular ones being in Quebec (Canada Green Building Council, 2019). They show that, since 2012, even if green building certifications have a positive progression, they still don't qualify for a common practice.





6. Conclusion

Through this analysis we can say that the **PAI X is not a common practice in Quebec.** We can easily say that **less than 1%** of the 640,000 buildings reported have currently implemented these projects. This PAI gives the possibility for WILL to accept in its methodology these designs and architectural projects that can significantly reduce energy consumption and GHG emissions As national building codes will improve and multiply their energy efficiency requirements, we can forecast that the number of these projects is going to increase for the next years, both for residential and ICI buildings. The increase of building certifications is a good sign of this trend.

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Generic Project Activity Instance XI

New Business Models of Transportation

Table of Contents

1. Description of the generic PAI IX

The goal of this PAI is to assess projects of clean transportation that result in significant GHG emission reductions. Transportation can be either the core activity of the company (e.g. car rental) or a secondary service (e.g. delivery services for food retailer). Nowadays, new developments in low emission and collective transportation models have emerged to replace those centered on individual car-use. The intention is to transform cities by reducing pollution, congestion and increasing collective and low emission transport for a better comfort and quality of life.

2. Research Methodology

We reviewed a study from the Institute of Statistics of Quebec reporting on companies in Quebec and Montreal that have social and environmental purposes. We also gathered information from the "Quartier de l'innovation", which reported on some sustainable transportation business model.

3. Analysis of government policies, regulations and laws

There currently are no regulations that specifically address this PAI. Nevertheless, the government of Quebec has developed several master plans for sustainable transportation for the next decade called “Sustainable transportation politics – 2030” (Gouvernement du Québec, 2018). It establishes measures and goals for several dimensions of transportation such as people transportation, supply chains and infrastructures. For instance, it plans to reduce by 40% the consumption of gas in all transportation sectors and by 20 % the individual car travel, reduce transport congestion, increase collective transport, and promote the electrification of transport and low emissive delivery services (Gouvernement du Québec, 2018). However, this plan also represents an opportunity to engage stakeholders from the transportation sector in a vast dialogue: i.e. supply chains, cities, consulting and engineering firms, citizens etc. The purpose is to combine the various stakes and actions of each operator in a global, coherent and harmonized vision.

Concretely, the Government of Quebec, through the “Transition Énergétique Québec” (TEQ), has set different programs for individuals and companies. For individuals, financial aid is available for the purchase of electric cars, used cars or charging stations (home or office) (Transition Énergétique Québec, 2019). For transportation companies or municipalities, TEQ offers formation on energy efficiency and eco-driving, as well as financial aid for the acquisition of new technologies (Transition Énergétique Québec, 2020).

In summary, the goals of these public actions are to offer guidelines, strategy, information support, incentives and dialogue.

4. Results

Most of the companies who develop these new business models are mainly services enterprises with strong social and environmental values. The “*Quartier de l’innovation*” reported lot of startups involved in sustainable transportation in Quebec (Quartier de l'innovation, s.d.). The main business models related to this category are usually:

- Home delivery services
- Relocation of suppliers
- Transportation services (carsharing, electric vehicles rental)
- Relocation services by bicycle.
- Zero-emission waste management services (with clean vehicles like SAESEM company)
- Events services

More detailed, the Institute of statistics of Quebec published in 2019 a report on companies involved in the social and environmental oriented economy. In 2016, among the **11,200 companies**, **3% have reported environmental activities** (i.e. 363 companies). Approximately **4% among these 363 companies** are linked with “green transportation and waste management” which represents around **164 companies** (Institut de la Statistique du Québec, 2019)**.** Their business model is based on sustainable, zero or low emission mobility.

Apart from these companies, some public projects have been planned in order to further develop sustainable transportation. For instance, the city of Montreal has launched an Urban delivery service, promoted by the society of commercial development of Montreal (SDC) in collaboration with Jalon MTL and COOP Carbone/Esplanade. Briefly, every merchant of Plateau Mont-Royal, Verdun and Villeray-Saint-Michel neighborhoods or the members of the SDC have the possibility to have their products delivered by a **bicycle transportation service** (Ville de Montréal, 2020). The goal of this public initiative is to improve and offer a more eco-friendly delivery service in Montreal that reduces GHG emissions, pollution and truck density. Furthermore, the city of Montreal has also launched a project called “Cité mobilité” in collaboration with Hydro-Québec. In a nutshell, in 2025, all buses purchased in Quebec by transportation companies will have to be electric (Boutros, 2019). Some of them are already in circulation in Montreal as a pilot project.

In order to ensure the additionality of the GHG reductions of these projects, companies will have to confirm that their clean transportation services are definitely replacing fossil-fuel dependent ones, or that this service should have been normally realized through fossil-fuel transportation. Ideally, companies should already offer transportation service. A typical **baseline scenario** should consist in a fossil-fuel transportation model; the **project scenario** should fulfill the same service but using clean transportation systems enabling a reduction in GHG emission.

5. Comparison with the first Project Document (PD)

Transportation was not included in the first PD. In the renewal of the PD, GHG’s transportation segment will be address as deviation methodology until we will update the VM0018 for the inclusion of these types of project reduction GHG.

6. Conclusion

In conclusion, statistically speaking, **new business models based on clean transportation are not a common practice in Quebec**. All transportation services could be admissible to this PAI since they can manage GHG emission reductions in replacement of current fossil-fuel transportation.

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Generic Project Activity Instance XII

Behaviour Changes in Transportation

Table of Contents

1. Description of the generic PAI XII

This PAI is defined as a change in behaviour towards sustainable mobility (i.e. practical low-polluting mobility), sustainable living environment and lifestyle (e.g. car sharing and carpooling, active transportation and public transit) as well as flexibility in work organization (e.g. teleworking, distance learning, videoconferencing as an alternative to business travel).

Based on various literature reviews, this change in behaviour towards sustainable mobility would effectively help to reduce GHG emissions.

2. Looking back on the generic PAI XII in previous cohorts

Behaviour change for sustainable mobility is a new PAI. In response to numerous requests from members of the Sustainable Community and potential future members wishing to submit GHG reduction projects in the transportation sector, WILL Solutions has decided to review its methodology in order to incorporate the project evaluation approaches for this sector.

3. Research methodology

The methodology used to carry out this work is a literature review conducted for several types of documentation. Most of the documents in this work are sourced from governmental and para-governmental scientific research and research chairs, such as the Statistics Canada survey reports and the Sustainable Mobility Policy 2030. A few are documents from pro-environmental associations and the others are information from grey literature (journals, newspapers and study or research reports).

4. Analysis of government policies, regulations and laws

There are no provincial, federal or municipal laws or regulations requiring companies to adopt measures and behaviours to reduce GHG emissions from business travel. However, there is a Sustainable Mobility Policy of Quebec Government published in 2018. According to this policy, by 2030, the government would like, among other things, to provide citizens with more sustainable mobility options, to reduce the number of solo car trips by 20% and to reduce commuting times by 20%. Still, we know that a law or regulation has constraints while a policy does not. Consequently, companies are not required to adopt behaviours aimed to reduce GHGs from employee and operational travel.

Concerning telework, not all companies allow their employees to telecommute. Yet, employers and employees are increasingly enthusiastic about the possibilities offered by remote working, teleworking and virtual commuting due to their respective benefits for them. However, teleworking is not sufficiently facilitated by the legislation of the Quebec and Canada governments. An increasing number of companies are exploring telework and virtual work teams, and research continues in this area. It is in this same vein that the *Télétravail Québec* group was registered in November 2019 in the Lobbyist Registry; its objective being to make a plea to the Quebec government to be proactive in promoting telecommuting. The emergence of this group was driven by the fact that Quebec is far behind in telework compared to Europe and the United States (Poirier, 2019).

5. Research results: The current status of transportation behaviour

In the most recent report of the *État de l'énergie au Québec 2020*, the transportation sector is considered as the second largest energy consumer in Quebec (30%), of which 97% is from fossil fuel origin. Also, the *Ministère de l'Environnement et de la Lutte contre les Changements Climatiques* (MELCC) classified this same sector as the largest GHG emitter in 2017, road transport being mainly responsible for approximately 79.6% of the sector's GHGs.

In this research, sustainable mobility and teleworking practices are examined.

5.1. Sustainable mobility practices: Carpooling, active transportation and public transit

In Quebec, more than ¾ of workers commute to work by private car. In 2016, of those Quebecers travelling to work in a private vehicle, nearly 79.5% drove alone, 10.5% carpooled, 9.4% took public transit and 6.1% used active transportation (cycling and walking). This means that nearly 26% of workers use sustainable transportation.

Furthermore, Statistics Canada (2013, 2017a and 2017b) showed that sustainable transportation, in this case carpooling, is less prevalent in the province of Quebec compared to other Canadian provinces, as Manitoba and the Atlantic provinces. For example, nearly 1/8 of Canadians carpooled in 2016; this corresponds to 12.5 %. In addition, the same study reveals that the lowest rates of carpooling to work are found in Quebec's metropolitan areas.

In fact, the 2011 and 2016 Origin-Destination Surveys of Workers conducted by Statistics Canada for certain cities and metropolises in Canada, show that the number of cars continues to increase in the Quebec province and that the number of people commuting to work in a private vehicle has continued to rise from 82.6% in 2006 to 83.6% in 2016. In contrast, the number of people travelling to work as passengers in private vehicles has declined between 2006 and 2017 from 5.9% in 2006 to 4% in 2016. The same survey also notes an increase of the proportion of workers using public transport, from 9.2% in 2006 to 9.4% in 2016. Details are provided Table 1 in the Appendix, designed by us based on Statistics Canada data for 2013, 2017a and 2017b. The provincial average obtained for each category is an extrapolation in the estimation of averages calculated from the data of the six Quebec cities and metropolises included in the surveys.

Although these data show a great disparity among participants in the province of Quebec (Saguenay, Quebec City, Sherbrooke, Trois-Rivières, Montreal, Gatineau) as can be seen in Table 1 (see Appendix), it remains that there is still an important gap to be filled in terms of sustainable mobility. For example, the percentages of carpoolers in Montreal and Quebec City are respectively 14.2% and 14.8% in 2011, as well as 8.6% and 10.6% in 2016. While in Saguenay and Trois-Rivières, they are respectively 11.1% and 11.3% in 2011 as well as 9.3% and 8.8% in 2016. On the other hand, the share of workers using active transportation (cycling and walking) in Montreal, Ottawa-Gatineau (Quebec side) and Saguenay are respectively 7.2%, 6% and 4.3% in 2016.

Furthermore, actions and flexibility measures to promote eco-mobility are based on the application and development of organisational and technological principles favouring alternative modes of travel in order to reduce the use of solo cars for work-related travel. Some of these multiple actions could include the following:

- paying a percentage of the cost of public transit fares;
- providing showers and bike racks for cyclists as well as parking for carpoolers;
- join a corporate car-sharing services and even more ensuring that the carpooling worker can return home in case of emergency by, for example, taking a commitment to pay the taxi.

By exploring some organizations that provide consulting services and promote sustainable mobility and telecommuting, it was found that only a handful of organizations out of the 320,000 that exist, according to *WILL Solutions* estimate, implement the above-mentioned measures, (see Table 2 in the Appendix for a brief numerical estimate). Thus, based on the data in Table 2, there are approximatively 98 companies out of 320,000 or 0.03% that implement the said measures.

5.2. Telecommuting practices

Telework is one way of improving the quality of life and well-being of employees in order to reconcile work and personal life. It is also a solution for preserving the environment and minimizing the carbon footprint for those who are used to commuting by car or motorcycle.

A review of the literature revealed that the definition of telework varies from one author to another. Some authors count the self-employed as teleworkers, and this could probably increase the number. Telework is generally defined as "a form of exercising all or part of a company's professional activity at a distance using telecommunications tools. These tools ensure that the person is able to access the resources (both internal and external to the company) needed to carry out his work, but also that he can be contacted and that his employer can set up remote forms of verification of his activity". Telework is also "a paid work at home for at least one day or the equivalent of one day per week, of which most of the work is done on a computer; this work should generally be transmitted to a client or employer over the Internet or on diskette". For this specific PAI, we have adopted the second definition, which is CEFRIO's vision of telecommuting. It seems more logical to us in the context of GHG reduction emitted during professional journeys.

As can be seen in Table 3 above, according to surveys conducted by CEFRIO in 2001, 10.2% of Canadian employees worked at home, while in Quebec this share was 4% which 58.8% were self-employed. In 2011, the IPSOS survey indicated that 17% of Canadians telecommute. In the same vein, the BMO survey reported in 2013 that 23% of Quebecers and 23% of Canadians work from home very often. And, in 2016, 23% of Quebecers and 31% of Canadians telecommute. In the same way, some sources claim that 47% of Canadians work from home for half the week based on Regus Canada survey in 2017; this probably include self-employed workers.

Table 3 : Percentage of teleworkers in Canada and the Province of Quebec

	Canada	Quebec
	% Teleworkers (including self-employed and casual teleworkers)	% Teleworkers (including self-employed and casual teleworkers)
2001	10.2	4
2008	11.2	11% for Montreal City/ 16% for Quebec City (≈20% for both including self-employed workers)
2011	17	/
2013	23	23
2016	31	23

Sources : CEFRIO (2001); Ipsos (2011); Scaillerez and Tremblay (2016); McKinnon (2020) and Tanguay & Lachapelle (2019)

At the same time, it appears that even at the government organization side, telework is no more advanced. This was discovered during the 2020 coronavirus crisis, where only 8% of federal public service employees work remotely (Venturelli, 2020).

6. Common practice analysis on generic PAI XII

To conclude on **Sustainable mobility practices**, in 2016, hardly **9.4%** of workers used public transit, 10.6% carpooled and only **6.1%** of workers used active transportation. Therefore, they were **26%** of workers who uses sustainable transportation in 2016. The situation has not significantly changed since

2006, so the automobile remains the common way to get to work for most employees. As a result, the sustainable mobility is not a common practice. Its usage is 26%, which represents less than 40%.

Telecommuting practices in Quebec have become more common nowadays, rising from **4%** in 2001 to **23%** in 2013 and around **23%** in 2016. However, the proportion of people who practice it does not yet allow us to identify telework as a common practice because these statistics include self-employed and casual teleworkers, and are less than 40%. Telework is therefore not a common practice. It also remains a challenge for Quebec companies to implement telework for at least one day a week.

Moreover, we estimate that there are 320,000 commercial and institutional industrial enterprises in Quebec that could implement work organization and flexibility measures as well as sustainable transportation practices in their respective companies. But, as shown in Table 2 (see appendix), despite the lack of data, barely 0.03% of Quebec companies (98/320,000 companies) implement these measures. Consequently, they are not common practices.

Nevertheless, with the introduction of government policies encouraging public or shared transportation as well as the development of flexible work regimes (teleworking, desk-sharing, office sharing and optimizing space allocation), the proportion of companies practicing the above measures is expected to increase in the future.

In addition, statistics on telecommuting could also change. Indeed, the corona virus pandemic has forced many public and private companies to institute telework within their organizations. Thus, if the majority of companies, as is currently the case, give employees the opportunity to telecommute at least one day per week, there will probably be an increase in the number of teleworkers across Canada and Quebec. What would become the new ratios of telecommuting and other related measures in Quebec? It is precisely at this point that uncertainty remains.

7. Conclusion

Altogether, based on the collected data, **s**ustainable mobility and telecommuting are not yet common practices. Then, we conclude that sustainable mobility and telecommuting are not current practices with 26% of workers who use sustainable transportation, 23% who telecommute and approximately 0.03% of companies with work organization and flexibility measures. All of these shares are less than 40% under which any practice is considered by *WILL Solutions* as non-common.

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9. Appendices

Table 1: Proportion of workers commuting to work by car, truck or van, by public transit, on foot, or by bicycle in some metropolitan areas in Quebec

Proportion of workers commuting to work in some metropolitan areas in Quebec (%)																						
	Car, truck or van (total)			Car, truck or van (as Driver)			Car, truck or van (as Passenger)			Public transit			Walking			Bicycle			Workers commuting by Car, truck or van who carpool		Commuters using sustainable transport	Active transport
	2006	2011	2016	2006	2011	2016	2006	2011	2016	2006	2011	2016	2006	2011	2016	2006	2011	2016	2011	2016	2016	2016
Saguenay	90.5	91.6	92.2	85.2	88.0	88.7	5.3	3.6	3.5	2.4	2.3	2.2	5.2	4.3	4.0	0.8	0.4	0.3	11.1	9.3	15.7	4.3
Quebec (Qc)	80.4	80.5	80.4	74.9	76.4	76.5	5.4	4.1	3.9	10.2	11.3	11.1	7.3	6.2	6.3	1.4	1.3	1.3	14.8	10.6	29.3	7.6
Sherbrooke	86.4	87.5	88.6	80.5	83.5	84.7	5.9	4.0	3.9	4.7	4.2	4.2	7.3	6.6	5.6	0.9	0.8	0.7	12.7	10.6	21.1	6.3
Trois-Rivières	89.5	90.8	91.6	84.9	87.5	88.2	4.6	3.4	3.3	2.4	2.3	2.3	6.0	5.1	4.5	1.4	1.0	0.8	11.3	8.8	16.4	5.3
Montreal	70.4	69.8	69.7	65.4	66.4	66.4	5.0	3.4	3.3	21.4	22.2	22.3	5.7	5.3	5.2	1.6	1.7	2.0	14.2	8.6	38.1	7.2
Ottawa-Gatineau (Qc side)	78.6	78.1	78.8	69.6	71.0	72.7	9.0	7.1	6.0	14.3	15.3	14.5	4.6	4.1	3.9	1.7	1.7	2.1	≃ 21.9	15.1	35.5	6.0
*Average estimate for Qc	≃ 82,6	≃ 83,1	≃ 83.6	≃ 76,8	≃ 78.8	≃ 79.5	≃ 5.9	≃ 4.3	≃ 4.0	≃ 9.2	≃ 9.6	≃ 9.4	≃ 6.0	≃ 5.3	≃ 6.1	≃ 1.3	≃ 1.15	≃ 0.8	≃ 14.3	≃ 10.5	≃ 26.0	≃ 6.1
Ottawa-Gatineau (Qc side)	78.6	78.1	78.8	69.6	71.0	72.7	9.0	7.1	6.0	14.3	15.3	14.5	4.6	4.1	3.9	1.7	1.7	2.1	≃ 21.9	15.1	35.5	6.0
Ottawa-Gatineau (Ontario side)	68.0	67.7	69.8	60.4	61.2	64.0	7.7	6.5	5.8	21.2	21.8	19.6	7.6	7.1	7.1	2.2	2.4	2.5	≃ 21.9	12.3	41.5	9.6
Ottawa-Gatineau (ON/ Qc)	70.8	70.4	72.1	62.8	63.8	66.2	8.0	6.7	5.9	19.4	20.1	18.3	6.8	6.3	6.3	2.1	2.2	2.4	21.9	13.0	40.0	8.7
***Note: All red are our estimates based on data retrieved from Statistics Canada.**																						

Source: Statistics Canada (2013, 2017a, 2017b)

Table 2: Some organizations providing sustainable mobility advisory services

Members of the Association des Centres de Gestion des Déplacements du Québec (ACGDQ), Sustainable mobility consulting services			https://www.acgdq.com/membres
Organization/member	**Clients of each member**		**URL**
	Details	**Total**	
Voyagez Futé	• Production companies **9** • Service companies **12** • Institutions and governments **8** • Promoters and property managers **5**	**34**	https://voyagezfute.ca/a-propos-de-nous/nos-clients/
Mobili-T	**Clients of Mobility Management Plan** • Institutions and governments **5** **Clients of consulting services interventions** • Institutions and governments , Production companies and Service companies **7** **Clients of Awareness and «vélo-boulot» activities** • Production companies and Service companies **6** **Clients of other projects** • Service companies **3** **Note**: There are clients who recur several times for different services.	**15**	http://mobili-t.com/wp-content/uploads/2019/11/RA_CGD_Mobili-T_2017-2018_VF_CA.pdf
Employeur en Mouvement (projet)	Service companies **10**	**10**	http://employeursenmouvement.com/
MOBA (Mobilité Alternative)	Service companies **20**	**20**	https://www.destl.ca/mobilite-durable/clients
Cgdeml (Est de Montréal & Lanaudière)	/	/	https://cgdeml.ca/
Roulons vert	Service companies **17**	**17**	http://roulonsvert.com/services/#clients
Cadus	/	/	http://cadus.ca/
Centre de mobilité durable de Sherbrooke	/	/	https://mobilitedurable.qc.ca/
MOBIO (Vos solutions Transport)	Service companies **12**	**12**	http://mobi-o.ca/a-propos/#section6
	Total	**98**	**≃ 0,03% de 320 000 companies**

Generic Project Activity Instance XIII
New Technologies for Clean Transport

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1. Description of the generic PAI XIII

This PAI consists in all transportation technologies that enabled significant GHG emission reduction. One part is related to energy efficiency measures to improve current vehicles. The other part corresponds to new designs generally replacing conventional technologies (typically electric and hybrid vehicles). The amount of emission avoided would be the property of the person buying and installing these technologies, and able to give enough proofs of their effectiveness. This PAI applies primarily to commercial or transportation businesses, but also to any individual who commits to sustainable development.

2. Research methodology

The objectives here are to define what kind of existing technologies are relevant in terms of cost, availability and utilization, and admissible to this PAI. For that purpose, we have reviewed global studies, both public and private, that specialize in analyzing the technologies normally used for GHG emission reductions. Public programs to help companies “green” their transportation system by providing technical and financial support are also reviewed.

3. Analysis of government policies, regulations and laws

For heavy transportation vehicles, there is the **"Q-2, r. 33 - Regulation respecting environmental standards for heavy vehicles"** (Gouvernement du Québec, 2020)**.** This act sets maximum emissions rate for heavy vehicles according to the year of construction, and for several types of particles. For example, vehicles constructed after 1998 may not emit more than 200 ppm hydrocarbons (HC) and 1% of carbon monoxide (CO). These rates and thresholds have to be respected; otherwise measures have to be taken to tackle excess emissions. However, this regulation concerns **air pollution** rather than **GHG emissions**. No regulations are currently in place to tackle the latter.

4. Results

The main technologies certified and recommended by scientific and technical organizations are resumed in the table below. They usually represent the recurrent and classic content of green transportation investment. Every project using or investing in these technologies could be eligible to our methodology:

Energy efficiency	High efficiency motorization High efficiency unit (refrigeration unit) Smart gear box Aerodynamic devices Low-rolling resistance tires
Low emission transportation	Hybrid vehicles Electric vehicles Biofuels vehicles (ethanol, natural gas, propane) Hydrogen vehicles Low speed vehicle (institutional, tourism, airports) Biofuel for train Bicycles

For some technologies, the Government of Quebec, through its program **"Transportez Vert"**, gives financial support that can hedge 50% of the total expenses (Gouvernement du Québec, 2020). Briefly, the technologies admissible are electric and hybrid with specific propulsion systems, refrigeration unit and other technologies (Gouvernement du Québec, 2020). However, it provides no financial support for hybrid and electric vehicles or fuel substitution expenses.

The International Council for Clean Transportation (ICCT) in a recent study reports clean equipment recommendations: engine, transmission and drive-line improvement, hybrid systems, lightweight materials, aerodynamic devices, and low-rolling resistance tires (ICCT, 2019). According to the ICCT, the implementation of these technology packages for heavy trucks “can improve fuel efficiency by 50% in the United States by 2027 from a 2015 baseline”. Consequently, significant GHG emission reductions can be reached.

Another example is the Canadian program SmartWay. The program provides technologies recommendations, and advises transportation companies and fleet managers to adopt clean and sustainable practices like energy efficiency and conservation (Government of Canada, 2020). It also proposes a list of effective technologies that can be added into vehicles such as aerodynamic devices, low rolling resistance and idling reduction technologies (EPA, 2016).

Rail transportation also takes effective measures to realize significant emissions reduction. In fact, as a result of energy efficiency actions and the increased use of renewable fuel for rail, Rail Canada reduced by 4 million tons of CO_2 its environmental impact (RAC, 2018).

Assessing the level of investment in this sector can provide additional insight in determining if a practice is common or not. A study from Clean Energy Canada could give us this possibility. Clean Energy Canada has analyzed Canadian investments in clean technologies for several economic fields such as transportation, energy, buildings and industries. It has reported that, among the 7.6 billion dollars spent in clean transportation in 2017, 1 billion (13%) were dedicated to electric vehicles and infrastructures, and 2.8 billion dollars (36.8%) to hybrid vehicles. **Put together, these represent around 12% of the total investment in clean energy in Canada (30.8 billion dollars)** (Navius Research, 2019)**.**

Thus, the Government of Canada reports that “more than 3,600 companies” are participating to the SmartWay program for sustainable transportation.

Moreover, Chair Energy Sector Management of HEC Montreal, in its last report on energy in Quebec shows that 2% of total fuel consumption originates from renewable energy sources: electricity accounting for 0.3% (all sector). Thus, 3% of vehicle sold in 2018 were electric vehicles (Whitmore & Pineau, 2020).

5. Comparison with previous Project Document (PD)

This is a new PAI; therefore there is no previous analysis in the previous PD for transportation.

6. Conclusion

In conclusion, we can say that low emission and high efficiency transportation technologies **are not yet a common practice**. However, due to regulatory decisions, and public programs for financial and technical support, an increasing amount of transportation companies are implementing these technologies to clean their current practices. Since the transportation sector is still one of the biggest GHG emission source in Quebec (Whitmore & Pineau, 2020), government and other actors will certainly increase efforts in reducing transportation emissions.

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Generic Project Activity Instance XIV

New Practices to Reduce GHG Emissions of Transport through Optimization

Table of Contents

1. Description of the generic PAI XIV

This generic PAI concerns all measures and actions that a company with transport activities can implement to reduce GHG emissions apart from technological transformation. It corresponds to “travel optimization” and derives from organizational, social and logistical management issues. Most of these actions concern freight and public transportation. Some of these measures include:

- Intermodality
- Eco-driving training
- Sustainable suppliers
- GPS tools
- Transportation infrastructures and urbanization issues for public policies.

2. Research methodology

First, we reviewed public and corporate studies, reports and plans on sustainable transportation in order to understand what the present and future issues of the transportation sector are, and the types of projects that are expected to transform the sector into a more sustainable way. Then, some real examples of projects that could possibly be relevant for this PAI were analyzed.

3. Analysis of government, policies, regulations and laws

We identified no regulations concerning projects linked to the activities of transportation companies. The only regulation that is somewhat related to this generic PAI is the **Regulation respecting environmental standards for heavy vehicles** that sets maximum emission rates for heavy trucks and obligatory antipollution measures (Gouvernment of Québec, 2020). For example, vehicles constructed after 1998 may not emit more than 200 ppm hydrocarbons (HC) and 1% of carbon monoxide (CO). Thus, every truck has to be equipped with antipollution technologies in order to limit emissions of pollutants particles. **Every projects going beyond these threshold could be admissible** to WILL's Sustainable Community.

4. Results

Since freight transportation is an essential economical sector, the government prioritizes dialogue, consultation and collaboration between private and public stakeholders in order to find a global and harmonized solution.

Some plans and guidelines have been set in the context of "**Sustainable mobility policy"** (MTMDET, 2018). This gives us the possibility to see what the trends and the opportunities for GHG emission reductions are. In this policy document, the predominance of road transportation sector in Quebec is underlined. A sustainable policy for road transportation has the difficult task to deal with several issues that sometimes contradict each other: the growth of the number of heavy trucks, the competition between transportation modes, fossil fuel dependence, and GHG emission reduction. The plan focuses on two main elements: **improvement in the organization of logistic systems and integration of technological advances** (MTMDET, 2018). The advances in organization can be a better **localization of storage**, **reduction of distance**, **logistic platform**, **smart interconnexion between transportation systems and intermodality** (MTMDET, 2018)**.** The technological aspect focuses mainly on **electric or efficient motorization**, **eco-driving, and shared information systems**. The combination of **optimized travel** and **efficient trucks** will reduce the environmental impact of the sector. Globally, intermodality has great potential in Quebec especially between interurban **trucking and rail transportation**, **maritime and aerial sectors**. However, the opportunities could be lower because 1) of the great advantages of trucking in terms of time, cost, flexibility (AQTR, 2013) and 2) the rise of flows without intermodality potential (CPCS, 2013). However, the increase of exchanges can prevent the achievement of environmental goals and put pressure on existing infrastructures.

The council of employers of Quebec released in 2017 a document on the major transformations in the supply chain sector with respect to sustainable development issues. This gives us an outline to examine the types of projects potentially admissible to this generic PAI. Three dimensions are identified:

1. Avoid non-essential displacements or reduce kilometers.
2. Transfer displacements to less emissive transportation modes.
3. Reduce vehicles emissions through technological advances.

More precisely, the study provides important recommendations, partly based on existing projects or initiatives. The most important and recurrent one is the development of an effective **information system and database** to inform supply chain actors and expeditors about **less emissive routing** depending on cost, delivery time, distances travelled, etc. The CPQ analysis also insists on the lack of information system. An effective solution suggested could be the development of **digital applications** in order to link full capacity displacements to logistical hubs and low emissive transports for the last kilometers, coordinate the different transportation modes and actors, clients, suppliers, etc. This promotes effective intermodality. Secondly, urban planning and strategic logistical hub are essential to maximize intermodality, reduce GHG emissions and avoid congestion. Finally, the integration of smart technologies tools to optimize displacements.

To summarize with the International Council on Clean Transportation, there are three core dimensions for clean transportation: 1) clean and efficient logistics 2) clean and efficient modes and 3) clean and efficient equipment (International Council on Clean Transportation, 2019).

We can give some examples of existing projects to illustrate how these concepts and strategies are materialized. We are solely giving here the most significant ones. For instance, Port of Montreal has installed new entrance gates that reduce waiting time and congestion outside the port. CargoM and Coop Carbone, in collaboration with Interuniversity research center on enterprise networks, logistics and transportation (CIRRELT), has developed a project to coordinate full capacity transportation to storage centers and delivery with low emissive transportation (CPQ, 2017). CargoM also has created a numeric platform giving transporters the best route to avoid congestion.

In the same way, other projects are emerging in Quebec for maritime transportation optimization. In this case, the Maritime Information System (Réseau Québec Maritime, 2019) developed an information system for Saint-Laurent and Saguenay actors, gathering, analyzing and sharing data on a numeric platform for ship owners, commercials, port administration, suppliers etc. (Innovation maritime, 2020). This information system enables organized and harmonized maritime freight transportation on the Saint-Laurent River.

For rail transportation, Clean Energy Canada, in its broad clean investment analysis, reported that 1.5 billion dollars (18% of clean transportation total investments) are spent for “rail and rapid transit” and 1.3 billion dollars (17%) for “railway lines” for sustainable development purposes (Navius Research, 2019). While the study does not precisely explain the content of these measures, it shows the interest and motivation of rail actors to develop sustainable oriented projects.

Considering technologies advances, several projects can be implemented such as new technologies and equipment that improve the energy efficiency of vehicles, the conversion to electric or hybrid motorization, etc. (International Council on Clean Transportation, 2019). In this idea, the government of Canada has launched an American program called Smartway in order to help transportation companies reduce their environmental impact by providing free energy evaluations, eco-driving training for drivers, organizational tools and advices to improve their energy efficiency. More than 3,600 companies are participating to this program (SmartWay, 2020). Then, numeric tools give precious information on congestion in urban area and best intermodal routing.

5. Conclusion

To conclude, we can say that this generic PAI **is not yet a common practice.** However, assessing these projects will be important since they will become more frequent in the future.

Through these few examples, we can see that several projects of travel optimization for GHG emission reduction purposes have emerged in Quebec in the past few years. For freight transportation companies, taking these actions can significantly reduce GHG emissions and improve the cost-effectiveness of every travel. For public authorities, improving intermodality infrastructures through urbanization can increase the use of collective and low emission transportation. One important issue of this generic PAI will be to address and avoid the double counting of the GHG reductions by transportation companies, the shipper and receiver of the transport of these goods.

The projects admissible are related to every initiative able to reduce GHG emissions through **travel optimization, intermodality, information system, and technological innovations.** Significant emission reductions can be assessed through these actions; the Pew Center on Global Climate change has calculated that 7 to 10 % of emissions can be avoided through supply chain optimization (CPQ, 2017).

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Generic Project Activity Instance XV

Land Application of Biosolids

Table of Contents

1. Description of the generic PAI XV

1.1 Scope of PAI XV

The PAI XV covers waste management approaches that avoid landfilling and thus methane emissions through the recovery of residual materials such as residues and sludge from paper mills, residues and sludge from municipal wastewater treatment plants, dry biomass residues, and biochar. This project involves the recovery and reuse of these organic materials by spreading them on the land as biosolids to replace agricultural fertilizers, restore mining areas, etc. in order to avoid methane emissions into the atmosphere. For example, Landfilled Pulp and Paper Mill Sludge (LPPMS) residues, with their high carbon potential, serve at the same time as greenhouse gas (GHG) sequestration, especially in the presence of low carbon soils; and biochar, which also reduces methane emissions, has a high potential for improving soil fertility and sequestering carbon in the soil.

1.2 Some definitions related to PAI XV

Municipal sludge, also known as **municipal biosolids** or sewage sludge, is the material that results from the treatment of municipal wastewater and septic tanks and is suitable for land application. Municipal biosolids are a good source of organic matter, nitrogen and phosphorus. It is a guaranteed source of fertilizer proven by American and Canadian research, since their application increases the population of earthworms and soil microorganisms. As for paper mill residues and sludge, these are residues from the production of pulp and paper. Biochar is a carbon-rich solid obtained by a process of thermal degradation of biomass in the presence of little or no oxygen. Land application is a simple, efficient and economical recycling method consisting of spreading residual organic matter on the ground, whether or not it has undergone prior composting or biomethanization treatment. In fact, the treatment of septic sludge in order to not release wastewater into the environment requires that the material first be left to stand to separate the liquid from the solid. Then, the solid matter is treated and used as fertilizer. These materials help to preserve or improve plant nutrition and soil quality. In addition, recycling organic matter by spreading contributes to limiting the waste of resources and the use of landfill or incineration, thus avoiding GHG emissions.

2. Looking back on the generic PAI XV in the firsts cohorts

The third cohort of the Sustainable Community project in Quebec (*VCS id project # 929*) counted 83 PAI XV out of 438 methane emission avoidance project, covering 3 of the 17 administrative regions of

Quebec. Of these 3 administrative regions, one region, Saguenay, represents nearly 43% of the total PAI XV, as shown in the table below. In the first two cohorts, the number of generic PAI XV was estimated at 0 PAIs for the first cohort and 12 PAIs for the second cohort.

Quebec Administrative Region	Name of members	PAI XV Reduction/ Reuse	PAI XV Composting	Total PAI XV	Nature of the project
Laurentides	Municipalité de Prévost (1PAI)		1	1	Sludge (biosolids)
	Régie Inter-municipale La Lièvre		12	12	Organic sludge from ICI Sector
Outaouais	Épursol		33	33	septic tank sludge
Saguenay–Lac-Saint-Jean	Récupèresol	1	/	1	Contaminated soil
	Gazon Savard (M.O.)		36	36	-Municipal wastewater treatment sewage sludge; -Septic tank sludge (STS); -Municipal biosolids (ponds); -Grease trap; -Pulp and Paper sludge; -Water to be treated; -Channel sand; -Residues STS; -Lixiviat landfill and pigeon droppings
Total				**83**	

Most of WILL's PAI XV projects relate to the composting of materials (septic tank sludge, paper mill sludge and municipal biosolids).

3. Research Methodology on generic PAI XV

The literature review conducted for this PAI focused mainly on government and research documents. Some documents come, for example, from Recyc-Québec and others from UQAC's Eco-counselling Chair.

4. Analysis of existing government policies, regulations and law

Several official documents, including policies, laws and regulations related to waste management, have been adopted at the provincial and federal levels. On the federal government side, there is, for example, the Canadian Environmental Protection Act of 1999. In Quebec, related legislation and regulations include, among others, the following:

- Q-2 Environment Quality Act of 2011, which has been amended. The new version became effective on March 23, 2018;
- S-22.01 Act respecting the Société québécoise de récupération et de recyclage.

Several regulations are linked to this Environment Quality Act, such as:

- Q-2, r.19 Regulation respecting the landfilling and incineration of residual materials

The purpose of this Regulation is to prescribe the residual materials that may be accepted in the dedicated facilities (various authorized landfill sites), the conditions under which the facilities must be established and operated, and the conditions that apply to their closure and post-closure management;

- Q-2, r. 43 Regulation respecting the charges payable for the disposal of residual materials

The purpose of this Regulation is to fix the charges to be paid for the disposal of residual materials in disposal sites.

In 2011, a Residual Materials Management (RMM) policy, whose fundamental objective is to make residual material disposed of in Quebec the ultimate waste, was adopted in accordance with the 2011 Environment Quality Act. The associated 2011-2015 action plan was updated for a new period from 2019-2024. Among the targets to be achieved in 2023 by the new action plan is the recycling of **60% of organic materials**, as shown in Table 1, which provides a comparative overview of some of the quantitative aims of the two action plans.

Table 1: Some goals and targets of the action plans of RMM 2011-2015 and 2019-2024

Entitled	2011-2015	2019-2024
Deadline	***2015***	***2023***
Reduce to **X kg** or less the amount of material disposed per capita	**X= 700 kg**	**X= 525 kg**
Recycle **Y%** of residual putrescible organic mater	**Y= 60 %**	**Y= 60 %**

Sources: MELCC (2011) and MELCC (2020a, February).

In addition, always in line with government actions related to RMM policy aimed at reducing the ultimate residue through recycling activities, Quebec launched a new strategy for the valorisation of organic matter on July 3, 2020. At the same time, an increase in royalties' payable for the landfilling of organic materials from $23 to $30 per tonne is announced to encourage the recovery, reuse and revalorization of materials. This reform will come into force in autumn 2022, following its adoption by the National Assembly, and will be fully operational in summer 2025.

On the other hand, concerning sewage sludge and its use regulation, at the federal level, there is the Fertilizers Act and Regulations, under the responsibility of the Canadian Food Inspection Agency (CFIA). At the provincial level, the MELCC (Ministère de l'Environnement et de la Lutte Contre les Changements Climatiques) of Quebec has developed rigorous and regularly revised rules in its Guidelines for the Recycling of Fertilizer Residual Materials.

Furthermore, it is known that it is prohibited to discharge contaminated residues (wastewater, pulp and paper mill sludge, contaminated soil, etc.) directly to the environment. Some companies, such as paper mills, have their own landfill or combustion facility in accordance with the relevant regulations. But, the use of these residues devoid of contaminants for soil rehabilitation and other useful purposes such as reducing methane emissions or carbon sequestration is a voluntary act. Thus, companies and municipalities have no regulatory obligation to reuse, recycle and compost these treated residues.

5. Results: Status of recycling organic materials and sludge in Quebec from 2015 to 2018

Our main interest focuses on the recycling of municipal wastewater sludge and residues, pulp and paper mill sludge (PPMS) and residues as well as other carbon-rich organic residues that can be used for composting, land application, soil restoration and even animal nutrition such as biochar. The sectors targeted here remain the industrial, commercial and institutional (ICI) and municipal sectors. However, an overview of organics recycling in general will be presented first. This will be followed by an overview of the trend in recycling of municipal sludge and paper mill sludge and residues, followed by other recycled materials such as biochar.

5.1. Organic materials

During 2018, **5,183,000 Metric tons** (MT) of organic materials for all sectors of activity were generated, 2,916,000 MT were landfilled and incinerated, and **2,267,000 MT** were recycled, giving a global recycling rate of 44% of the organic waste produced. These numbers seem high, but they hide very large disparities in the data. Excluding agri-food residues, the total quantity of putrescible organic materials generated in 2018 is **3,933,000 MT**, of which **1,057,000 MT** have been recycled, representing **27%** of the total. Despite the fact that the quantity recycled in 2018 is increasing (from **22%** in 2012 to **27%** in 2018), it remains very low compared to the total quantity of generated putrescible organic materials.

The quantity of organic matter generated by ICI is **997,000 MT** in 2015 and **1,019,000 MT** in 2018, while the quantities recycled in the same years are respectively **29,000 MT** and **51,000 MT**, i.e. **3%** and **5%**. In sum, the data collected shows us that the proportions of recycled organic materials from the ICI sector are **2%** in 2012, **3%** in 2015 and **5%** in 2018. Although the quantity recycled is increasing, it still remains very low compared to the generated quantity (see Table 2 in the appendix for details).

5.2. Municipal and paper mill sludge and residues

5.2.1. Municipal residues and sludge

In 2015, the municipal sector recycled 687,000 MT out of 2,348,000 MT of organic matter generated, including sludge, which represented 29%. Of this quantity recycled in 2015, nearly half was used for composting (50.2%) and the rest was spread. In 2018, 675,000 MT out of 1,937,000 MT were recycled, representing 35 %. About 2/3 of the recycled quantity was composted; see Table 3 in the Appendix for more details. Things are different when considering municipal sludge taken alone by excluding other types of organic matter. In 2015, the municipal sector recycled 431,000 MT of the 851,000 MT of sludge generated, or 51%, of which 13% were composted and 38% were spread. In 2018, out of 692,000 MT of sludge generated, 288,000 MT were recycled (i.e. 42%), of which 12% were composted and 30% spread (see Table 4 in the Appendix for summarized details). So, the recycling rate of municipal sludge decreased from 51% in 2015 to 42% in 2018.

On another side, although the quantity of organic matter landfilled increased from 2015 to 2018 rising from 5,450,000 MT to 5,848,00 MT (an increase of 3.9%), the quantity of landfilled sludge from all sources remained slightly variable with an increase rate of 0.1% (see Table 5 in the appendix). On the other hand, always from 2015 to 2018, the quantity of incinerated municipal sludge increased by 4.8% and the quantity of landfilled sludge decreased by -23%, in contrast to the quantity of other types of landfilled sludge from agro-food and industrial sources, which increased drastically with an increase rate of 458.8% (see Table 5 in the Appendix).

Furthermore, all municipalities are supposed to have sewage treatment plants. However, some cities still discharge their sewage into rivers and streams. In February 2019, Quebec City discharged 125 million liters of wastewater into the St. Lawrence River, and in autumn 2015, the same phenomenon occurred in

Montreal. According to the Fondation rivières, 93 Quebec municipalities still discharge untreated water into waterways because they don't have the appropriate facilities in place. Considering the fact that some Quebec municipalities still discharge their wastewater into waterways and that there are also leaks and partial discharges from other municipalities, there is every reason to believe that the total quantity of municipal sludge that is not recycled is higher than what is estimated.

5.2.2. Paper mill residues and sludge

In 2015, the paper mills, which are part of the ICI, generated 1,066,000 MT of residues and sludge of which 367,000 MT were recycled (i.e. 34%) practically all of it (99.2%) was used for land application. In 2018, 331,000 MT of residues and sludge from paper mills were recycled out of the 977,000 MT generated, or 34%, of which 98.8% went to land application (see Tables 3 and 4 in the Appendix). As a result, between 2015 and 2018, the recycling rate for paper mill residues and sludge remained stable at 34%, while it was 39% in 2012.

Overall, in 2015, **798,000 MT** of sludge from the municipal and pulp and paper sectors were recycled out of the **1,917,000 MT** generated (i.e. **41.6%)**. In 2018, only **619,000 MT**, or **37.1 %**, were recycled out of the **1,669,000 MT** generated; see Table 4 in the Appendix. However, as the figures in Tables 3 and 4 show, municipal sludge is used for both land application and composting, while nearly all pulp and paper sludge and residues are used for land application.

5.3 Biochar

Several biochar projects have been developed around the world, some of them related to agriculture (soil amendment) and others to energy (syngas, bio-oil). On the research side, a number of scientific articles have been published on biochar over the last two decades, showing the growing interest for this practice. Even the Intergovernmental Panel on Climate Change (IPCC) presents biochar as a promising technology for large-scale carbon sequestration in its special 2018 report on global warming (See additional information on biochar in the Appendices).

6. Common practice analysis on generic PAI XV and Emission factors

6.1. Common practice analysis on use of Municipal sludge, PPMS and biochar

This research showed that in 2015, the municipal sector recycled 29% of the organic matter generated, including sludge, and 35% in 2018. And in 2015, the municipal sector recycled 51% of the sludge generated and 42% in 2018. Although this amount has decreased from 51% to 42%, it is still above the 40% common practice threshold we have set. But, given that some municipalities do not treat their wastewater, discharging it directly into waterways, and that municipal biosolids are one of the products of wastewater treatment, the recycling rate of municipal sludge would have to be less than the current 42%, or even less than 40% if all 1,140 municipalities were to adopt this approach to wastewater treatment. Therefore, we consider this practice to be uncommon, although not all quantification parameters are available. We then conclude that municipal and sewage sludge reclamation is not yet common practice.

For paper mill sludge, in 2015, 34% of residues and sludge were recycled. The same 34% were recycled in 2018. This means that it is not common practice, as this percentage (34%) is less than 40%, which is defined as the threshold for common practice.

As for biochar, the practice is at an exploratory stage and there is not yet a popularized scientific methodology to quantify the associated GHG emissions. Moreover, the scarcity of data and research on biochar valorization and quantification of related emissions makes this practice uncommon.

6.2. Emission factors and parameters for the calculation of emissions

6.2.1. Emission factors for PPMS and residues

Scientists from research institutions, including the UQAC Eco-counselling Chair, have conducted several laboratory and field studies on the emissions and factors to be taken into account in calculating GHG emissions from the management of paper mill biosolids. Tables 7 and 8 in the appendix present the different scenarios studied, including landfilling, land application, combustion and composting. However, the emission factors presented in these publications can only be used where the standards allow, as the studies were conducted on a pilot scale. Additional research is therefore required to quantify direct GHG emissions at the industrial scale and confirm the importance of N_2O emissions in the carbon footprint associated with PPMS landfill.

Furthermore, on its site, the NCASI (National Council for Air and Stream Improvement) is putting forward tools for calculating GHG emissions related to the management of paper mill sludge and residues. These include three documents (Excel files) that were revised in 2020. The first document, ICFPA/NCASI Spreadsheets for Calculating GHG emissions from pulp and paper manufacturing Version 3.3.a, is for the Canadian Mandatory Reporting Program (Large Final Emitters program). The second document is the

“Spreadsheets for Calculating GHG Emissions from Pulp and Paper Manufacturing Under the Canadian GHG Reporting Program (GHGRP) Version 4.0” and the third is the “Spreadsheets for Calculating GHG Emissions from Pulp and Paper Manufacturing Under the Output-Based Pricing System (OBPS) Regulations : SOR/2019-266”.

6.2.1.1. Landfilling

The NCASI model that has just been revised in May 2020, an Excel document available on its site called “GHG Reporting Requirements in Canada, Version 3.3a, last updated May 2020”, provides, in its “other - Waste Management” sheet, three scenarios (methods) for calculating CH4 emissions from landfilling. This model can therefore be used to find emissions or emission factors according to the specificities of our clients. These methods can also be used for municipal sludge and wastewater.

However, the default emission factor, **1.5** Mg CO_2e Mg^{-1} dry PPMS, from Table 8 that was determined with the calculations for the default model conditions could probably be suitable.

6.2.1.2. Land application

Emission factors are variable depending on certain conditions such as regional temperature and soil composition. Chapter 11 of Volume 4 provides emission factors for IPCC 2019 methods for mineral and organic fertilizer application. The default aggregate emission factor is **0.010** Kg N_2O–N (kg N^{-1}), with values varying within the uncertainty range of **0.010** to 0**.018**. Details are provided in Table 9 below.

Table 9: Default emission factors to estimate direct N_2O emissions from managed soils

Emission factor	Aggregated		Disaggregated		
	Default value	Uncertainty range	Disaggregation[4]	Default value	Uncertainty range
EF_1 for N additions from synthetic fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon[1] [kg N_2O–N (kg N)$^{-1}$]	0.010	0.001 – 0.018	Synthetic fertiliser inputs[5] in wet climates	0.016	0.013 – 0.019
			Other N inputs[6] in wet climates	0.006	0.001 – 0.011
			All N inputs in dry climates	0.005	0.000 – 0.011
EF_{1FR} for flooded rice fields[2,7] [kg N_2O–N (kg N)$^{-1}$]	0.004	0.000 – 0.029	Continuous flooding	0.003	0.000 – 0.010
			Single and multiple drainage	0.005	0.000 – 0.016
$EF_{3PRP, CPP}$ for cattle (dairy, non-dairy and buffalo), poultry and pigs[3] [kg N_2O–N (kg N)$^{-1}$]	0.004	0.000– 0.014	Wet climates	0.006	0.000 – 0.026
			Dry climates	0.002	0.000 – 0.006
$EF_{3PRP, SO}$ for sheep and 'other animals'[3] [kg N_2O–N (kg N)$^{-1}$]	0.003	0.000 – 0.010	-	-	-

Source: IPCC (2019), 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Chapter 11

6.2.1.3. Combustion

NCASI suggests factors for fuel and wood waste combustion in its Excel file mentioned above. The factors are in the « Stationary Combustion » sheet on lines 107 and 108 for Wood fuel/Wood waste and Pulping liquors, respectively. For Wood fuel/Wood waste, the emission factors are 0.00016 kg/kg (CH_4) and 0.0001 kg/kg (N_2O). For Pulping liquors, the emission factors are 0.000033 kg/kg (CH_4) and 0.000027 kg/kg (N_2O).

6.2.2. Calculation Parameters of Municipal and Paper Mill Sludge and Residue Emissions

Default Factors for Calculating Fossil CO_2 Emissions from the Incineration or Thermal Treatment of Municipal Waste and Sewage Sludge

Default factors for the calculation of CO_2 emissions		
Type of non-municipal residual materials incinerated or treated	**FC: Fraction of carbon in dry matter (%)**	**References**
Municipal sludge	**31**	2019 Refinement to the 2006 IPCC Guidelines for National
Sludge from the food industry	**44**	

Sludge from the paper industry (process sludge)	**28**	Greenhouse Gas Inventories. Volume 5 : Waste, Chapter 2, Table 2.4A
Sludge from the paper industry (sewage sludge)	**31**	

Source: MELCC (2019: 52).

CH_4 and N_2O Emission Factors Corresponding to the Incineration of Different Types of Residual Materials

Default factors for calculating CH_4 and N_2O emissions		
Types of residual materials incinerated or treated	**FEi CH_4 (kg CH_4/ton of residual materials)**	**FEi N_2O (kg N_2O/ ton of residual materials)**
Municipal	**0.3471**	**0.148**
Industrial	**0.03** (kg/GJ)	**0.004** (kg/GJ)
Sewage sludge	**1.6** (fluidized bed incinerators, dry base)	**0.8** (dry base)
	3.2 (stepped floors, dry base)	

Source: MELCC (2019: 53).

CH_4 and N_2O Emission Factors Associated with Different Types of Treatment or Disposal Routes for Domestic and Industrial Wastewater

CH_4 and N_2O emission factors associated with different types of wastewater treatment		
Type of wastewater treatment or disposal route	**FE CH_4 (kg CH_4/kg DBO)**	**FE N_2O (kg N_2O/kg N)**
Untreated wastewater		
Discharges to reservoirs, lakes and estuaries (Level 2)	**0.114**	**0.005**
Discharge into stagnant water	**0.3**	**/**
Treated wastewater		
Aerobic treatment plant	**0.018**	**0.016**
Biofiltration on anaerobic sludge. UASB Reactor (Upflow Anaerobic Sludge Blanket)	**0.48**	**0**
Septic tank	**0.3**	**0**
Septic tank + sewage field	**0.3**	**0.0045**
Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5 Waste. Chapitre 6. Wastewater treatment and discharge. Tableau 6.3.		

Source: MELCC (2019: 56,57, 58).

7. Conclusion

Overall, the collected data showed that biochar research was still in an exploratory phase; the recycling rate for paper mill sludge and residues was 34% in 2018, less than 40%; the recycling rate for municipal sludge was 42% in 2018. However, given that some municipalities discharge their water into waterways or do not treat it as we have argued later in this document, and based on the data and our analysis**, we conclude that the recycling of municipal sludge, residues and paper mill sludge as well as the development and use of biochar are not common practices**.

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9. Appendices

Definition of biochar

Biochar is defined by the International Biochar Initiative (IBI) as: « a solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment. Biochar can be used as a product itself or as an ingredient within a blended product, with a range of applications as an agent for soil improvement, improved resource use efficiency, remediation and/or protection against particular environmental pollution, and as an avenue for GHG mitigation ».

Characteristics of biochar

The technology is emerging and has not yet stabilized. Many activities around biochar are linked to IBI, which is a non-profit organization open to scientists, NGOs and industry and where many biochar research projects are affiliated. Studies show that biochar stimulates soil metabolism, the immune defences of plants, which defend themselves against diseases without the help of fungicides. When the soil dries out at the surface, biochar acts as a moisture retainer and saves 8% of water; the more acidic the soil, the better it works (Lamoureux, 2015). In addition, biochar stores carbon in solid form and also reduces emissions of other GHG, including methane (CH_4) and nitrous oxide or protoxide (N_2O). Systems using biochar are sustainable, as they have a negative carbon balance by transforming biomass carbon into stable structures that remain sequestered in soils for hundreds or even thousands of years. Thus, biochar acts as a carbon sink and allows a net reduction of CO_2 in the atmosphere (Woolf and al, 2010).

Uses of biochar

Biochar is used as an ecological amendment for soil health and carbon sequestration. The reduction of GHGs through the use of biochar has been demonstrated mainly on soils and associated crops on the one hand and on animal health on the other hand. Further details on biochar and its positive impact on soils, crops, animal health and organic matter can be found in the Appendices.

Positive impact of biochar on soils and associated crops

- Soil fertility: Biochar improves soil fertility and stimulates plant growth, which then absorbs more CO_2 in a positive feedback effect. It improves the biological activity of the soil, increases the pH of acidic soils, improves nutrient and water retention in soils and increases organic matter;
- Reduction of Biomass Emissions: Converting agricultural and forestry waste into biochar can avoid CO_2 and CH_4 emissions generated by the natural decomposition or combustion of waste;

- Reduced fertilizer inputs: Biochar reduces the need for chemical fertilizers, resulting in lower GHG emissions from fertilizer manufacture and use;
- Reduced emissions from agricultural soils: Biochar reduces emissions of N_2O and CH_4, two major GHG released from cultivated soils.

Positive impact of biochar on animal health and organic matter

- Food additive: biochar can be used as a food additive for animals, mainly large livestock;
- Diet and Health improvement: biochar improves animal nutrition, rapidly reduces diarrhea, eliminates allergies, and helps to calm animals while improving their overall health;
- Food efficiency: passing through the digestive system, biochar takes up plant nutrients that tend to be lost or transformed into gaseous emissions;
- Emissions reductions: Biochar also reduces CH_4 emissions from animals. Biochar in livestock diets at 1% of daily food intake reduces CH_4 emissions by 12%.

The GHG reduction potential related to the use of biochar has been evaluated by authors Van der Gaast and Spijker (2013) and appears in the table below.

Table 6: Biochar's contributions to GHG emissions reduction

GHG reduction	Description	GHG	% of Reductions
Carbon sequestration	Photosynthesis sequesters carbon in biomass as it grows. When this biomass decomposes, it releases the carbon back into the atmosphere. If the biomass is instead converted through pyrolysis into biochar, the carbon originally sequestered in the biomass will be stored for a much longer time – for hundreds or thousands of years depending on the characteristics of the biochar and the environment into which it is incorporated. This is because biochar is significantly more resistant to decomposition than the biomass used to produce it. Pyrolysing biomass therefore enhances carbon sequestration.	CO_2	50-65%
Renewable energy	The energy which can be produced from the gases and oils generated by pyrolysis can replace the combustion of fossil fuels. Pyrolysis could produce electricity (which would offset fossil-fuelled power plants) or heat (which could replace thermal demand at or near the pyrolysis plant previously supplied with fossil fuels).	CO_2	20-40%
Waste diversion	Many feedstocks, including rice residues, green waste sent to landfills and manure, are left to decompose without oxygen in rice paddies, landfills and lagoons. This anaerobic decomposition emits methane (CH_4). Collecting and pyrolysing feedstocks that would otherwise anaerobically decompose avoids CH_4 emissions.	CH_4	0-20%
Reduction in soil emissions	Applying biochar to soils may reduce soil emissions of nitrous oxide (N_2O) and increase the ability of soils to uptake CH_4. These reductions are highly variable and the precise mechanism through which they occur is not yet fully understood.	N_2O, CH_4	0-5%
Reduction in fertilizer manu-facturing	Applying biochar to fields may reduce the need to apply other conventional fertilizers. Many conventional fertilizers are energy intensive to manufacture. Reducing the demand for fertilizers reduces its manufacture, thereby reducing CO_2-emissions. When nitrogen fertilizers are applied to field, a small percentage of the nitrogen is emitted as N_2O. Reducing nitrogen fertilizer applications also reduces N_2O emissions	CO_2, N_2O	Not quantified

Source: Based on ranges reported in (Woolf, 2010) and (Roberts, 2010)[12]

Source: Van der Gaast and Spijker (2013).

Methodology for quantifying GHGs related to biochar

The review of the literature reveals that GHG quantification of reduction projects related to the use of biochar remains a challenge.

Methodological test

In 2013, a methodology proposal was made by The Climate Trust, The Prasino Group, the IBI and Carbon Consulting to the American Carbon Registry (ACR). But, the peer review of the scientific committee indicated that the methodology should not be accepted as it was not yet mature. They found that the scientific literature did not provide sufficient evidence of the stability of soil carbon sequestration in biochar-treated fields using the H:C organic ratio correlations as cited in the IBI's standard test method. Until now, this methodology has been the only one available in biochar GHG registries.

However, there are GHG assessments conducted through fieldwork and laboratory studies such as those of Woolf and al. (2010) or by NGOs such as PRO-NATURA INTERNATIONAL, as we will see.

Research results from Woolf and al. (2010)

A decade ago, Woolf and al. (2010) carried out work on sustainable biochar for climate change mitigation and related GHG estimates. Their analyses showed that a maximum of **12%** of current GHG emissions, CO_2- C equivalent (CO_2-Ce) from anthropogenic emissions (human activities) could be annually offset by the development of biochar, i.e. **1.8 Pg[31] CO_2-Ce** per year out of the **15.4 Pg CO_2-Ce** emitted annually, and that over the course of a century, the total net offset of biochar would be **130 Pg CO_2-Ce**. The same studies reveal that **converting sustainably obtained biomass** to maximize bioenergy production, rather than **biochar**, can offset a maximum of **10%** of current anthropogenic CO_2-Ce emissions. However, according to the authors, a comparison of the two approaches shows that the mitigation impact of renewable energy obtained from biochar production and biomass combustion depends on the carbon intensity of the offsetting energy sources, i.e. the mass of carbon emitted per unit of total energy produced.

Cumulative avoided emissions from both strategies decrease as the carbon intensity of the offset energy mix decreases, but the rate of decrease for biomass combustion is **2.5** to **2.7** times higher than for biochar. As expected, the cumulative avoided emissions for biomass combustion are essentially zero when the carbon intensity of the energy mix is also zero. In contrast, the cumulative avoided emissions for biochar are still substantial at **48-91 PgCO_2-Ce**.

Example of NGO Pro-Natura

Pro-Natura has been working for more than ten years on the development of biochar in Africa and has also conducted numerous biochar experiments around the world. In order to promote the use of biochar (green charcoal), Pro-Natura launched a pilot project in 2008 at its main green charcoal production site in Ross Bethio, Senegal. A preliminary calculation showed that each ton of green charcoal added to the soil could, under conservative assumptions, sequester at least 3 tCO_2e (i.e. 30 tCO_2e per hectare for a

[31] 1Pg=1Gt (Woolf et al, 2010)

standard biochar amendment of 1 kg of biochar per m_2). It is important to note that Pro-Natura biochar is obtained by pyrolysis of vegetal biomass of various origins, generally agricultural residues (cotton stalks, millet stalks, maize canes, rice husks, coffee husks, bamboo, dried palms, etc.) (Lamoureux, 2015).

Pro-Natura reports that it sells carbon credits from GHG reductions related to the use of biochar in Senegal projects. She used studies of Woolf and al (2010) to estimate that one ton of biochar used corresponds to 2.7 tons of CO_2 equivalent avoided, which is equal to 2.7 tons of carbon credits (Lamoureux, 2015).

Nevertheless, efforts are being undertaken by the IPCC regarding the development and use of biochar. In 2019, in one of the appendices of Volume 4 of "Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories", the IPCC provided a basis for the future methodological development of a Tier 1 method for estimating the change in mineral soils organic C stocks from biochar amendments to soil, rather than a comprehensive guidance.

In sum, according to Woolf and al. (2010), the relative climate mitigation potentials of biochar and bioenergy depend on the fertility of the amended soils and the carbon intensity of the offset fuel, as well as on the type of biomass. Therefore, in the perspective where a GHG quantification methodology for the use of biochar would be approved, the project proponent should define an applicable baseline scenario and provide documentation on a number of elements, because the carbon composition of biochar and even soils is fluctuating.

Table 2: Trends in organic materials management from 2012 to 2018

Category	Generated quantities (in Metric Tons)		Disposed quantities (Landfill + Incineration) (in Metric Tons)		Recycled quantities (in Metric Tons)			Composting in recycled quantities
	2015	2018	2015	2018	2012	2015	2018	2018
Organic materials from municipal sector **including sludge**	2,348,000	1,937,000	1,661,000	1,262,000	20 %	687,000 (29 %)	675,000 (35 %)	443,000 (65.6 %)
Sludge and putrescible organic materials from **pulp and paper mills**	1,066,000	977,000	699,000	646,000	39 %	367,000 (34 %)	331,000 (34 %)	4,000 (1.2 %)
Organic materials from ICI sector	997,000	1,019,000	968,000	968,000	2 %	29,000 (3 %)	51,000 (5 %)	37,000 (72.6 %)
Total putrescible organic materials (excluding agri-food wastes)	**4,411,000**	**3,933,000**	**3,328,000**	**2,877,000**	**22 %**	**1,083,000 (25 %)**	**1,057,000 (27 %)**	**484,000 (45.8 %)**
Agri-food sludge and organic materials	/	1,249,000	/	39,000	927,678 96 %	1,047,000 (97 %)	1,210,000 (97 %)	15,000 (1.24 %)
Total putrescible organic materials	**/**	**5,183,000**	**/**	**2,916,000**	**40 %**	**2 130 000 (38 %)**	**2,267,000 (44 %)**	**499,000 (22.01 %)**

Sources: Compiled using Recyc-Québec (2017) and Recyc-Québec (2019b).

Table 3: Trends in organic materials management including municipal and PPMS from 2015 to 2018

Category	Generated quantities (in Metric Tons)		Recycled quantities (in Metric Tons)		Composted component		Landspread component	
	2015	2018	2015	2018	2015	2018	2015	2018
Organic materials from municipal sector **including sludge**	2,348,000	1,937,000	687,000 (29 %)	675,000 (35 %)	**345,000** (50.2 %)	**443,000** (65.6 %)	**342,000** (49.8 %)	**211,000** (31.3 %)
Sludge and putrescible organic materials from **pulp and paper mills**	1,066,000	977,000	367,000 (34 %)	331,000 (34 %)	**3,000** (0.8 %)	**4,000** (1.2 %)	**364,000** (99.2 %)	**327,000** (98.8 %)
Organic materials from ICI sector	997,000	1,019,000	29,000 (3 %)	51,000 (5 %)	**29,000** (100 %)	**37,000** (72.6 %)	**0**	**0**
Total putrescible organic materials (excluding agri-food wastes)	**4,411,000**	**3,933,000**	**1,083,000 (25 %)**	**1,057,000 (27 %)**	**377,000** (34.8 %)	**484,000** (45.8 %)	**706,000** (65.2 %)	**538,000** (50.9 %)

Sources: Compiled using Recyc-Québec (2017) and Recyc-Québec (2019b).
Table 4: Generation, recycling and disposal of municipal and paper mill residues and sludge from 2015 to 2018

	Total generated		Composting		Landspreading		Total recycled		Total disposal	
	2015	2018	2015	2018	2015	2018	2015	2018	2015	2018
Municipal sludge (in Metric Tons)	851,000	692,000	106,000 13 %	83,000 12 %	325,000 38 %	205,000 30 %	431,000 51 %	288,000 42 %	420,000 49 %	404,000 58 %
Paper mill residues and sludge (in Metric Tons)	1,066,000	977,000	3,000 (0.8 %)	4,000 (1.2 %)	364,000 (99.2 %)	327,000 (98.8 %)	367,000 34 %	331,000 (34 %)	699,000 (65.6 %)	646,000 (66.1 %)
Total municipal and paper mill sludge	**1,917,000**	**1,669,000**	**109,000**	**87,000**	**689,000**	**532,000**	**798,000** (41.6 %)	**619,000** (37.1 %)	**1,119,000** (58.4 %)	**1,050,000** (62.9 %)

Compiled using Recyc-Québec (2017) and Recyc-Québec (2019b).

Table 5: Trends in the quantities of disposed materials from 2015 to 2018 (Incineration and landfilling)

	2015	2016	2017	2018	Variation rate between 2015 and 2018 (%)
Disposal sites	82	82	82	79	-3.7
Quantities of disposed waste, excluding sludge (in Metric Tons)	**5,140,000**	**5,004,000**	**5,417,000**	**5,361,000**	**4.3**
Municipal sludge incinerated	323,000	297,000	328,000	338,000	4.8
Municipal sludge landfilled	160,000	142,000	142,000	123,000	-23
Other landfilled sludge (agri-food, industrial, etc.)	5,000	7,000	7,000	26,000	458.8
Total Disposal sludge	**487,000**	**446,000**	**477,000**	**487,000**	**0.1**
Total disposal materials	**5,627,000**	**5,450,000**	**5,894,000**	**5,848,000**	**3.9**

Sources: Compiled using Recyc-Québec (2019c).

Table 7: Pulp and paper mill biosolid emissions (N_2O and CH_4)

	Specification of PPMS	GHG emissions in ton of dry matter in CO_2e ($t\ CO_2e\ t^{-1}$ dry PPMS)	References	Observation
Landfilling	Primary	0.017	Faubert and al. (2015)	Most of the sludge produced by the pulp and paper industries in Quebec is **mixed sludge** (**primary + secondary**).
	Mixed (primary-secondary)	**0.90**		
Land application	**Mixed** (primary-secondary)	**0.12**	Faubert and al. (2015)	
Combustion	Mixed (primary-secondary) primary dominated	0.13	Faubert and al. (2015)	
	Primary-secondary-deinking	0.00057		
	Mixed (primary-secondary)	**0.014**		
Composting	/	E.F. need to be evaluated for PPMS composting (Faubert et al. (2016)		

Table 8: GHG emission factors from the management of PPMS by landfilling and land application

	Specification of PPMS	Study description and soil type		EF in CO_2e (Mg CO_2e Mg^{-1} dry PPMS)	References	Observation
Landfilling	Indifferentiated	GHG included in the emission factors in CO_2e is CH_4	**Default parameter values** • L_0=100 m^3 Mg^{-1} dry PPMS • k=0.03 y^{-1} • OX=0.1	**1.5**	NCASI (2005, 2013); Heath et al. (2010)	The majority of sludge produced by the pulp and paper industries in Quebec is mixed sludge (primary + secondary).
			Other recommended parameter values • L_0=80.5 m^3 Mg^{-1} dry PPMS • k=0.013 y^{-1} • OX=0.1	0.94		
	Low-ash	Theoretical estimation		6	Buswell & Mueller (1952); Likon & Saarela (2012); Likon & Trebše (2012)	
Land application	Unspecified	GHGs included in the emission factors in CO_2e are CH_4 and N_2O/ **Direct N_2O emission measurements from agricultural soils**	• Site location : eastern Scotland • Soil type: **sandy loam** • Crop : calabrese •Application rate : 44.4 Mg dry PPMS ha^{-1}	0.069	Baggs et al. (2002)	
	Mixed (primary-secondary) / De-inking	GHG included in the emission factors in CO_2e is N_2O/ **Time frame of the emission factors**: one snow-free season (May-October) following a single application and repeated on two sites over two consecutive seasons/ **Direct N_2O emission measurements from agricultural soils**	• Site location : eastern Canada • Soil types: **clay and silty clay** • Crop: Silage corn • C:N : 17–21 • Mixed PPMS • Application rates : 4.89–6.90 Mg dry PPMS ha^{-1} •De-inking PPMS •C:N : 61–71 •Application rates : 25.9–38.1 Mg dry PPMS ha^{-1}	0.085 – 0.12 -0.016 – -0.0038	Chantigny et al. (2013)	• EF year 1 : 0.085 • EF year 2 : 0.12 •EF year 1 : -0.016 •EF year 2 : -0.0038

	Mixed (primary-secondary)	GHG included in the emission factors in CO_2e is N_2O/ **Time frame of the emission factors** : one snow-free season (July-October) following a single application and repeated on two sites over two consecutive seasons/ **Direct GHG emission measurements from nonacidic mine tailings site prior to reforestation**	•Site location: eastern Canada •Soil type : **technosol** •LPPMS • C:N : 18.7–23.3 **Treatments** • Applications of 0, 50 or 100 Mg dry LPPMS ha^{-1} combined with absence or presence of white clover **Treatments** • 50 Mg dry LPPMS ha^{-1} •100 Mg dry LPPMS ha^{-1}	0.058 – 0.077 0.071 – 0.17	Faubert et al. (2017a)	•EF year 1 : 0.058 •EF year 2 : 0.077 •EF year 1 : 0.071 •EF year 2 : 0.17
		GHGs included in the emission factors in CO_2e are N_2O and CH_4/ **Time frame of the emission factors** : one snow-free season (May/June-October) following a single application and repeated on two sites over two consecutive seasons/ **Direct GHG emission measurements from agricultural soils**	•Site location: eastern Canada •Soil type: **clay loam** •Crop: wheat •Mixed PPMS • C:N : 17.2–17.8 • Application rates : 7.36–32.0 Mg dry PPMS ha^{-1} **Treatments** • Crop N requirements (90–120 kg ha^{-1}) supplied by a PPMS : Urea mixture, with 0, 25, 50, 75 and 100% of N derived from PPMS	0.09 – 0.48	Faubert et al. (2017 b)	•EF year 1 : 0.09 •EF year 2 : 0.48
Combustion	/	/		/	Faubert et al. (2016)	**No GHG emission factor is yet available for the combustion of PPMS**
Composting	/	/		/	Faubert et al. (2016)	**No GHG emission factors were specifically found for PPMS composting**
Method of the first order of decay, parameters • **L_0** : CH_4 generation potential (m^3 Mg^{-1} dry PPMS)/• **k** : reaction rate constant (y^{-1})/• **OX** : CH_4 oxidation factor (fraction) **Note**: 1 Mg **= 1 Megagram=** 1 Ton						

Source: Faubert et al. (2019)

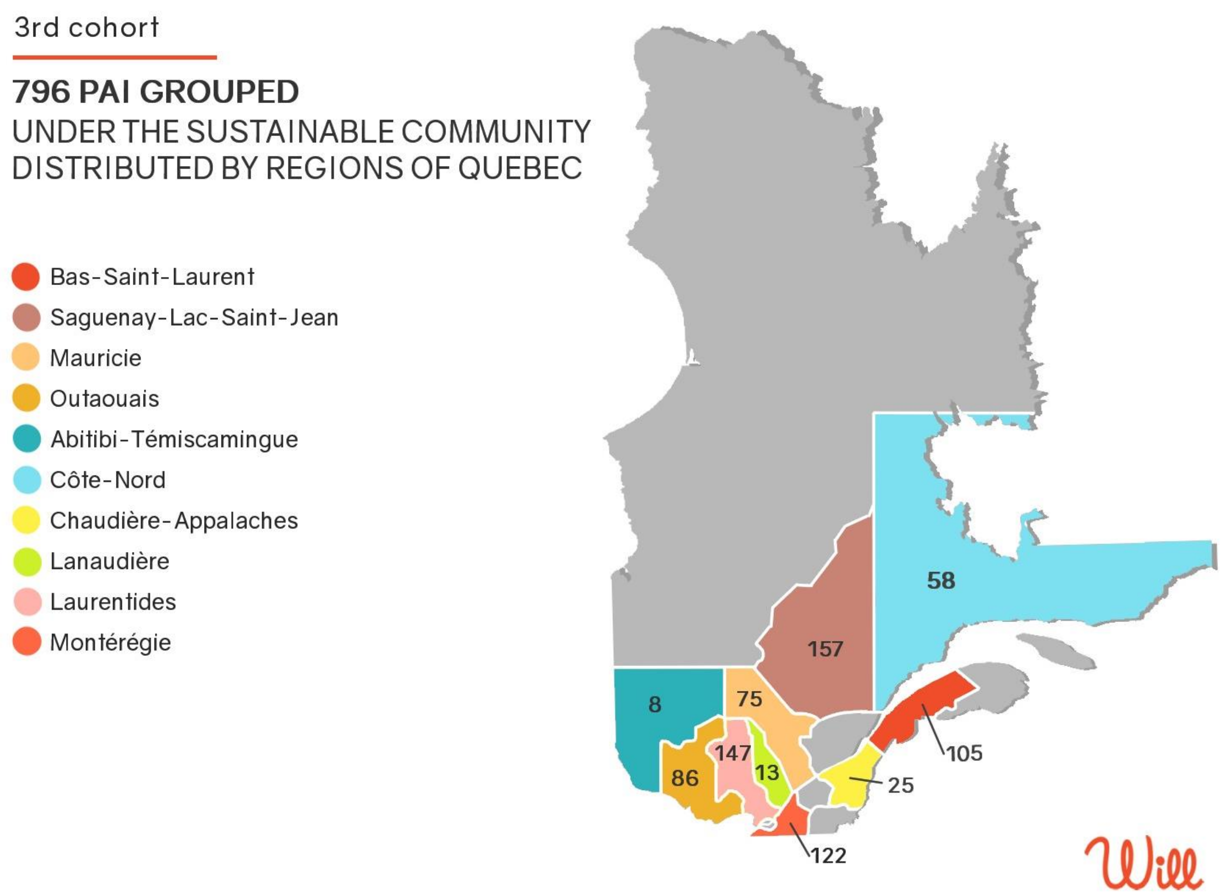
APPENDIX 4

Will's Sustainability Plan and Latest Yearly Report - June 2020

Sustainable Development Goals Report 2020 (June 2020)

APPENDIX 5

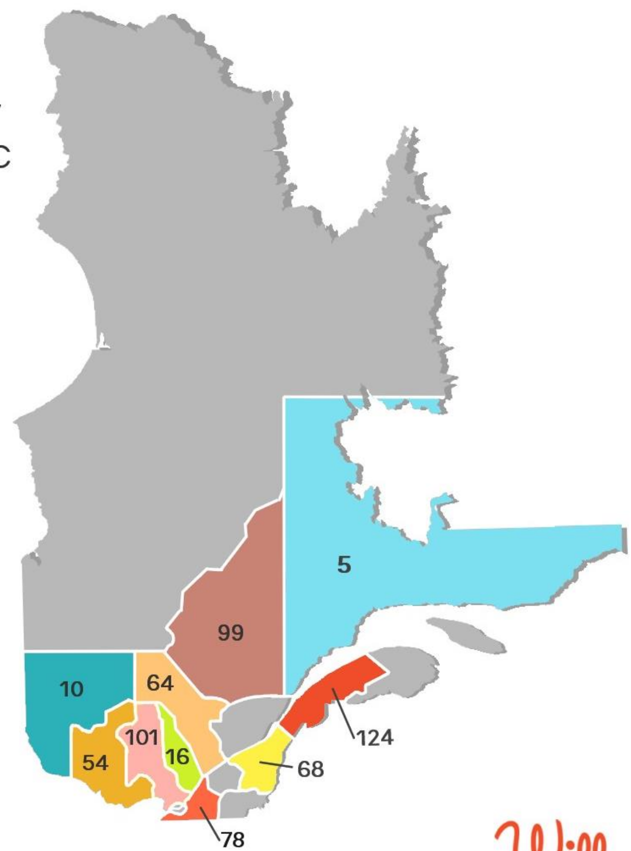
Map of the geographical Distribution of the Clients Facilities and their PAI



3rd cohort

619 BUILDINGS
FROM THE SUSTAINABLE COMMUNITY
DISTRIBUTED BY REGIONS OF QUEBEC

- Bas-Saint-Laurent
- Saguenay-Lac-Saint-Jean
- Mauricie
- Outaouais
- Abitibi-Témiscamingue
- Côte-Nord
- Chaudière-Appalaches
- Lanaudière
- Laurentides
- Montérégie



Will