



Quantification of CO₂eq Emission Reductions from Slag-based Recycling Operations by
Les Minéraux Harsco

*Greenhouse Gas Project Report
Period January 1st 2017 to December 31st 2019*

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SOMMAIRE EXÉCUTIF

(Please note that the rest of the document is in English)

Melri et Recmix, deux compagnies spécialisée dans le traitement et le conditionnement de différents produits comprenant des métaux ferreux tels que l'acier et des métaux non ferreux tels que l'alumine, ont fusionné et ont créé une nouvelle entreprise appelée *Les Entreprises Matériaux Excell* en 2005. En 2010, *Matériaux Excell* est devenu *Les Minéraux Harsco*, la succursale québécoise de la multinationale Harsco Corporation. *Les Minéraux Harsco* a son siège social à Contrecoeur au Québec et possède des installations à Sorel-Tracy.

L'entreprise recycle les scories et des résidus miniers pour les transformer en métaux ferreux, non-ferreux et divers types d'agréats. *Les Minéraux Harsco* récupère les scories qui rencontrent leurs critères. L'usine a les équipements et la technologie nécessaires afin de traiter les matières reçues, donc ses équipements permettent les opérations suivantes : écraser, tamiser, sécher et nettoyer les scories.

Le scénario de projet est le recyclage des scories et des résidus miniers et de l'industrie de la métallurgie en récupérant le métal, en utilisant la partie récupérable de la portion non métallique comme agréats pour la construction. Tout est récupéré, aucun résidu n'est envoyé à l'enfouissement. Ce scénario est comparé à la situation qui aurait été implantée c'est-à-dire pour la partie métallique, l'utilisation de matériaux vierges pour produire le métal et pour la partie non métallique, l'enfouissement et l'utilisation de ces matières pour le recouvrement des sites d'enfouissement.

Le projet et les réductions d'émissions de GES seront enregistrés au Registre des GES ÉcoProjets®. Ces réductions sont quantifiées conformément aux principes et lignes directrices de la norme ISO 14064 tel que stipulé par le Registre des GES ÉcoProjets®. La méthodologie utilisée est basée sur la méthodologie définie dans le document de l'U.S. EPA (Environmental Protection Agency of the United States) nommé : "*Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sink*"¹. Elle a été sélectionnée afin de choisir les sources, puits et réservoirs de GES à inclure dans la quantification ainsi que comme guide pour les calculs de réductions et les facteurs d'émissions.

Les réductions d'émission pour les années 2017-2018-2019 sont au nombre de :

Année	Réductions d'émission (tCO ₂ e)
2017	105 749
2018	101 368
2019	78 338

¹ SOLID WASTE MANAGEMENT AND GREENHOUSE GASES: A Life-Cycle Assessment of Emissions and Sinks, (September 2006), 3rd edition.

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ABBREVIATIONS

BS	Baseline Scenario (GHG Emission Source)
CDM	Clean Development Mechanism
CH ₄	Methane
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalent (usually expressed in metric tons)
CSA	Canadian Standards Association
EF	Emission Factor
EPA	Environmental Protection Agency (USEPA)
HDD	Heating degree day
GHG	Greenhouse gases
ISO	International Organization for Standardization
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt hour
N ₂ O	Nitrous oxide
PS	Project Scenario (GHG emission source)
SSR	Source, Sink and Reservoir
t	Ton (metric)
VERR	Verified Emission Reductions-Removals

1. INTRODUCTION

Melri and Recmix, two companies specialized in the treatment and conditioning of different products containing ferrous metals such as iron and non-ferrous metals such as alumina, merged together and created a new company called *Les Entreprises MATÉRIAUX EXCELL* in 2005. In 2010, *Matériaux Excell* became *Les Minéraux Harsco*, the Quebec's branch of the multinational Harsco Corporation. Harsco Corporation has a goal of developing environmental solutions for waste management of the metal industry. *Les Minéraux Harsco* has its head office in Contrecoeur in the province of Quebec and other sites in Sorel-Tracy.

The company recycles slag and mining waste and transforms it into ferrous and non-ferrous metals as well as aggregates (sand and different size stone). *Les Minéraux Harsco* recovers slag that meets its criteria. The plant has the equipments and technology to carry out operations such as crushing, sifting, drying, and cleaning of the slag. No contaminated material is treated at *Les Minéraux Harsco*'s plants. If some material is contaminated, contaminants are removed before being purchased by *Les Minéraux Harsco*.

The project scenario of the recycling of the entire amount of slags and mining and metal industry wastes is compare to the scenario that would have been implemented which is the use of virgin inputs for metals and the aggregates and remaining slag would have been sent to landfill or those wastes would have been used in landfill as a covering material².

Two different methodologies are selected as a reference documents for the project. Two cases are evaluated: the metal part of the waste and the remaining of slag and waste used as aggregates.

In the first case, a methodology based on a study realized for Environment Canada and Natural Resources Canada called: *Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update*³ is selected to identify the sources, sinks and reservoirs (SSRs) to be included in the quantification and chosen to offer a guideline for the calculation of emission reductions. This methodology is deemed to be the most appropriate. In fact, in the report, the SSRs that are included and the methodology that is applied slightly differ from what is stated in the methodology. Those differences are explained in section 2.8, 4 and 5.

In the second case, a methodology based on the U.S. EPA (Environmental Protection Agency of the United States) document called: “*Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sink*”⁴ and its evolution: “*Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model*

² Recyc-Québec. *Bilan 2012 de la gestion des matières résiduelles au Québec*, (2014). pp. 28-29. Internet link: <https://www.recyc-quebec.gouv.qc.ca/sites/default/files/documents/bilan-gmr-2012.pdf> et *Bilan 2015 de la gestion des matières résiduelles au Québec*, (2017), p.34. Internet link: <https://www.recyc-quebec.gouv.qc.ca/sites/default/files/documents/bilan-gmr-2015.pdf>

³ *Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update*, (October, 2005).

⁴ *SOLID WASTE MANAGEMENT AND GREENHOUSE GASES: A Life-Cycle Assessment of Emissions and Sinks*, (September 2006), 3rd edition.

(WARM): *Construction Materials Chapters*”⁵, is selected to identify the sources, sinks and reservoirs (SSRs) to be included in the quantification and chosen to offer a guideline for the calculation of emission reductions. This methodology is deemed to be the most appropriate since it is recognized by Government of Canada; for example, the tool to calculate greenhouse gases for municipal waste from government of Canada is based on the WARM tool and documentation⁶. As in the previous case, in the report, the SSRs that are included and the methodology that is applied slightly differ from what is stated in the methodology. Those differences are explained in section 2.8, 4, and 5.

In section 3, the selection of the baseline scenario and the assessment of additionality were performed according to best practices and the expertise of the quantification team. A barrier analysis is performed and used to confirm the most plausible scenario and to provide a solid argumentation on which to base the additionality assessment.

This GHG report meets the requirements of the CSA’s GHG CleanProjects® Registry and the ISO 14064-2 (2006) guidelines and principles:

- Relevance

All relevant GHG sources are meticulously selected and presented in section 4. A precise methodology is used along with project specific parameter values.

- Completeness

A complete assessment of GHG sources is made and all GHG types are considered in the applied quantification methodology. Complete information regarding project implementation, activities and GHG quantification is given through this GHG report.

- Consistency

Chosen quantification methodologies are appropriate for *Les Minéraux Harsco*’s project. The established baseline scenario, as described in section 3, is consistent with the project level of activity related to waste management of slag and other metal and mining industry waste.

- Accuracy

Calculation uncertainties are kept as small as possible.

- Transparency

Project related information is transparently communicated throughout this document so that the intended user can identify important data, how they are collected, and how the project actually leads to GHG emission reductions. Data monitoring and GHG emission reductions calculation are clearly detailed in order to provide the reader sufficient information to allow the user to confidently make decisions.

- Conservativeness

⁵ *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Construction Materials Chapters*, (May 2019), Version 15. Internet link:

https://www.epa.gov/sites/production/files/2019-06/documents/warm_v15_construction_materials.pdf

⁶ *Greenhouse gas calculator for waste management*, (August 2013). Page consulted on February 16, 2020, Internet link: <https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/municipal-solid/greenhouse-gases/calculator.html>

GHG emission reductions are not overestimated. When accuracy is jeopardized because of assumptions, conservative choices are made to make sure that GHG reductions are not overestimated.

This report will be made available for public consultation. It is intended to serve as a transparent reference document to support the prospection of potential verified emission reductions (VER) buyers.

2. PROJECT DESCRIPTION

The project consists of quantifying the greenhouse gas emissions reduction resulting from *Les Minéraux Harsco*'s activities taking place at their plants in Contrecoeur and Sorel-Tracy, in the Province of Quebec, Canada. *Les Minéraux Harsco* is the Quebec's branch of Harsco Corporation and was formerly known as *Matériaux Excell*. Post-consumer slag-based products are recycled by transforming materials recovered from different industries into sand, alumina, steel and iron oxide. Those products are sold to different industries integrating the recycled products into new products.

2.1. Project Title

Quantification of CO₂eq Emission Reductions from Slag-based Recycling Operations by *Les Minéraux Harsco*

2.2. Objectives

The objective of this project is to lower the total amount of GHG emitted by recycling slags and residues from metal industry and use them as valuable products instead of using raw material and instead of emitting GHG emissions for the manufacturing process of those products.

2.3. Project Lifetime

Expected reductions are presented for only ten years in this report since the general market situation and the regulation can change and cause a change in the baseline scenario. The start date was October 27th, 2003. The second crediting period starts January 1st, 2014 and will end December 31st, 2023 as long as the project is still additional.

2.4. Type of GHG Project

The project is one of waste management by recycling slag-based metals. Emission reductions result from a decrease of acquisition and manufacturing of raw materials leading to less GHG emissions produced since the recycling manufacturing and transportation processes emit a smaller amount of GHG emissions.

2.5. Location

Les Minéraux Harsco's head office is in Contrecoeur and its main plant is also in Contrecoeur. Their coordinates are indicated below.

Head office

Les Matériaux Harsco
1200, Route des Aciéries
Contrecoeur, (Québec)
J0L 1C0
Latitude: 45°48'24.74"N
Longitude: 73°16'23.10"W

Main plant

1499, Montée Lapierre
Contrecoeur, (Québec)
J0L 1C0
Latitude: 45°48'36.24"N
Longitude: 73°16'46.89"W

Les Minéraux Harsco's also has a garage at the address below, but the operations related to this project are done at the above-mentioned main plant.

Garage

Les Matériaux Harsco
1100, Route des Aciéries
Contrecoeur, (Québec)
J0L 1C0

2.6. Conditions prior to Project Initiation

Prior to the project activities, 2 different companies existed and they merged and opened a new plant to put the focus on their recycling activities.

2.7. Description of how the Project will achieve GHG Emission Reductions or Removal Enhancements

The project is the recycling of the slags and residues from mining and metal industry. The manufactured recycled products are compared to the situation that would have happened if they were not made from waste but from the actual mix of raw material and recycled inputs and takes account of the manufacturing processes that would have been used. The comparison is made based on a life cycle methodology for the calculations of GHG emissions. The change in GHG emissions is calculated to show how source reduction and recycling affect emissions of raw material acquisition and manufacturing processes. For the latter case, it requires energy intensive upstream processes which translate in significant GHG emissions. In the case of recycling, the energy required is far less so the GHG emissions are significantly reduced compared to the usual processes from raw material.

2.8. Project Technologies, Products, Services and Expected Level of Activity

The goal is to divert as much waste from the landfill to be recycled to provide aggregates or metals from those recuperated waste (project scenario) instead of the use of virgin inputs using the usual manufacturing processes (baseline scenario). To be able to realize the project scenario, the waste and slags need to be recuperated, crushed, sifted, dried, and cleaned.

A literature review of different methodologies, protocols and various studies which include detailed information on the methodology used has been done. None of the Clean Development Mechanism, Verified Carbon Standard methodologies and Climate Action Reserve protocols is suitable. Two studies conducted for National Entities have been selected and are presented in the following discussion, one for the metal portion of the waste and one for the remaining waste. The two studies are necessary since none of them cover both portions of the waste.

In the case of metal recycling, the *Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update study*⁷ is used. The methodology used in this study leads to diverse data such as energy consumed or avoided for different waste

⁷ *Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update*, (October, 2005).

management options for many materials and other data such as emissions related to those options and those materials. The emissions are calculated from the energy consumed or avoided and lead to an aggregated emission factor. The data of energy consumed or avoided will be used since it reflects the energy related to the processes and transportation through a life cycle study and since the processes GHG emissions are mainly due to the energy use. Data for the appropriate energy emissions factors included in the *National Inventory Report (NIR) 1990-2017*⁸ of Canada will be used to transfer the energy data from the study into the corresponding level of emissions for Canada and when the data is available directly for the province of Quebec. Doing so, the calculated values can have the rigor of the data from the study but can represent the site specific reality of the project. The end products sold all come from ferrous metals and they are all products containing iron with a content of carbon (steel, stainless steel or cast iron) or from the steel production process (calamine: oxide layer on steel), they are all assimilated to steel for the calculation. This is considered relatively fair since the end products production derived from iron involves very similar energy-intensive processes.

For the case of the aggregates, the EPA *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)*⁹ study is used. The methodology employed in this study leads to diverse data such as energy consumed or avoided for different waste management options for many materials and other data such as emissions related to those options and those materials. The emissions are calculated from the energy consumed or avoided and lead to an aggregated emission factor. The aggregated factor is reverse engineered to picture which quantity of each GHG is emitted. This can be done because the overall GHG emissions amount stays the same and it is only possible in this case because of the simplicity of the processes related to recycling, manufacturing and transportation of aggregates that can all be assimilated to mobile or fixe equipments using diesel combustion engines. All aggregates are assimilated to asphalt concrete category because the composition is essentially the same, as per the document definition: “*Asphalt concrete is composed primarily of aggregate, which consists of hard, graduated fragments of sand, gravel, crushed stone, slag, rock dust or powder*”¹⁰, the only difference will be the binding agent used in asphalt. Further details on the data used are shown in section 4 and 5.

2.9. Aggregate GHG Emission Reductions and Removal Enhancements likely to occur from the GHG Project

A first report was done at the end of 2009 to report emissions for years 2003 to 2007. A second report was produced for the year 2014, a third for year 2015 and a fourth one for 2016. This is the fifth report for the project and it reports emissions for the years 2017, 2018, and 2019.

⁸ *National Inventory Report 1990-2017: Greenhouse Gas Sources and Sinks*, (2019).

⁹ *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)* (May 2019), Version 15. Internet link: <https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-energy-and-economic-factors-used-waste-reduction>

¹⁰ *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)* (May 2019): Background and Overview, Version 15. p. 1-10. Internet link: https://www.epa.gov/sites/production/files/2019-06/documents/warm_v15_background.pdf

We can assume that this is the second crediting period for the project. Since *Les Minéraux Harsco* is the only company to recycle those wastes and to market them in valuable and good quality products, a second crediting period of 10 years (ending in year 2023) is conceivable and seems adequate. The viability of the project will be revalidated at each report submitted.

Table 2.1: Expected and Achieved Emission Reductions (t CO₂e)

Year	Expected Emission Reductions (t CO ₂ e)	Achieved Emission Reductions (t CO ₂ e)
2003	24 000	108 468
2004	142 000	149 467
2005	142 000	124 751
2006	142 000	141 145
2007	142 000	154 774
2014	142 000	148 565
2015	142 000	180 369
2016	142 000	137 879
2017	142 000	105 749
2018	142 000	101 368
2019	142 000	78 338
2020	142 000	
2021	142 000	
2022	142 000	
2023	142 000	
TOTAL	2 012 000	1 430 873

2.10. Identification of Risks

Major changes in the Quebec market for the slags and mining and metal industry residues could be problematic if the project scenario becomes a common way to deal with those wastes, the project would no longer be additional. A change in the regulation could also lead to the same problem if recycling of slags and mining and metal industry residues becomes mandatory. Regulation and the Quebec market for those residues and co-products will be monitored for each report to make sure that the project is still additional.

The Regulation respecting a cap-and-trade system for greenhouse gas emission allowances¹¹ was identified as a risk for this project, but this is a project regarding recycling materials not an energy efficiency project. Les minéraux Harsco is not subjected to the regulation meaning it is not on the list of the subjected sites¹². Furthermore, this project doesn't lead to less emissions at Harsco site; even though the quantification of the sources, sinks and reservoirs is translated in fuel consumption, this project is not related to the regulation since the emission reductions are due to the avoidance of production of raw materials and avoidance of landfilling the materials that are recycled. In comparison, the regulation allows companies such as Les minéraux Harsco to develop projects and to participate to the cap-and-trade system via offset credits (*crédits compensatoires*) issued by the government. Those projects include fuel consumption and are still valid projects accepted by the government; therefore, this project, just like those projects for offset credits allowed in the regulation, leads to no overlapping nor double counting with the cap-and-trade regulation.

Even if the study *Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update study* is now a more than 10-year old document, the newest version of the *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)* still refer to that study. Moreover, the energy quantities required for the processes should remain equivalent for the same processes and the emission factors for the various energy sources used are those from the latest NIR to be able to be the most accurate.

Furthermore, the EPA document used for the methodology is completed by a tool and documentation which offer updated emission factors based on the latest studies and statistics. If this tool and its related documents are not being supported anymore and are no longer updated, the data for emission factors can be outdated and no longer usable. Another appropriate methodology would need to be found or to be developed for the calculation related to aggregates to pursue the GHG project. This is more a long-term risk since the data have been updated in May 2019 for both the tool (model)¹³ and its documentation¹⁴.

This emission reductions report was written according to ISO 14064-2 Specifications Requirements for quantification, monitoring and reporting of greenhouse gas emission reductions and removal enhancements assertions. In order to minimize risks, the methodology and GHG emission factors were selected based on their completeness and their international recognition.

¹¹ Gouvernement du Québec, *Regulation respecting a cap-and-trade system for greenhouse gas emission allowances* chapter Q-2, r. 46.1, Internet link : <http://legisquebec.gouv.qc.ca/en/ShowDoc/cr/Q-2,%20r.%2046.1>

¹² Gouvernement du Québec. *Émetteurs visés par le règlement concernant le système de plafonnement et d'échange de droits d'émission de gaz à effet de serre, par établissement et par année, et participants inscrits au système*, Internet link : <http://www.environnement.gouv.qc.ca/changements/carbone/etablissements-SPEDE.pdf>

¹³ *Waste Reduction Model (WARM)*, (May 2019). Internet link: <https://www.epa.gov/warm/versions-waste-reduction-model-warm#15>

¹⁴ *Documentation for the Waste Reduction Model (WARM)*, (May 2019), Version 15. Internet link: <https://www.epa.gov/warm/documentation-waste-reduction-model-warm#documentation>

2.11. Roles and Responsibilities

2.11.1 Project Proponent and Representative

Les minéraux Harsco

M. Gaétan Veilleux
Directeur de site
1200 route des Aciéries
Contrecoeur, Québec
J0L 1C0
GVeilleux@harsco.com
450-587-8000

2.11.2 Monitoring and Data Collection

Les minéraux Harsco is responsible for the project implementation and data monitoring. Data are provided by Richard Provençal, in charge of the quality, the environment and technical support in the company.

Les minéraux Harsco

Richard Provençal
Quality - Environment - Technical Support
1200 route des Aciéries
Contrecoeur, Québec
J0L 1C0
rprovençal@harsco.com
450-587-8000

2.11.3 Quantification and reporting Responsible Entity

Écocrédit is a firm specialized in non-traditional corporate financing. An expertise has been developed in the quantification of GHG emissions. Services are offered for GHG inventory, GHG emissions reduction project implementation, GHG markets advising, regulatory requirements and much more.

Joséanne Bélanger-Gravel works as consultant of energy, environment and clean technologies. She has a mechanical engineering degree from Université de Sherbrooke and EPF-École d'ingénieurs de Sceaux in France. She also completed an engineering master degree in renewable energies and a second master in environment with a specialization in sustainable development. With over 7 years of experience, she also developed a keen expertise on the carbon market and GHG reduction projects. She is responsible for GHG project planning and development and acts as team leader in this project.

Joséanne Bélanger-Gravel, B.Eng, M.A.Sc, M.Env.

Consultant - Energy, Environment & Clean Technologies
joseanne.bg@gmail.com
438-275-7499

2.11.4 Authorized Project Contact

Me Jean Dionne has the signing authority for Écocredit. He is authorized by the project proponent to perform requests and administrative tasks regarding the project registration.

Me Jean Dionne

Président

Écocredit

jdionne@gestionenviro.com

(418) 806-1781

2.12. Project eligibility under the GHG Program

The project is eligible under the GHG CleanProjects® Registry. It is implemented following the ISO 14064-2 guidelines and principles, is not attempted to be registered under another GHG program and does not create any other environmental credit.

2.13. Environmental Impact Assessment

There are limitations to the use of the wastes treated by *Les Minéraux Harsco* especially for aggregates. A valorization agreement exists between *Les Minéraux Harsco* and the government of Quebec to identify the specific uses for the aggregates. *Les Minéraux Harsco* complies with the local regulation.

The very nature of the project and of the company is to limit or diminish the impacts of the residues on the environment. Other than reducing GHG emissions, recycling those wastes provides a safer way to manage them since the treatment and conditioning help to extract the maximum of the metals in the wastes which means less metals oxides leakage in the environment. Ferrous oxides are already present in important quantities in nature so their impact is limited but non-ferrous oxides can be damaging for the environment. Other waste management methods such as combustion can be more damaging for the environment so recycling those residues is beneficial on many aspects for the environment not only for GHG emission reductions: less contaminants in general and less raw materials extraction as examples.

Moreover, the company is certified ISO14001:2004 which demonstrates its commitment to manage its environmental impacts.

2.14. Socio-Economic Impact Assessment

Les Minéraux Harsco helps the economic development of the region of Sorel and represents well its values related to sustainable development by merging economic development and environmental protection. *Les minéraux Harsco* offers jobs to around 90 qualified employees and promote innovation and expertise to continue offering high quality products.

2.15. Stakeholder Consultations and Mechanism for on-going

Les Minéraux Harsco is responsible for the communications with the quantifier, the verifier and with all relevant stakeholders within and outside the company. The company has an open

dialog with the city and presents the city and the government with all the required reports and documentation.

2.16. Detailed Chronological Plan

In the first crediting period, one report was done for years 2003 to 2007. The project start date was October 27th 2003. The project second crediting period started in 2014 and will end in 2023. A second report was produced for year 2014, a third one for year 2015, and a fourth for year 2016. GHG emission reductions are reported in this report for the years 2017, 2018, and 2019. This is the fifth report.

Table 2.2: Chronological Plan

	Date	Steps in Process
Before Project Implementation	-	-
During Project	October 27 th , 2003	Project start date
	2009	1 st GHG report covering 2003-2007
	2015	2 nd GHG report covering 2014
	2016	3 rd GHG report covering 2015
	2017	4 th GHG report covering 2016
	2020	5 th GHG report covering 2017, 2018 and 2019
After Project	-	-

2.17. Ownership

Matériaux Excell is the name under which Nova Scotia Company (3230907) operated in Quebec. Nova Scotia Company (3230907) has been constituted in 2005 from a fusion of Nova Scotia Company (3191285) and Harsco Metal Canada Inc. Since 2010, the company operates under the name *Les Minéraux Harsco* in Quebec. Legal documents can be produced if additional proof is necessary. *Les Minéraux Harsco* owns the subsequent credits.

3. SELECTION OF THE BASELINE SCENARIO AND ASSESSMENT OF ADDITIONALITY

The baseline scenario is selected among alternative scenarios representing what would have happened in the absence of this project. The alternative scenario that is most likely to occur is selected as the baseline scenario.

Scenarios identified are options normally used for waste management and that are included in the two main studies used as reference for this report^{15,16}. Those waste management options normally include landfill, combustion, compost, and recycling and source reducing. In the case of reducing and recycling, the acquisition and manufacturing of the products are also taking into account and the production of the recycled product is compared to the one that would have happened otherwise which is the production of the end use product with virgin inputs or the current mix inputs (partially from virgin inputs and partially from recycled inputs) depending of the product and studies. The options for the baseline scenario can be summarized as the use of virgin inputs and one of the following waste management options:

Option 1: landfill

Option 2: combustion

Option 3: compost

Option 4: recycling or source reducing the co-products

The waste received by *Les minéraux Harsco* can be qualified in two categories of end use products once processed: metals and aggregates. With each of those products, a baseline scenario is associated in the case of recycling or source reducing.

Landfill can be a plausible scenario because the residues can be safely managed and no non-ferrous oxides can leak and damaged the environment. In Quebec, in the 2012 guide for landfill, it is cited that slags can be used as an alternative for covering materials¹⁷. Aggregates can go to compost but if there is a possibility that the aggregates still contain a great amount of non ferrous oxides, it can be damaging for the environment. One composting site was accepting slags in Quebec but it is now closed as per the enterprise register of Quebec.¹⁸ Combustion is not recommended because when metals are in a combustion chamber it takes all the heat and that diminishes the effect of the combustion process on other waste, resulting in waste not being fully combusted. Furthermore, the ashes will contain a high level of metals which can be toxic for the environment and cannot be used for any purposes, therefore

¹⁵ *Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update*, (October, 2005).

¹⁶ *Documentation for the Waste Reduction Model (WARM)*, (May 2019), Version 15. Internet link: <https://www.epa.gov/warm/documentation-waste-reduction-model-warm#documentation>

¹⁷ Gouvernement du Québec. *Guide d'application du règlement sur l'enfouissement et l'incinération de matières résiduelles (REIMR)*. Internet link: <http://www.environnement.gouv.qc.ca/matieres/reglement/Guide-application-REIMR.pdf>

¹⁸ Recyc-Québec. *Guide sur la collecte et le compostage des matières organiques du secteur municipal: Document technique*. (2006). Internet link: <http://www.recyc-quebec.gouv.qc.ca/upload/publications/MICI/GuideCollCompostMatOrgMun.pdf>

combustion for those kinds of waste is not recommended. Recycling is the other option left besides landfilling, more metal is extracted from the slags and the residues are used mostly as aggregates for mainly construction purposes.

Table 3.1: Barrier Assessment

Potential Barrier	Baseline Landfilling	Project Scenario Recycling	Other Scenario Compost	Other Scenario Combustion
Law and regulation	Not a barrier	Barrier Specific agreement needs to be made with the government of Quebec.	Barrier Compost needs to meet specific standards.	Not a barrier
Financial	Not a barrier	Barrier Manufacturing of recycled products needs equipments which lead to substantial investments.	Not a barrier	Not a barrier
Technology/ feasibility	Not a barrier	Barrier Manufacturing of recycled products needs research and development to stay competitive with products manufactured by virgin inputs.	Not a barrier	Barrier Not recommended since it affect the combustion of other waste in the combustion chamber.
Common practice	Not a barrier	Barrier A very few companies are specialized in the waste management of those waste. Most companies recuperated and recycled metals from scraped metals not from slags and other mining and metals industry waste.	Barrier Not often chosen because it can affect the quality of the compost.	Barrier Not a recommended option.

For the assessment of additionality of the project scenario, a barrier analysis has been performed.

The compost and combustion options have barriers since the waste recuperated by *Les minéraux Harsco* can alter the process or the product of those waste management options and those situations are not wanted. Those options are ruled out.

Sending the recuperated waste to landfill is the usual option and presents no barrier to its implementation, therefore this option is the baseline scenario.

The recycling option is chosen as the project scenario and it has a few barriers. Concerning the law and regulation barrier, the use of the aggregates made from the recuperated waste is regulated and a specific agreement with the government of Quebec is needed to define uses allowed for those waste. The financial barrier is important. The equipments required to process the recuperated waste necessitate substantial investments and are more complex than those used in landfill or for compost. Those equipments also need regular maintenance and repair, and specific training for the employees. The quantities treated and involved are important and need a site with an important size to accommodate the materials and equipments. Discussing the technology / feasibility barrier, specific knowledge, equipments and research and development is needed to keep the recycled products valuable products on the market to compete the products made from virgin inputs.

A company such as *Les minéraux Harsco* cannot be improvised since the project of recycling need important planning regarding law and regulation, specific know-how (employees, R&D, maintenance and repair, etc.) and substantial financial resources (site, equipments, repair, etc.) to process those waste. Furthermore, this is the only company in Canada processing this kind of waste and one of the few internationally.

4. IDENTIFICATION AND SELECTION OF GHG SOURCES, SINKS AND RESERVOIRS

The SSRs for the baseline and the project scenarios are identified in the table below which also indicates whether they are included or excluded from the quantification and whether they are controlled, related, or affected. Since the calculations used 2 different studies based on the end use products: metals and aggregates, the SSRs for the baseline and project scenarios will be presented separately for both products. Even if the two reference studies have a very similar approach, they both advice to use the data presented in the study for both the project and baseline scenarios, so not to use them separately. The goal is to obtain more accurate and consistent results. The first case to be studied is the metal portion of the waste. In the second case, the remaining of the waste is studied: aggregates and ultimate waste.

In the first case, the “*Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*”¹⁹ has been chosen because the methodology is well described and the selection of GHG sources, sinks, and reservoirs accounted for in the data presented for the quantification is well described as well. Furthermore, the material, steel, is considered and analysed in that study. All the metals recuperated is associated to the category of the study named steel. This hypothesis has been made since steel is the most important metals to be treated in quantity by the company and all the metals are related pricewise to the one of steel. The exhibit 2-1 of the study (see next image) presents the SSRs included and the philosophy behind the methodology for the calculations for all the management options and all the materials included in that study. First, the SSRs for the process for raw materials acquisition and manufacturing/fabrication are considered, then the carbon change in the forest or soil carbon sink is taken into account and finally the GHG emissions directly related to the waste management option are accounted for.

¹⁹ *SOLID WASTE MANAGEMENT AND GREENHOUSE GASES: A Life-Cycle Assessment of Emissions and Sinks*, (September 2006), 3rd edition.

Exhibit 2-1. Components of Net Emissions for Various Waste Management Options

Solid Waste Management Strategy	GHG Sources and Sinks		
	<i>Process GHGs from Raw Materials Acquisition and Manufacturing/Fabrication</i>	<i>Change in Forest or Soil Carbon Sink</i>	<i>Waste Management GHG Emissions and Sinks</i>
Recycling	Decrease in GHG emissions due to lower energy requirements (compared to manufacture/fabrication from virgin inputs) and avoided process non-energy GHGs	Increase in forest carbon sink associated with forest products	Process emissions are counted in the manufacturing stage
Aerobic Composting	No emissions/sinks*	Possible increase in soil carbon after application of compost	Compost machinery emissions
Anaerobic Digestion	Baseline process emissions due to manufacture/fabrication from the current mix of virgin and recycled inputs	Possible increase in soil carbon after application of compost	Avoided utility emissions, no CH ₄ emissions (because capture efficiency is assumed to be 100%)
Combustion	Baseline process emissions due to manufacture/fabrication from the current mix of virgin and recycled inputs	No change	Nonbiogenic CO ₂ , N ₂ O emissions, avoided utility emissions
Landfilling	Baseline process emissions due to manufacture/fabrication from the current mix of virgin and recycled inputs	No change	CH ₄ emissions, long-term carbon sink, avoided utility emissions (in cases where CH ₄ is recovered for energy)

* No manufacturing GHG emissions are considered for composting of food scraps and yard trimmings because these materials are not considered to be manufactured.

The specific SSRs analysed for the particular case of steel are presented in the next two tables for the baseline scenario and for the project scenario. GHG accounted for are CO₂, CH₄ and N₂O since emissions are mostly related to fuel combustion. Those are also the GHG taken into account in the reference study for the combustion of fuel. PFC, HFC and SF₆ are not included in the quantification since those emissions are not related to fuel combustion.

Table 4.1: SSR's Baseline Scenario Inventory for Steel - Virgin Production of Steel

SSR - Baseline	Included / Excluded	Controlled/ Related / Affected	GHG	Explanation
Raw Materials Acquisition Process	Included	Affected	CO2 CH4 N2O	---
Manufacturing Process - Energy	Included	Affected	CO2 CH4 N2O	---
Manufacturing Process - Non-Energy	Excluded	---	---	The GHG emissions come from essentially the large amount of fuel combusted to provide the energy needed in the process. Not including the manufacturing process for non-energy related processes is conservative. The GHG emissions would be much higher in the case of the baseline scenario than for the case of the project scenario, therefore the GHG emissions are not overestimated.
Transportation	Included	Affected	CO2 CH4 N2O	Transportation accounts for GHG emissions related to transport for each steps: raw materials acquisition, manufacturing, and transportation to end use with an average of 426km for the last one.

Table 4.2: SSR's Project Inventory for Steel - Recycled Production of Steel

SSR - Project	Included / Excluded	Controlled/ Related / Affected	GHG	Explanation
Raw Materials Acquisition Process	Included	Related	CO2 CH4 N2O	The raw materials acquisition for recycled production is considered as the processes required to separate metals or steel from other products.
Manufacturing Process - Energy	Included	Controlled	CO2 CH4 N2O	Those are the GHG emissions related to the manufacturing of the recycled inputs into the final product.
Manufacturing Process - Non-Energy	Excluded	---	---	The GHG emissions come from essentially the large amount of fuel combusted to provide the energy needed in the process especially for the recycled inputs.
Transportation	Included	Related	CO2 CH4 N2O	Transportation accounts for GHG emissions related to transport for each steps: raw materials acquisition, manufacturing, and transportation to end use with an average of 426km for the last one.

In the second case, the “*Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)*”^{20,21} (and its update) has been chosen for the same reason as the previous one and because the type of materials is well analysed and presented in that study. The aggregates and ultimate waste is associated to the category of asphalt concrete in the study since their constitution is roughly the same (asphalt concrete is made of 94.8% of aggregates)²² and the end use of aggregates is for the construction of roads, therefore most probably used as asphalt. Moreover the processes and equipments involved are highly similar.

²⁰ *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)*, (March 2015), Version 13.

²¹ *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Construction Materials Chapters*, (May 2019), Version 15. Internet link:

https://www.epa.gov/sites/production/files/2019-06/documents/warm_v15_construction_materials.pdf

²² Idem. p.1-3

The study presents at Exhibit 1-2 the sources and sinks considered in the model specifically for the category of asphalt concrete.

Exhibit 1-2: Asphalt Concrete GHG Sources and Sinks from Relevant Materials Management Pathways

Materials Management Strategies for Asphalt Concrete	GHG Sources and Sinks Relevant to Asphalt Concrete		
	Raw Materials Acquisition and Manufacturing	Changes in Forest or Soil Carbon Storage	End of Life
Source Reduction	Offsets • Avoided process energy emissions, including aggregate production, asphalt binder production, combination of asphalt and binder • Avoided transportation for production of virgin crude oil • Avoided transportation of asphalt concrete materials to roadway project	NA	NA
Recycling	Offsets • Avoided virgin material extraction • Avoided process energy for aggregate and asphalt binder production • Avoided virgin material transport (especially crude oil)	NA	Emissions • Extraction/recovery • Transport to mixing plant • Crushing and remixing of asphalt concrete
Composting	Not applicable because asphalt concrete cannot be composted		
Combustion	Not modeled in WARM		
Landfilling	NA	NA	Emissions • Transport to construction and demolition landfill • Landfilling machinery
Anaerobic Digestion	Not applicable because asphalt concrete cannot be anaerobically digested		

NA = Not applicable.

GHG accounted for are CO₂, CH₄ and N₂O since emissions are related to fuel combustion. Those are also the GHG taken into account in the reference study for the combustion of fuel. PFC, HFC and SF₆ are not included in the quantification since those emissions are not related to fuel combustion.

In the specific case of the project scenario of this report, the entire amount of material received is recycled; therefore there is no ultimate waste sent to landfill. The remaining material is classified, stored and, kept to be used another year. Since there is transportation and the use of machinery on site to place the remaining material, the storage operation is considered highly similar to the operations of landfilling described in the above-mentioned study.

Table 4.3: SSR's Baseline Scenario Inventory for Aggregates - Virgin Inputs

SSR - Baseline	Included / Excluded	Controlled/ Related / Affected	GHG	Explanation
Virgin inputs process	Excluded from baseline	---	---	The study prescribes to account for GHG emissions avoided in the project scenario for recycling instead of putting those emissions in the baseline scenario. This is what has been done in this report to be consistent with the approach and methodology describes in the reference study.
Virgin inputs transportation	Excluded from baseline	---	---	
Landfill - transportation	Included	Related	CO2 CH4 N2O	The GHG emissions for fuel combustion are included.
Landfill - operating equipment	Included	Related	CO2 CH4 N2O	The GHG emissions related to operating equipment are included/studied but no GHG emission is emitted for the landfill of asphalt concrete according to the study.

Table 4.4: SSR's Project Inventory for Aggregates - Recycled Inputs

SSR - Project	Included / Excluded	Controlled/ Related / Affected	GHG	Explanation
Avoided virgin inputs process	Included	Affected	CO2 CH4 N2O	The study prescribes to account for GHG emissions avoided in the project scenario for recycling instead of putting those emissions in the baseline scenario, therefore those emissions have a negative value.
Avoided virgin inputs transportation	Included	Affected	CO2 CH4 N2O	
Recycled inputs manufacturing	Included	Controlled	CO2 CH4 N2O	All GHG emissions related to operations related to recycled inputs acquisition and the manufacturing are calculated here.
Landfill - transportation (or storage operations)	Included	Related	CO2 CH4 N2O	The GHG emissions for fuel combustion are included.
Landfill - operating equipment (or storage operations)	Included	Related	CO2 CH4 N2O	The GHG emissions related to operating equipment are included/studied but no GHG emission is emitted for the landfill of asphalt concrete according to the study.

5. QUANTIFICATION OF GHG EMISSIONS AND REMOVALS

As it was done for the identification and selection of SSRs, two studies are used as reference and those studies are also the reference for the methodology for the calculations and they will be further described in this section. Like it was done in the previous section, the metal portion and the remaining of the waste (non metal portion) are studied separately.

5.1. Baseline and Project GHG Emissions for Steel

For the metal portion the methodology explained in this study is used: “*SOLID WASTE MANAGEMENT AND GREENHOUSE GASES: A Life-Cycle Assessment of Emissions and Sinks*”²³. In the above mentioned document, emission factors and energy factors are elaborated from national studies and renowned expert studies. The study presents an aggregated emission factor which account for energy, transportation and non-energy processes. Since the standard requires a non-aggregated factor, the disaggregated energy factor is used. This is deemed to be conservative because it doesn't account for the non-energy process emissions. In that case, emissions come mostly from energy processes. Furthermore, the baseline scenario would have more process non-energy emissions than the project therefore the GHG emissions are not overestimated.

The energy factor account for energy used for raw materials acquisition, manufacturing and transportation and the energy embedded in materials that are consumed during the manufacturing processes. The disaggregated energy factor is presented per categories (raw materials acquisition, manufacturing, and transportation) and per type of materials or energy types (electricity, coal, natural gas, diesel, LPG, residual fuel, gasoline, oil/lubricant, and petroleum). In the case of the metal portion of the waste, the category related to is steel. In the study for the steel category, no LPG, residual fuel and oil/lubricant is accounted for. The petroleum is not included since it is normally used / consumed for electrodes in the manufacturing process, not combusted.

To be able to have non aggregated emission factors, the energy factors par energy types (GJ/metric tonne) are used²⁴ and converted in the unit appropriate for each type of energy per metric tonne using the RDOCECA²⁵ higher heating value (HHV). It is done for both scenarios: baseline (virgin inputs) and project (recycled inputs).

$\text{EnFelec} = \text{EnFGJelec} * \text{CF}$

EnFelec = Energy factor of electricity (kWh / tonne of steel)

²³ *SOLID WASTE MANAGEMENT AND GREENHOUSE GASES: A Life-Cycle Assessment of Emissions and Sinks*, (September 2006), 3rd edition.

²⁴ Idem pp. 127-128

²⁵ RDOCECA - *Règlement sur la déclaration obligatoire de certaines émissions de contaminants dans l'atmosphère*, (November 2019). Tableau 1-1. Internet link : RDOCECA - *Règlement sur la déclaration obligatoire de certaines émissions de contaminants dans l'atmosphère*, (November 2019). Tableau 1-1. <http://legisquebec.gouv.qc.ca/fr/ShowDoc/cr/Q-2,%20r.%2015>

EnFGJelec = Energy factor of electricity (GJ / tonne of steel)

CF = conversion factor for unit conversion

$$\text{EnFcoal} = \text{EnFGJcoal} / \text{HHVcoal} * \text{CF}$$

EnFcoal = Energy factor (tonne of coal / tonne of steel)

EnFGJcoal = Energy factors (GJ / tonne of steel)

HHVcoal = Higher heating value (GJ / tonne)

CF = conversion factor for unit conversion

$$\text{EnFng} = \text{EnFGJng} / \text{HHVng} * \text{CF}$$

EnFng = Energy factor of natural gas (m3 / tonne of steel)

EnFGJng = Energy factor of natural gas (GJ / tonne of steel)

HHVng = Higher heating value of natural gas (m3 / GJ)

CF = conversion factor for unit conversion

$$\text{EnFdiesel} = \text{EnFGJdiesel} / \text{HHVdiesel} * \text{CF}$$

EnFdiesel = Energy factor of diesel (L / tonne of steel)

EnFGJdiesel = Energy factor of diesel (GJ / tonne of steel)

HHVdiesel = Higher heating value of diesel (GJ / kL)

CF = conversion factor for unit conversion

$$\text{EnFoil} = \text{EnFGJoil} / \text{HHVoil} * \text{CF}$$

EnFoil = Energy factor of light fuel oil (L / tonne of steel)

EnFGJoil = Energy factor of light fuel oil (GJ / tonne of steel)

HHVoil = Higher heating value of light fuel oil (GJ / kL)

CF = conversion factor for unit conversion

$$\text{EnFgas} = \text{EnFGJgas} / \text{HHVgas} * \text{CF}$$

EnFgas = Energy factor of diesel (L / tonne of steel)

EnFGJgas = Energy factor of diesel (GJ / tonne of steel)

HHVgas = Higher heating value of diesel (GJ / kL)

CF = conversion factor for unit conversion

Then the quantities are calculated for the energy use for each type of energy using the quantity of steel recycled and the above calculated energy factor for both cases: baseline scenario and project scenario. In each scenario, the emissions are calculated for each category: raw materials acquisition, manufacturing, and transportation.

$$E_{elec} = Q_{steel} * E_{nFelec} * (E_{Felec,co2} + E_{Felec,ch4} * GWP_{ch4} + E_{Felec,n2o} * GWP_{n2o}) * 0.000\ 001$$

E_{elec} = Emissions related to electricity consumption (tCO₂e)

Q_{steel} = Quantity of steel recycled (metric tonne)

$E_{Felec,co2}$, $E_{Felec,ch4}$, $E_{Felec,n2o}$ = Emission factors for CO₂, CH₄ and N₂O emissions related to electricity consumption (g/kWh)

$$E_{coal} = Q_{steel} * E_{nFocal} * (E_{Fcoal,co2} + E_{Fcoal,ch4} * GWP_{ch4} + E_{Fcoal,n2o} * GWP_{n2o}) * 0.001$$

E_{coal} = Emissions related to coal consumption (tCO₂e)

Q_{steel} = Quantity of steel recycled (metric tonne)

$E_{Fcoal,co2}$ = Emission factors for CO₂ emissions related to electricity consumption (kg/tonne of coal)

$E_{Fcoal,ch4}$, $E_{Fcoal,n2o}$ = Emission factors for CH₄ and N₂O emissions related to coal consumption (g/kg)

$$E_{ng} = Q_{steel} * E_{nFng} * (E_{Fng,co2} + E_{Fng,ch4} * GWP_{ch4} + E_{Fng,n2o} * GWP_{n2o}) * 0.000\ 001$$

E_{ng} = Emissions related to natural gas consumption (tCO₂e)

Q_{steel} = Quantity of steel recycled (metric tonne)

$E_{Fng,co2}$, $E_{Fng,ch4}$, $E_{Fng,n2o}$ = Emission factors for CO₂, CH₄ and N₂O emissions related to natural gas consumption (g/m³)

$$E_{diesel} = Q_{steel} * E_{nFdiesel} * (E_{Fdiesel,co2} + E_{Fdiesel,ch4} * GWP_{ch4} + E_{Fdiesel,n2o} * GWP_{n2o}) * 0.000\ 001$$

E_{diesel} = Emissions related to diesel consumption (tCO₂e)

Q_{steel} = Quantity of steel recycled (metric tonne)

$E_{Fdiesel,co2}$, $E_{Fdiesel,ch4}$, $E_{Fdiesel,n2o}$ = Emission factors for CO₂, CH₄ and N₂O emissions related to diesel consumption (g/L)

$$E_{oil} = Q_{steel} * E_{nFoil} * (E_{Foil,co2} + E_{Foil,ch4} * GWP_{ch4} + E_{Foil,n2o} * GWP_{n2o}) * 0.000\ 001$$

E_{oil} = Emissions related to light fuel oil consumption (tCO₂e)

Q_{steel} = Quantity of steel recycled (metric tonne)

$E_{Foil,co2}$, $E_{Foil,ch4}$, $E_{Foil,n2o}$ = Emission factors for CO₂, CH₄ and N₂O emissions related to light fuel oil consumption (g/L)

$$E_{gas} = Q_{steel} * E_{nFgas} * (E_{Fgas,co2} + E_{Fgas,ch4} * GWP_{ch4} + E_{Fgas,n2o} * GWP_{n2o}) * 0.000\ 001$$

E_{gas} = Emissions related to gasoline consumption (tCO₂e)

Q_{steel} = Quantity of steel recycled (metric tonne)

$E_{Fgas,co2}$, $E_{Fgas,ch4}$, $E_{Fgas,n2o}$ = Emission factors for CO₂, CH₄ and N₂O emissions related to gasoline consumption (g/m³)

5.2. Emission Reductions for Steel

$$ER_{\text{steel}} = BE_{\text{steel}} - PE_{\text{steel}}$$

ER_{steel} = Emissions reductions related to steel recycling for year y (tCO₂e)

BE_{steel} = Baseline scenario emissions for year y (tCO₂e)

PE_{steel} = Project scenario emissions for year y (tCO₂e)

$$BE_{\text{steel}} = BRAM + BM + BT$$

$BRAM$ = Baseline emissions for raw materials acquisition for year y (tCO₂e)

BM = Baseline emissions for manufacturing for year y (tCO₂e)

BT = Baseline emissions for transportation for year y (tCO₂e)

$$PE_{\text{steel}} = PRAM + PM + PT$$

$PRAM$ = Baseline emissions for raw materials acquisition for year y (tCO₂e)

PM = Baseline emissions for manufacturing for year y (tCO₂e)

PT = Baseline emissions for transportation for year y (tCO₂e)

$$BRAM = E_{\text{elec}} + E_{\text{coal}} + E_{\text{eng}} + E_{\text{diesel}} + E_{\text{gas}}$$

$BRAM$ = sum of the emissions related to energy consumption for the raw materials acquisition (tCO₂e)

The same operation is done for BM , BT , $PRAM$, PM , and PT .

5.3. Baseline and Project GHG Emissions for Aggregates

For the non-metal portion of the waste, the methodology explained in this study is used: “*Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)*”²⁶. In the above mentioned document, emission factors and energy factors are elaborated from national studies and renowned expert studies. The study presents an aggregated emission factor which account for energy, transportation and non-energy processes. The project scenario is associated with the recycling case which is in the study: asphalt concrete recycled in a type of asphalt concrete or aggregate. This case is very similar to the project scenario. The way the methodology is done, the baseline is the case where all the non-metal waste goes to the landfill and for the project scenario, a part of the waste (ultimate waste) is still going to the landfill and a part is recycled into aggregates. The suggested methodology of calculation developed in the study is used, therefore the recycled part of the waste leads to input credit (negative value) because it is assumed that the recycled material avoids or offsets the GHG emissions associated with the producing of the aggregates from virgin inputs.

²⁶ *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Construction Materials Chapters*, (May 2019), Version 15. Internet link: https://www.epa.gov/sites/production/files/2019-06/documents/warm_v15_construction_materials.pdf

Since the standard requires a non-aggregated factor, the detailed information on how the aggregated factor is calculated is used to calculate emissions for each gas: CO₂, CH₄ and N₂O. This is deemed to be appropriate because the processes involved are simple and can be related to mobile or fixed combustion of diesel:

- Landfill operations are done by mobile equipment therefore the data for diesel combustion is used.
- As per the explanation done in the study, the virgin inputs process and transportation are related to mobile equipment; therefore the data of diesel combustion is also used.
- Recycled production is related to mostly fixed equipment; therefore the data of oil combustion is used.
- Transportation of recycled production is related to mobile equipment; therefore the data of diesel combustion is used.

As explained in the previous section, CO₂, CH₄ and N₂O are calculated in the quantification for both baseline and project emissions.

BASELINE EMISSIONS

$$BE_{agg} = BE_{landfill}$$

BE_{agg} = Baseline scenario total emissions resulting from the baseline scenario in year y (tCO₂e)

$$BE_{landfill} = BC_{diesel} * (EF_{diesel,co2} + EF_{diesel,ch4} * GWP_{ch4} + EF_{diesel,n2o} * GWP_{n2o}) * 0.000\ 001$$

$BE_{landfill}$ = Baseline scenario total emissions resulting from the baseline scenario: landfill in year y (tCO₂e)

BC_{diesel} = Baseline scenario diesel consumption related to landfill option (L)

$EF_{diesel,co2}$, $EF_{diesel,ch4}$, $EF_{diesel,n2o}$ = Emission factors for CO₂, CH₄ and N₂O emissions related to diesel consumption (g/L)

$$BC_{diesel} = CFL_{diesel} * Q_{aw}$$

CFL_{diesel} = Consumption factor of diesel for landfill option (L/ metric tonne of material)

Q_{aw} = Quantity of aggregates and ultimate waste (metric tonne)

$$Q_{aw} = QT - Q_{steel}$$

QT = Total quantity of material recuperated (metric tonne)

Q_{steel} = Quantity of steel recycled (metric tonne)

$$CFL_{diesel} = AEF_{landfill,m} / (AEF_{diesel}/1000/1000)$$

$AEF_{landfill,m}$ = Aggregated emission factor for landfill option (tCO₂e / metric tonne of material)

AEFdiesel = Aggregated emission factor for diesel consumption (g/L)

$$AEFlandfill,m = AEFlandfill,s / 0.90718474$$

AEFlandfill,s= Aggregated emission factor for landfill option (tCO₂e / short ton of material)

0.90718474 = Conversion factor (metric tonne / short ton)

$$AEFdiesel = EF_{diesel,co2} + EF_{diesel,ch4} * GWP_{ch4} + EF_{diesel,n2o} * GWP_{n2o}$$

EF_{diesel,co2}, EF_{diesel,ch4}, EF_{diesel,n2o} = Emission factors for CO₂, CH₄ and N₂O emissions related to diesel consumption (g/L)

PROJECT EMISSIONS

$$PE_{agg} = PE_{vip} + PE_{vit} + PE_{rp} + PE_{storage}$$

PE_{agg} = Project scenario total emissions resulting from the project scenario in year y (tCO₂e)

PE_{vip} = Project scenario credit resulting from avoided virgin inputs process in year y (tCO₂e)

PE_{vit} = Project scenario credit resulting from avoided virgin inputs transportation in year y (tCO₂e)

PE_{rp} = Project scenario emissions resulting recycling production in year y (tCO₂e)

PE_{storage} = Project scenario emissions resulting from ultimate waste sent to landfill (tCO₂e)

$$PE_{vip} = VIPCdiesel * (EF_{diesel,co2} + EF_{diesel,ch4} * GWP_{ch4} + EF_{diesel,n2o} * GWP_{n2o}) * 0.000\ 001$$

VIPCdiesel = Diesel consumption for virgin inputs process (L)

$$VIPCdiesel = VIPCFdiesel * Q_{agg}$$

VIPCFdiesel = Consumption factor of diesel for virgin inputs process (L/ metric tonne of material)

Q_{agg} = Quantity of aggregates (metric tonne)

$$VIPCFdiesel = AEF_{vip,m} / (AEFdiesel/1000/1000)$$

AEF_{vip,m} = Aggregated emission factor for virgin inputs process (tCO₂e / metric tonne of material)

$$AEF_{vip,m} = AEF_{vip,s} / 0.90718474$$

$AEF_{vip,s}$ = Aggregated emission factor for virgin inputs process (tCO₂e / short ton of material)

0.90718474 = Conversion factor (metric tonne / short ton)

$$PE_{vit} = VITC_{diesel} * (EF_{diesel,co2} + EF_{diesel,ch4} * GWP_{ch4} + EF_{diesel,n2o} * GWP_{n2o}) * 0.000\ 001$$

$VITC_{diesel}$ = Diesel consumption for virgin inputs transportation (L)

$$VITC_{diesel} = VITCF_{diesel} * Q_{agg}$$

$VITCF_{diesel}$ = Consumption factor of diesel for virgin inputs transportation (L/ metric tonne of material)

$$VITCF_{diesel} = AEF_{vit,m} / (AEF_{diesel}/1000/1000)$$

$AEF_{vit,m}$ = Aggregated emission factor for virgin inputs transportation (tCO₂e / metric tonne of material)

$$AEF_{vit,m} = AEF_{vit,s} / 0.90718474$$

$AEF_{vit,s}$ = Aggregated emission factor for virgin inputs transportation (tCO₂e / short ton of material)

0.90718474 = Conversion factor (metric tonne / short ton)

$$PE_{rp} = RPC_{oil} * (EF_{oil,co2} + EF_{oil,ch4} * GWP_{ch4} + EF_{oil,n2o} * GWP_{n2o}) * 0.000\ 001$$

RPC_{oil} = Oil consumption related to recycling production (L)

$EF_{oil,co2}$, $EF_{oil,ch4}$, $EF_{oil,n2o}$ = Emission factors for CO₂, CH₄ and N₂O emissions related to oil consumption (g/L)

$$RPC_{oil} = RPC_{oil} * Q_{agg}$$

RPC_{oil} = Consumption factor of oil for recycling process (L/ metric tonne of material)

$$RPC_{oil} = AEF_{rp,m} / (AEF_{oil}/1000/1000)$$

$AEF_{rp,m}$ = Aggregated emission factor for recycling process (tCO₂e / metric tonne of material)

$$AEF_{rp,m} = AEF_{rp,s} / 0.90718474$$

$AEF_{rp,s}$ = Aggregated emission factor for recycling process (tCO₂e / short ton of material)

0.90718474 = Conversion factor (metric tonne / short ton)

$$AEF_{oil} = EF_{oil,co2} + EF_{oil,ch4} * GWP_{ch4} + EF_{oil,n2o} * GWP_{n2o}$$

$EF_{oil,co2}$, $EF_{oil,ch4}$, $EF_{oil,n2o}$ = Emission factors for CO₂, CH₄ and N₂O emissions related to oil consumption (g/L)

$$PE_{\text{storage}} = PC_{\text{diesel}} * (EF_{\text{diesel,co2}} + EF_{\text{diesel,ch4}} * GWP_{\text{ch4}} + EF_{\text{diesel,n2o}} * GWP_{\text{n2o}}) * 0.000\ 001$$

PC_{diesel} = Project scenario diesel consumption related ultimate waste going to landfill (L)

$$PC_{\text{diesel}} = CFL_{\text{diesel}} * Quw$$

CFL_{diesel} = Consumption factor of diesel for landfill option (L/ metric tonne of material)

Quw = Quantity of ultimate waste (metric tonne)

$$Quw = QT - Q_{\text{steel}} - Q_{\text{agg}}$$

5.4. Emission Reductions for Aggregates

$$ER_{\text{agg}} = BE_{\text{agg}} - PE_{\text{agg}}$$

ER_{agg} = Emissions reductions related to aggregates recycling for year y (tCO₂e)

5.5. Total Emission Reductions

$$TER = ER_{\text{steel}} + ER_{\text{agg}}$$

TER = Total emissions reductions for year y (tCO₂e)

5.6. Emission Factors and other Parameters

Table 5.1: Emission Factors Summary for Fuel Combustion

Factor	Gas	Value	Unit	Source
EFelec	CO2	1.2	g/kWh	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 3, Table A13-6, p.93
	CH4	0.0000	g/kWh	
	N2O	0.0001	g/kWh	
EFcoal	CO2	2662	kg/tonne	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 2, table A6-8 p.224
	CH4	0.03	g/kg	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 2, table A6-8 p.224
	N2O	0.02	g/kg	
EFng	CO2	1887	g/m ³	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 2, table A6-1 p.220
	CH4	0.037	g/m ³	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 2, table A6-2 p.221
	N2O	0.033	g/m ³	
EFdiesel	CO2	2681	g/L	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 2, table A6-13 p.226
	CH4	0.14	g/L	
	N2O	0.082	g/L	
EFgas	CO2	2307	g/L	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 2, table A6-4 p.222
	CH4	0.01	g/L	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 2, table A6-13 p.226
	N2O	0.02	g/L	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 2, table A6-4 p.222
EFoil	CO2	2753	g/L	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 2, table A6-4 p.222
	CH4	0.006	g/L	
	N2O	0.031	g/L	

Table 5.2: Primary Energy Factors for Steel for Virgin Inputs Summary (GJ/tonne)

	Electricity (EnFelec)	Coal (EnFcoal)	Natural Gas (EnFng)	Diesel (EnFdiesel)	Gasoline (EnFgas)
Raw Material Acquisition	0.7	0	0.7	0.8	0.003
Manufacturing	0.4	15.6	5.5	0	0
Transportation	0	0	0	0.6	0

Source: *SOLID WASTE MANAGEMENT AND GREENHOUSE GASES: A Life-Cycle Assessment of Emissions and Sinks*, (September 2006), 3rd edition, p. 127, Exhibit B-13.
Internet link: <http://www.rcbc.ca/files/u3/ICF-final-report.pdf>

Table 5.3: Primary Energy Factors for Steel for Recycled Inputs Summary (GJ/tonne)

	Electricity (EnFelec)	Coal (EnFcoal)	Natural Gas (EnFng)	Diesel (EnFdiesel)	Gasoline (EnFgas)
Raw Material Acquisition	0.01	0	0	0	0
Manufacturing	3.7	0	5.5	0	0
Transportation	0	0	0	0.4	0

Source: *SOLID WASTE MANAGEMENT AND GREENHOUSE GASES: A Life-Cycle Assessment of Emissions and Sinks*, (September 2006), 3rd edition, p. 128, Exhibit B-14.
Internet link: <http://www.rcbc.ca/files/u3/ICF-final-report.pdf>

Table 5.4: Parameters Summary

Parameter	Value	Unit	Source
GWP CO2	1	tCO ₂ /tCO ₂	National Inventory Report 1990-2017, Greenhouse Gas Sources and Sinks in Canada, Part 1, Table 1-1, p.18
GWP CH4	25	tCO ₂ e / tCH ₄	
GWP N2O	298	tCO ₂ e / tN ₂ O	
Conversion factor metric / short ton	0.9071847	metric tonne / short ton	https://physics.nist.gov/cuu/pdf/sp811.pdf p.55
Conversion factor MJ / kWh	3.6	MJ / kWh	ISO System Unit: https://physics.nist.gov/cuu/pdf/sp811.pdf p.51
HHVdiesel	38.3	GJ / kL	RDOCECA - <i>Règlement sur la déclaration obligatoire de certaines émissions de contaminants dans l'atmosphère</i> , (November 2019). Tableau 1-1.
HHVgas	34.87	GJ / kL	
HHVoil	38.78	GJ / kL	
HHVcoal	29.82	GJ / tonne	http://legisquebec.gouv.qc.ca/fr/ShowDoc/cr/Q-2,%20r.%2015
HHVng	38.32	GJ / m ³	

6. DATA MONITORING AND CONTROL

6.1. Data Management and Backups

A data acquisition system is in place and directly linked to the plant scale. The scale is checked every quarter. Equipments in place have a long lifespan but regular maintenance and repair are done as well as equipment improvement. The company integrates a continuous improvement approach concerning its equipments so they are always in good working conditions.

The accounting system is managed by the software Oracle. A daily backup is done and data are linked with the main company in United States where the backups are managed.

Data are provided by Les Minéraux Harsco from Richard Provençal. Internally, Richard Provençal ask the data to financial controller, Claude Arsenault. Data are on a server Finance that only him and his team can access.

The access to all servers is limited to specifically authorized staff members. Other specific environmental information is managed by Richard Provençal and only a total of 4 persons have access to this CERD system.

All computers and VPN connections have passwords specific to the person using it. A strict control of the passwords policy is applied. Passwords are controlled by the IT team (Information Technology) from the main company in the United States. Password changes are required many times per year with a strict protocol using the internal web platform: entering the personal logging, entering old password, then new password, confirmation of the new password and to submit the new password. After that, the staff member needs to log out and login with the new password. The security of the password required must be high; therefore, it must contain the following: no login ID nor their name, minimum 3 of the following characters: uppercase letters, lowercase letters, numbers, special characters and it must be at least 8 characters long. Furthermore, it cannot match previous passwords and cannot be changed again for at least 24 hours.

6.2. Data Control and Procedures

Data from the scale are validated with the accounting system and there is a verification done on site with a loader to corroborate the data from the scale. Verifications are done to check if all the data (scale, loader, and accounting system) are consistent.

Table 6.1: Data Monitoring Summary - year 2017

Data/ Parameters	Value	Units	Measurement method; Source of data to be used	QA/QC procedures
QT	559 991.11	metric tonne	scale; data from the automated system linked with the scale	validated with on site loader and verification done with the accounting system
Qsteel	47 821.83	metric tonne	(scale); data used is the sum of the sales for metals	
Qagg	323 215.99	metric tonne	(scale); data used is the sum of aggregates sold	

Table 6.2: Data Monitoring Summary - year 2018

Data/ Parameters	Value	Units	Measurement method; Source of data to be used	QA/QC procedures
QT	578 734.28	metric tonne	scale; data from the automated system linked with the scale	validated with on site loader and verification done with the accounting system
Qsteel	44 209.1427731844	metric tonne	(scale); data used is the sum of the sales for metals	
Qagg	331 535.8448298	metric tonne	(scale); data used is the sum of aggregates sold	

Table 6.3: Data Monitoring Summary - year 2019

Data/ Parameters	Value	Units	Measurement method; Source of data to be used	QA/QC procedures
QT	542 289.22	metric tonne	scale; data from the automated system linked with the scale	validated with on site loader and verification done with the accounting system
Qsteel	28 281.0145740486	metric tonne	(scale); data used is the sum of the sales for metals	
Qagg	334 524.347242101	metric tonne	(scale); data used is the sum of aggregates sold	

7. REPORTING AND VERIFICATION DETAILS

The project plan and report is prepared in accordance with ISO 14064-2 standard and the GHG CleanProjects® Registry requirements. The methodology that is used, the choice of region specific emission factors and a rigorous monitoring plan allow for a reasonably low level of uncertainty. Écocredit is confident that the emission reductions are not overestimated and that the numbers of emission reductions that are reported here are real and reflect the actual impacts of the project.

Emission reductions will be verified by an independent third party to a reasonable level of assurance in accordance with ISO 14064-3 (2006) standard and the GHG CleanProjects® Registry requirements. The verification for this report was performed by Roger Fournier CPA,CA and GHG lead verifier at Carbon Quantum Inc. The first year of this second crediting period was 2016. Emission reductions are reported here for years 2017, 2018 and 2019. Calculation examples are presented in Appendix I for year 2017 and emissions are detailed in Appendix II.

Table 7.1: Baseline Scenario GHG Emissions for Steel for 2017, 2018 and 2019 by Sources and Total (t CO2e)

Year	Raw Materials Acquisition (BRAM)				Manufacturing (BM)				Transportation (BT)				Baseline - Steel (BEsteel)			
	CO2	CH4	N2O	Sub-total	CO2	CH4	N2O	Sub-total	CO2	CH4	N2O	Sub-total	CO2	CH4	N2O	TOTAL
2017	2736	0	9	2745	66 614	18	149	66 781	2008	2	18	2028	71 358	20	176	71 554
2018	2526	0	8	2537	61 581	17	137	61 735	1856	2	16	1874	65 966	19	161	66 146
2019	1617	0	5	1622	39 394	11	88	39 493	1187	1	10	1198	41 198	12	103	42 313

Table 7.2: Baseline Scenario GHG Emissions for Aggregates for 2017, 2018 and 2019 by Sources and Total (t CO₂e)

Year	Landfill (BElandfill)				Baseline - Aggregates (BEagg)			
	CO2	CH4	N2O	Sub- total	CO2	CH4	N2O	TOTAL
2017	11 174	14	101	11 289	11 174	14	101	11 289
2018	11 662	15	106	11 783	11 662	15	106	11 783
2019	11 215	14	102	11 331	11 215	14	102	11 331

Table 7.3: Project Scenario GHG Emissions for Steel for 2017, 2018 and 2019 by Sources and Total (t CO₂e)

Year	Raw material acquisition (PRAM)				Manufacturing (PM)				Transportation (PT)				Project - Steel (PEsteel)			
	CO2	CH4	N2O	Sub- total	CO2	CH4	N2O	Sub- total	CO2	CH4	N2O	Sub- total	CO2	CH4	N2O	TOTAL
2017	1	0	1	2	72	1	1	74	1340	2	13	1355	1413	3	15	1431
2018	1	0	1	2	67	1	1	69	1238	2	12	1252	1306	3	14	1323
2019	1	0	1	2	43	1	1	45	792	2	8	802	836	3	10	849

Table 7.4: Project Scenario GHG Emissions for Aggregates for 2017, 2018 and 2019 by Sources (t CO₂e)

Year	Virgin Inputs Process (PEvip)				Virgin Inputs Transportation (PEvit)				Recycling Process (PERp)				Landfill (PEstorage)			
	CO2	CH4	N2O	Sub-total	CO2	CH4	N2O	Sub-total	CO2	CH4	N2O	Sub-total	CO2	CH4	N2O	Sub-total
2017	-21 157	-28	-193	-21 378	-17 631	-24	-161	-17 816	10 653	1	36	10 690	4123	6	38	4167
2018	-21 702	-29	-198	-21 929	-18 085	-24	-165	-18 274	10 927	1	37	10 965	4429	6	41	4476
2019	-21 897	-29	-200	-22 126	-18 248	-24	-167	-18 439	11 025	1	37	11 063	3 917	6	36	3 959

Table 7.5: Project Scenario GHG Emissions for Aggregates for 2017, 2018 and 2019 TOTAL (t CO₂e)

Project - Aggregates (PEagg)				
Year	CO2	CH4	N2O	TOTAL
2017	-24 012	-45	-280	-24 337
2018	-24 431	-46	-285	-24 762
2019	-25 203	-46	-294	-25 543

Table 7.6: GHG Emission Reductions for Steel for 2017, 2018 and 2019 (t CO₂e)

Year	ERsteel - TOTAL			
	CO2 t CO ₂ e	CH4 t CO ₂ e	N2O t CO ₂ e	TOTAL t CO ₂ e
2017	69 945	17	161	70 123
2018	64 660	16	147	64 823
2019	41 362	9	93	41 464

Table 7.7: GHG Emission Reductions for Aggregates for 2017, 2018 and 2019 (t CO₂e)

Year	ERagg - TOTAL			
	CO2 t CO ₂ e	CH4 t CO ₂ e	N2O t CO ₂ e	TOTAL t CO ₂ e
2017	35 186	59	381	35 626
2018	36 093	61	391	36 545
2019	36 418	60	396	36 874

Table 7.8: Total GHG Emission Reductions for 2017, 2018 and 2019 (t CO₂e)

Year	ER - TOTAL			
	CO2 t CO ₂ e	CH4 t CO ₂ e	N2O t CO ₂ e	TOTAL t CO ₂ e
2017	105 131	76	542	105 749
2018	100 753	77	538	101 368
2019	77 780	69	489	78 338

APPENDIX I - CALCULATION EXAMPLES

Examples are based on year 2017.

STEEL

Example for Baseline Scenario - Raw material Acquisition (BRAM)

$$\text{EnFelec} = \text{EnFGJelec} * \text{CF}$$

$$\text{EnFelec} = 0.7 \text{ GJ / tonne} * 2.778 \text{ kWh / GJ}$$

$$\text{EnFelec} = 194.444 \text{ kWh / tonne of steel}$$

$$\text{EnFcoal} = \text{EnFGJcoal} / \text{HHVcoal} * \text{CF}$$

$$\text{EnFcoal} = 0 \text{ GJ / tonne} / 29.82 \text{ GJ / tonne} * 1$$

$$\text{EnFcoal} = 0 \text{ tonne of coal / tonne of steel}$$

$$\text{EnFng} = \text{EnFGJng} / \text{HHVng} * \text{CF}$$

$$\text{EnFng} = 0.7 \text{ GJ / tonne} / 38.32 \text{ GJ / m}^3 * 1$$

$$\text{EnFng} = 0.018267223 \text{ m}^3 / \text{tonne of steel}$$

$$\text{EnFoil} = \text{EnFGJoil} / \text{HHVoil} * \text{CF}$$

$$\text{EnFoil} = 0.8 \text{ GJ / tonne} / 38.78 \text{ GJ / kL} * 1$$

$$\text{EnFoil} = 20.6291903 \text{ L / tonne of steel}$$

$$\text{EnFgas} = \text{EnFGJgas} / \text{HHVgas} * \text{CF}$$

$$\text{EnFgas} = 0.003 \text{ GJ / tonne} / 34.87 \text{ GJ / kL} * 1$$

$$\text{EnFgas} = 0.08603384 \text{ L / tonne of steel}$$

$$\text{Eelec} = \text{Qsteel} * \text{EnFelec} * (\text{EFelec,co2} + \text{EFelec,ch4} * \text{GWPch4} + \text{EFelec,n2o} * \text{GWPn2o}) * 0.000001$$

$$\text{Eelec} = 47\,821.8300634557 \text{ tonnes} * 194.444444444 \text{ kWh/tonne of steel} * (1.2 + 0 * 25 + 0.0001 * 298) \text{ g/kWh} * 0.000001$$

$$\text{Eelec} = 9\,298\,689.18 \text{ kWh} * (1.2 + 0 * 25 + 0.0001 * 298) \text{ g/kWh} * 0.000001$$

$$\text{Eelec} = 11.16 \text{ tCO}_2 + 0.00 * 25 \text{ tCH}_4 + 0.00 * 298 \text{ tN}_2\text{O}$$

$$\text{Eelec} = 11 \text{ tCO}_2 + 0 \text{ tCO}_2 + 0 \text{ tCO}_2 \text{ rounded down for baseline (in the case of the project, rounded up)}$$

$$\text{Eelec} = 11 \text{ tCO}_2$$

$$\text{Ecoal} = \text{Qsteel} * \text{EnFcoal} * (\text{EFcoal,co2} + \text{EFcoal,ch4} * \text{GWPch4} + \text{EFcoal,n2o} * \text{GWPn2o}) * 0.001$$

$$\text{Ecoal} = 47\,821.8300634557 \text{ tonnes} * 0 \text{ tonne of coal / tonne of steel} * (2662 + 0.03 * 25 + 0.02 * 298) \text{ g/kg} * 0.001$$

$$\text{Ecoal} = 0 \text{ tonne of coal} * (2662 + 0.03 * 25 + 0.02 * 298) \text{ g/kg} * 0.001$$

$$\text{Ecoal} = 0 \text{ tCO}_2 + 0 \text{ tCH}_4 + 0 \text{ tN}_2\text{O} \text{ rounded down for baseline (in the case of the project, rounded up)}$$

$$E_{\text{coal}} = 0$$

$$Eng = Q_{\text{steel}} * En_{\text{Fng}} * (EF_{\text{ng,co2}} + EF_{\text{ng,ch4}} * GWP_{\text{ch4}} + EF_{\text{ng,n2o}} * GWP_{\text{n2o}}) * 0.000\ 001$$

$$Eng = 47\ 821.8300634557 \text{ tonnes} * 0.018267223 \text{ m}^3/\text{tonne of steel} * (1887 + 0.037 * 25 + 0.033 * 298) \text{ g/m}^3 * 0.000\ 001$$

$$Eng = 873.57 \text{ m}^3 * (1887 + 0.037 * 25 + 0.033 * 298) \text{ g/m}^3 * 0.000\ 001$$

$$Eng = 1.65 \text{ tCO}_2 + 0.00 * 25 \text{ tCH}_4 + 0.00 * 298 \text{ tN}_2\text{O}$$

$$Eng = 1 \text{ tCO}_2\text{e} + 0 \text{ tCO}_2\text{e} + 0 \text{ tCO}_2\text{e rounded down for baseline (in the case of the project, rounded up)}$$

$$E_{\text{oil}} = 1 \text{ tCO}_2\text{e}$$

$$E_{\text{oil}} = Q_{\text{steel}} * En_{\text{Foil}} * (EF_{\text{oil,co2}} + EF_{\text{oil,ch4}} * GWP_{\text{ch4}} + EF_{\text{oil,n2o}} * GWP_{\text{n2o}}) * 0.000\ 001$$

$$E_{\text{oil}} = 47\ 821.8300634557 \text{ tonnes} * 20.6291903 \text{ L/tonne of steel} * (2753 + 0.006 * 25 + 0.031 * 298) \text{ g/L} * 0.000\ 001$$

$$E_{\text{oil}} = 986\ 525.63 \text{ L} * (2753 + 0.006 * 25 + 0.031 * 298) * 0.000\ 001$$

$$E_{\text{oil}} = 2715.91 \text{ tCO}_2 + 0.01 * 25 \text{ tCH}_4 + 0.03 * 298 \text{ tN}_2\text{O}$$

$$E_{\text{oil}} = 2715 \text{ tCO}_2\text{e} + 0 \text{ tCO}_2\text{e} + 9 \text{ tCO}_2\text{e rounded down for baseline (in the case of the project, rounded up)}$$

$$E_{\text{oil}} = 2724 \text{ tCO}_2\text{e}$$

$$E_{\text{gas}} = Q_{\text{steel}} * En_{\text{Fgas}} * (EF_{\text{gas,co2}} + EF_{\text{gas,ch4}} * GWP_{\text{ch4}} + EF_{\text{gas,n2o}} * GWP_{\text{n2o}}) * 0.000\ 001$$

$$E_{\text{gas}} = 47\ 821.8300634557 \text{ tonnes} * 0.08603384 \text{ L/tonne of steel} * (2307 + 0.01 * 25 + 0.02 * 298) \text{ g/L} * 0.000001$$

$$E_{\text{gas}} = 4114.30 \text{ L} * (2307 + 0.01 * 25 + 0.02 * 298) * 0.000001$$

$$E_{\text{gas}} = 9.49 \text{ tCO}_2 + 0.000411 * 25 \text{ tCH}_4 + 0.000082 * 298 \text{ tN}_2\text{O}$$

$$E_{\text{gas}} = 9 \text{ tCO}_2\text{e} + 0 \text{ tCO}_2\text{e} + 0 \text{ tCO}_2\text{e rounded down for baseline (in the case of the project, rounded up)}$$

$$E_{\text{gas}} = 9 \text{ tCO}_2\text{e}$$

$$\text{BRAM} = E_{\text{elec}} + E_{\text{coal}} + Eng + E_{\text{oil}} + E_{\text{gas}}$$

$$\text{BRAM} = 11 + 0 + 1 + 2724 + 9 = 2745 \text{ tCO}_2\text{e}$$

The same operation is done for BM, BT, PRAM, PM, and PT.

$$\text{BE}_{\text{steel}} = \text{BRAM} + \text{BM} + \text{BT}$$

$$\text{BE}_{\text{steel}} = 2745 + 66\ 781 + 2028 = 71\ 554 \text{ tCO}_2\text{e}$$

$$\text{PE}_{\text{steel}} = \text{PRAM} + \text{PM} + \text{PT}$$

$$\text{PE}_{\text{steel}} = 3 + 74 + 1355 = 1431 \text{ tCO}_2\text{e}$$

$$\text{ER}_{\text{steel}} = \text{BE}_{\text{steel}} - \text{PE}_{\text{steel}}$$

$$\text{ER}_{\text{steel}} = 71\ 554 - 1431 = 70\ 123 \text{ tCO}_2\text{e}$$

AGGREGATES

Baseline scenario

$$BE_{agg} = BE_{landfill}$$

$$BE_{landfill} = BC_{diesel} * (EF_{diesel,co2} + EF_{diesel,ch4} * GWP_{ch4} + EF_{diesel,n2o} * GWP_{n2o}) * 0.000\ 001$$

$$BE_{landfill} = 4\ 168\ 204.9\ L * (2681 + 0.14 * 25 + 0.082 * 298)\ g/L * 0.000\ 001$$

$$BE_{landfill} = 11\ 174.96\ tCO_2 + 0.58 * 25\ tCH_4 + 0.34 * 298\ tN_2O$$

$$BE_{landfill} = 11\ 174\ tCO_2e + 14\ tCO_2e + 101\ tCO_2e$$

$$BE_{landfill} = 11\ 289\ tCO_2e$$

$$BC_{diesel} = CFL_{diesel} * Q_{aw}$$

$$BC_{diesel} = 8.13833445698237\ L / \text{metric tonne of material} * 512\ 169.28\ \text{tonnes of material}$$

$$BC_{diesel} = 4\ 168\ 204.9\ L$$

$$Q_{aw} = Q_T - Q_{steel}$$

$$Q_{aw} = 559\ 991.11\ \text{tonnes of recuperated material} - 47\ 821.8300634557\ \text{tonnes of steel}$$

$$Q_{aw} = 512\ 169.28\ \text{tonnes of material}$$

$$CFL_{diesel} = AE_{landfill,m} / (AE_{diesel}/1000/1000)$$

$$CFL_{diesel} = 0.02204622719056\ tCO_2e / \text{metric tonne of material} / (2708.936\ g/L)$$

$$CFL_{diesel} = 8.13833445698237\ L / \text{metric tonne of material}$$

$$AE_{landfill,m} = AE_{landfill,s} / 0.9071847$$

$$AE_{landfill,m} = 0.02\ tCO_2e / \text{short ton of material} / 0.9071847\ \text{metric tonne} / \text{short ton}$$

$$AE_{landfill,m} = 0.02204622719056\ tCO_2e / \text{metric tonne of material}$$

$$AE_{diesel} = EF_{diesel,co2} + EF_{diesel,ch4} * GWP_{ch4} + EF_{diesel,n2o} * GWP_{n2o}$$

$$AE_{diesel} = 2681 + 0.14 * 25 + 0.082 * 298 = 2708.936\ g/L$$

Project scenario

$$PE_{agg} = PE_{vip} + PE_{vit} + PE_{rp} + PE_{storage}$$

$$PE_{agg} = -21\,378 \text{ tCO}_2e + -17\,816 + 10\,690 + 4167 = -24\,337 \text{ tCO}_2e$$

$$PE_{vip} = VIPCDiesel * (EF_{diesel,co2} + EF_{diesel,ch4} * GWP_{ch4} + EF_{diesel,n2o} * GWP_{n2o}) * 0.000\,001$$

$$PE_{vip} = -7\,891\,319.56 \text{ L} * (2681 + 0.14 * 25 + 0.082 * 298) \text{ g/L} * 0.000\,001$$

$$PE_{vip} = -21\,156.63 \text{ tCO}_2 + -1.10 * 25 \text{ tCH}_4 + -0.65 * 298 \text{ tN}_2\text{O}$$

$$PE_{vip} = -21\,157 \text{ tCO}_2e + -28 \text{ tCO}_2e + -193 \text{ tCO}_2e$$

$$PE_{vip} = -21\,378 \text{ tCO}_2e$$

$$VIPCDiesel = VIPCF_{diesel} * Q_{agg}$$

$$VIPCF_{diesel} = -24.4150037 \text{ L / metric tonne of material} * 323\,215.993215199 \text{ tonnes}$$

$$VIPCF_{diesel} = -7\,891\,319.56 \text{ L}$$

$$VIPCF_{diesel} = AEF_{vip,m} / (AEF_{diesel}/1000/1000)$$

$$VIPCF_{diesel} = -0.0661386815716799 \text{ tCO}_2e / \text{metric tonne} / 2708.936 \text{ g/L} / 1000 / 1000$$

$$VIPCF_{diesel} = -24.4150037 \text{ L / metric tonne of material}$$

$$AEF_{vip,m} = AEF_{vip,s} / 0.9071847$$

$$AEF_{vip,m} = -0.06 \text{ tCO}_2e / \text{short ton} / 0.9071847 = -0.0661386815716799 \text{ tCO}_2e / \text{metric tonne}$$

$$PE_{vit} = VITCDiesel * (EF_{diesel,co2} + EF_{diesel,ch4} * GWP_{ch4} + EF_{diesel,n2o} * GWP_{n2o}) * 0.000\,001$$

$$PE_{vit} = -6\,576\,099.63657757 \text{ L} * (2681 + 0.14 * 25 + 0.082 * 298) \text{ g/L} * 0.000\,001$$

$$PE_{vit} = -17\,630.52 \text{ tCO}_2 + -0.92 * 25 \text{ tCH}_4 + -0.54 \text{ tN}_2\text{O}$$

$$PE_{vit} = -17\,631 \text{ tCO}_2e + -24 \text{ tCO}_2e + -161 \text{ tCO}_2e$$

$$PE_{vit} = -17\,816 \text{ tCO}_2e$$

$$VITCDiesel = VITCF_{diesel} * Q_{agg}$$

$$VITCDiesel = -20.3458361424559 \text{ L/tonnes of material} * 323\,215.993215199 \text{ tonnes}$$

$$VITCDiesel = -6\,576\,099.63657757 \text{ L}$$

$$VITCF_{diesel} = AEF_{vit,m} / (AEF_{diesel}/1000/1000)$$

$$VITCF_{diesel} = -0.0551155679764 \text{ tCO}_2e / \text{metric tonne} / 2717.936 \text{ g/L} / 1000 / 1000$$

$$VITCF_{diesel} = -20.3458361424559 \text{ L/tonnes of material}$$

$$AEF_{vit,m} = AEF_{vit,s} / 0.9071847$$

$$AEF_{vit,m} = -0.05 \text{ tCO}_2e / \text{short ton} / 0.9071847 = -0.0551155679764 \text{ tCO}_2e / \text{metric tonne}$$

$$PE_{rp} = RPC_{oil} * (EF_{oil,co2} + EF_{oil,ch4} * GWP_{ch4} + EF_{oil,n2o} * GWP_{n2o}) * 0.000\ 001$$

$$PE_{oil} = 3\ 869\ 311.56197723\ L * (2753 + 0.006 * 25 + 0.031 * 298)\ g/L * 0.000\ 001$$

$$PE_{oil} = 10\ 652.21\ tCO_2 + 0.02 * 25\ tCH_4 + 0.12 * 298\ tN_2O$$

$$PE_{oil} = 10\ 653\ tCO_2e + 1\ tCO_2e + 36\ tCO_2e$$

$$PE_{oil} = 10\ 690\ tCO_2e$$

$$RPC_{oil} = RPC_{foil} * Q_{agg}$$

$$RPC_{oil} = 11.9712874461661\ L/metric\ tonne * 323\ 215.993215199\ tonnes\ of\ aggregates$$

$$RPC_{oil} = 3\ 869\ 311.56197723\ L$$

$$RPC_{foil} = AE_{frp,m} / (AE_{foil}/1000/1000)$$

$$RPC_{foil} = 0.03306934078584\ tCO_2e/metric\ tonne / 2762.388\ g/L/1000/1000$$

$$RPC_{foil} = 11.9712874461661\ L/metric\ tonne$$

$$AE_{frp,m} = AE_{frp,s} / 0.9071847$$

$$AE_{frp,m} = 0.03\ tCO_2e/short\ ton / 0.9071847 = 0.03306934078584\ tCO_2e/metric\ tonne$$

$$AE_{foil} = EF_{oil,co2} + EF_{oil,ch4} * GWP_{ch4} + EF_{oil,n2o} * GWP_{n2o}$$

$$AE_{foil} = 2753 + 0.006 * 25 + 0.031 * 298 = 2762.388\ g/L$$

$$PE_{storage} = PC_{diesel} * (EF_{diesel,co2} + EF_{diesel,ch4} * GWP_{ch4} + EF_{diesel,n2o} * GWP_{n2o}) * 0.000\ 001$$

$$PE_{storage} = 1\ 690\ 303.23032847\ L * (2681 + 0.14 * 25 + 0.082 * 298)\ g/L * 0.000\ 001$$

$$PE_{storage} = 4122.75\ tCO_2 + 0.22 * 25\ tCH_4 + 0.13 * 298\ tN_2O$$

$$PE_{storage} = 4123\ tCO_2e + 6\ tCO_2e + 38\ tCO_2e$$

$$PE_{storage} = 4167\ tCO_2e$$

$$PC_{diesel} = CFL_{diesel} * Q_{uw}$$

$$PC_{diesel} = 8.13833445698237\ L / metric\ tonne\ of\ material * 207\ 696.456721346\ tonnes\ of\ material$$

$$PC_{diesel} = 1\ 537\ 765.0440844\ L$$

$$Q_{uw} = Q_T - Q_{steel} - Q_{agg}$$

$$Q_{uw} = 559\ 991.11 - 47\ 821.8300634557 - 323\ 215.993215199 = 188\ 953.286721346\ tonnes\ of\ material$$

$$ER_{agg} = BE_{agg} - PE_{agg}$$

$$ER_{agg} = 11\ 289 - (-24\ 337) = 35\ 626\ tCO_2e$$

TOTAL

$$\text{TER} = \text{ER}_{\text{steel}} + \text{ER}_{\text{agg}}$$

$$\text{TER} = 70\,123 + 35\,626 = 105\,749 \text{ tCO}_2\text{e}$$

APPENDIX II - EMISSIONS DETAILED 2017

Steel - Baseline Scenario

Baseline scenario						
Raw Material Acquisition	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	194.44	0.00	0.02	20.63	0.09	---
Consommation totale	9298689.18	0.00	873.57	986525.63	4114.30	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	11.16	0.00	1.65	2715.91	9.49	2738.20
Emissions CH4 tCH4	0.00	0.00	0.00	0.01	0.000411	0.01
Emissions N2O tN2O	0.00	0.00	0.00	0.03	0.000082	0.03
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	11	0	1	2715	9	2736
Emissions CH4 tCO2e	0	0	0	0	0	0
Emissions N2O tCO2e	0	0	0	9	0	9
Émissions totales tCO2e	11	0	1	2724	9	2745

Manufacturing	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	111.11	0.52	0.14	0.00	0.00	---
Consommation totale	5313536.67	25017.46	6863.78	0.00	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	6.38	66596.47	12.95	0.00	0.00	66615.80
Emissions CH4 tCH4	0.00	0.75	0.00	0.00	0.00	0.75
Emissions N2O tN2O	0.00	0.50	0.00	0.00	0.00	0.50
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	6	66596	12	0	0	66614
Emissions CH4 tCO2e	0	18	0	0	0	18
Emissions N2O tCO2e	0	149	0	0	0	149
Émissions totales tCO2e	6	66763	12	0	0	66781

Transportation	Electricity kWh	Coal tonne	Natural Gas m3	Diesel L	Gasoline L	
Par tonne de matières	0.00	0.00	0.00	15.67	0.00	---
Consommation totale	0.00	0.00	0.00	749167.05	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	0.00	0.00	0.00	2008.52	0.00	2008.52
Emissions CH4 tCH4	0.00	0.00	0.00	0.10	0.00	0.10
Emissions N2O tN2O	0.00	0.00	0.00	0.06	0.00	0.06
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	0	0	0	2008	0	2008
Emissions CH4 tCO2e	0	0	0	2	0	2
Emissions N2O tCO2e	0	0	0	18	0	18
Émissions totales tCO2e	0	0	0	2028	0	2028

Steel - Project Scenario

Project scenario						
Raw Material Acquisition	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	2.78	0.00	0.00	0.00	0.00	---
Consommation totale	132838.42	0.00	0.00	0.00	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	0.16	0.00	0.00	0.00	0.00	0.16
Emissions CH4 tCH4	0.00	0.00	0.00	0.00	0.00	0.00
Emissions N2O tN2O	0.00	0.00	0.00	0.00	0.00	0.00
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	1	0	0	0	0	1
Emissions CH4 tCO2e	0	0	0	0	0	0
Emissions N2O tCO2e	1	0	0	0	0	1
Émissions totales tCO2e	2	0	0	0	0	2

Manufacturing	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	1027.78	0.00	0.14	0.00	0.00	---
Consommation totale	49150214.23	0.00	6863.78	0.00	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	58.98	0.00	12.95	0.00	0.00	71.93
Emissions CH4 tCH4	0.00	0.00	0.00	0.00	0.00	0.00
Emissions N2O tN2O	0.00	0.00	0.00	0.00	0.00	0.00
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	59	0	13	0	0	72
Emissions CH4 tCO2e	0	0	1	0	0	1
Emissions N2O tCO2e	0	0	1	0	0	1
Émissions totales tCO2e	59	0	15	0	0	74

Transportation	Electricity kWh	Coal tonne	Natural Gas m3	Diesel L	Gasoline L	
Par tonne de matières	0.00	0.00	0.00	10.44	0.00	---
Consommation totale	0.00	0.00	0.00	499444.70	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	0.00	0.00	0.00	1339.01	0.00	1339.01
Emissions CH4 tCH4	0.00	0.00	0.00	0.07	0.00	0.07
Emissions N2O tN2O	0.00	0.00	0.00	0.04	0.00	0.04
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	0	0	0	1340	0	1340
Emissions CH4 tCO2e	0	0	0	2	0	2
Emissions N2O tCO2e	0	0	0	13	0	13
Émissions totales tCO2e	0	0	0	1355	0	1355

Aggregates - Baseline scenario

Baseline scenario - landfill	
<i>Transportation</i>	Diesel mobile L
Par tonne de matières	8.138334457
Consommation totale	4168204.90
Émissions par gaz	
Emissions CO2 tCO2	11174.96
Emissions CH4 tCH4	0.58
Emissions N2O tN2O	0.34
Émissions en TCO2e	
Emissions CO2 tCO2e	11174
Emissions CH4 tCO2e	14
Emissions N2O tCO2e	101
Émissions totales tCO2e	11289

Aggregates - Project scenario

Project scenario - recycling and landfill	
Virgin inputs, process	Diésel mobile, L
Par tonne de matières	-24.41500337
Consommation totale	-7891319.56
Émissions par gaz	
Emissions CO2 tCO2	-21156.63
Emissions CH4 tCH4	-1.10
Emissions N2O tN2O	-0.65
Émissions en TCO2e	
Emissions CO2 tCO2e	-21157
Emissions CH4 tCO2e	-28
Emissions N2O tCO2e	-193
Émissions totales tCO2e	-21378

Virgin inputs, transportation	Diésel mobile, L
Par tonne de matières	-20.34583614
Consommation totale	-6576099.637
Émissions par gaz	
Emissions CO2 tCO2	-17630.52
Emissions CH4 tCH4	-0.92
Emissions N2O tN2O	-0.54
Émissions en TCO2e	
Emissions CO2 tCO2e	-17631
Emissions CH4 tCO2e	-24
Emissions N2O tCO2e	-161
Émissions totales tCO2e	-17816

<i>Recycling production</i>	Diésel fixe, L
Par tonne de matières	11.97128745
Consommation totale	3869311.562
Émissions par gaz	
Emissions CO2 tCO2	10652.21
Emissions CH4 tCH4	0.02
Emissions N2O tN2O	0.12
Émissions en TCO2e	
Emissions CO2 tCO2e	10653
Emissions CH4 tCO2e	1
Emissions N2O tCO2e	36
Émissions totales tCO2e	10690

Landfill / Storage	Diésel mobiel, L
Par tonne de matières	8.138334457
Consommation totale	1537765.044
Émissions par gaz	
Emissions CO2 tCO2	4122.75
Emissions CH4 tCH4	0.22
Emissions N2O tN2O	0.13
Émissions en TCO2e	
Emissions CO2 tCO2e	4123
Emissions CH4 tCO2e	6
Emissions N2O tCO2e	38
Émissions totales tCO2e	4167

APPENDIX III - EMISSIONS DETAILED 2018

Steel - Baseline Scenario

Baseline scenario						
<i>Raw Material Acquisition</i>	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	194.44	0.00	0.02	20.63	0.09	---
Consommation totale	8596222.21	0.00	807.58	911998.82	3803.48	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	10.32	0.00	1.52	2510.73	8.77	2531.35
Emissions CH4 tCH4	0.00	0.00	0.00	0.01	0.000380	0.01
Emissions N2O tN2O	0.00	0.00	0.00	0.03	0.000076	0.03
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	10	0	1	2510	8	2529
Emissions CH4 tCO2e	0	0	0	0	0	0
Emissions N2O tCO2e	0	0	0	8	0	8
Émissions totales tCO2e	10	0	1	2518	8	2537

Manufacturing	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	111.11	0.52	0.14	0.00	0.00	---
Consommation totale	4912126.97	23127.52	6345.26	0.00	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	5.89	61565.46	11.97	0.00	0.00	61583.32
Emissions CH4 tCH4	0.00	0.69	0.00	0.00	0.00	0.69
Emissions N2O tN2O	0.00	0.46	0.00	0.00	0.00	0.46
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	5	61565	11	0	0	61581
Emissions CH4 tCO2e	0	17	0	0	0	17
Emissions N2O tCO2e	0	137	0	0	0	137
Émissions totales tCO2e	5	61719	11	0	0	61735

Transportation	Electricity kWh	Coal tonne	Natural Gas m3	Diesel L	Gasoline L	
Par tonne de matières	0.00	0.00	0.00	15.67	0.00	---
Consommation totale	0.00	0.00	0.00	692571.43	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	0.00	0.00	0.00	1856.78	0.00	1856.78
Emissions CH4 tCH4	0.00	0.00	0.00	0.10	0.00	0.10
Emissions N2O tN2O	0.00	0.00	0.00	0.06	0.00	0.06
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	0	0	0	1856	0	1856
Emissions CH4 tCO2e	0	0	0	2	0	2
Emissions N2O tCO2e	0	0	0	16	0	16
Émissions totales tCO2e	0	0	0	1874	0	1874

Steel - Project Scenario

Project scenario						
<i>Raw Material Acquisition</i>	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	2.78	0.00	0.00	0.00	0.00	---
Consommation totale	122803.17	0.00	0.00	0.00	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	0.15	0.00	0.00	0.00	0.00	0.15
Emissions CH4 tCH4	0.00	0.00	0.00	0.00	0.00	0.00
Emissions N2O tN2O	0.00	0.00	0.00	0.00	0.00	0.00
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	1	0	0	0	0	1
Emissions CH4 tCO2e	0	0	0	0	0	0
Emissions N2O tCO2e	1	0	0	0	0	1
Émissions totales tCO2e	2	0	0	0	0	2

Manufacturing	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	1027.78	0.00	0.14	0.00	0.00	---
Consommation totale	45437174.52	0.00	6345.26	0.00	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	54.52	0.00	11.97	0.00	0.00	66.50
Emissions CH4 tCH4	0.00	0.00	0.00	0.00	0.00	0.00
Emissions N2O tN2O	0.00	0.00	0.00	0.00	0.00	0.00
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	55	0	12	0	0	67
Emissions CH4 tCO2e	0	0	1	0	0	1
Emissions N2O tCO2e	0	0	1	0	0	1
Émissions totales tCO2e	55	0	14	0	0	69

Transportation	Electricity kWh	Coal tonne	Natural Gas m3	Diesel L	Gasoline L	
Par tonne de matières	0.00	0.00	0.00	10.44	0.00	---
Consommation totale	0.00	0.00	0.00	461714.28	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	0.00	0.00	0.00	1237.86	0.00	1237.86
Emissions CH4 tCH4	0.00	0.00	0.00	0.06	0.00	0.06
Emissions N2O tN2O	0.00	0.00	0.00	0.04	0.00	0.04
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	0	0	0	1238	0	1238
Emissions CH4 tCO2e	0	0	0	2	0	2
Emissions N2O tCO2e	0	0	0	12	0	12
Émissions totales tCO2e	0	0	0	1252	0	1252

Aggregates - Baseline scenario

Baseline scenario - landfill	
Transportation	Diesel mobile L
Par tonne de matières	8.138334457
Consommation totale	4350144.34
Émissions par gaz	
Emissions CO2 tCO2	11662.74
Emissions CH4 tCH4	0.61
Emissions N2O tN2O	0.36
Émissions en TCO2e	
Emissions CO2 tCO2e	11662
Emissions CH4 tCO2e	15
Emissions N2O tCO2e	106
Émissions totales tCO2e	11783

Aggregates - Project scenario

Project scenario - recycling and landfill	
Virgin inputs, process	Diésel mobile, L
Par tonne de matières	-24.41500337
Consommation totale	-8094448.77
Émissions par gaz	
Emissions CO2 tCO2	-21701.22
Emissions CH4 tCH4	-1.13
Emissions N2O tN2O	-0.66
Émissions en TCO2e	
Emissions CO2 tCO2e	-21702
Emissions CH4 tCO2e	-29
Emissions N2O tCO2e	-198
Émissions totales tCO2e	-21929

Virgin inputs, transportation	Diésel mobile, L
Par tonne de matières	-20.34583614
Consommation totale	-6745373.974
Émissions par gaz	
Emissions CO2 tCO2	-18084.35
Emissions CH4 tCH4	-0.94
Emissions N2O tN2O	-0.55
Émissions en TCO2e	
Emissions CO2 tCO2e	-18085
Emissions CH4 tCO2e	-24
Emissions N2O tCO2e	-165
Émissions totales tCO2e	-18274

Recycling production	Diésel fixe, L
Par tonne de matières	11.97128745
Consommation totale	3968910.897
Émissions par gaz	
Emissions CO2 tCO2	10926.41
Emissions CH4 tCH4	0.02
Emissions N2O tN2O	0.12
Émissions en TCO2e	
Emissions CO2 tCO2e	10927
Emissions CH4 tCO2e	1
Emissions N2O tCO2e	37
Émissions totales tCO2e	10965

Landfill / Storage	Diésel mobiel, L
Par tonne de matières	8.138334457
Consommation totale	1651994.753
Émissions par gaz	
Emissions CO2 tCO2	4429.00
Emissions CH4 tCH4	0.23
Emissions N2O tN2O	0.14
Émissions en TCO2e	
Emissions CO2 tCO2e	4429
Emissions CH4 tCO2e	6
Emissions N2O tCO2e	41
Émissions totales tCO2e	4476

APPENDIX IV - EMISSIONS DETAILED 2019

Steel - Baseline Scenario

Baseline scenario						
<i>Raw Material Acquisition</i>	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	194.44	0.00	0.02	20.63	0.09	---
Consommation totale	5499086.17	0.00	516.62	583414.43	2433.12	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	6.60	0.00	0.97	1606.14	5.61	1619.33
Emissions CH4 tCH4	0.00	0.00	0.00	0.00	0.000243	0.00
Emissions N2O tN2O	0.00	0.00	0.00	0.02	0.000049	0.02
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	6	0	0	1606	5	1617
Emissions CH4 tCO2e	0	0	0	0	0	0
Emissions N2O tCO2e	0	0	0	5	0	5
Émissions totales tCO2e	6	0	0	1611	5	1622

Manufacturing	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	111.11	0.52	0.14	0.00	0.00	---
Consommation totale	3142334.95	14794.90	4059.12	0.00	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	3.77	39384.02	7.66	0.00	0.00	39395.45
Emissions CH4 tCH4	0.00	0.44	0.00	0.00	0.00	0.44
Emissions N2O tN2O	0.00	0.30	0.00	0.00	0.00	0.30
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	3	39384	7	0	0	39394
Emissions CH4 tCO2e	0	11	0	0	0	11
Emissions N2O tCO2e	0	88	0	0	0	88
Émissions totales tCO2e	3	39483	7	0	0	39493

Transportation	Electricity kWh	Coal tonne	Natural Gas m3	Diesel L	Gasoline L	
Par tonne de matières	0.00	0.00	0.00	15.67	0.00	---
Consommation totale	0.00	0.00	0.00	443044.61	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	0.00	0.00	0.00	1187.80	0.00	1187.80
Emissions CH4 tCH4	0.00	0.00	0.00	0.06	0.00	0.06
Emissions N2O tN2O	0.00	0.00	0.00	0.04	0.00	0.04
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	0	0	0	1187	0	1187
Emissions CH4 tCO2e	0	0	0	1	0	1
Emissions N2O tCO2e	0	0	0	10	0	10
Émissions totales tCO2e	0	0	0	1198	0	1198

Steel - Project Scenario

Project scenario						
<i>Raw Material Acquisition</i>	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	2.78	0.00	0.00	0.00	0.00	---
Consommation totale	78558.37	0.00	0.00	0.00	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	0.09	0.00	0.00	0.00	0.00	0.09
Emissions CH4 tCH4	0.00	0.00	0.00	0.00	0.00	0.00
Emissions N2O tN2O	0.00	0.00	0.00	0.00	0.00	0.00
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	1	0	0	0	0	1
Emissions CH4 tCO2e	0	0	0	0	0	0
Emissions N2O tCO2e	1	0	0	0	0	1
Émissions totales tCO2e	2	0	0	0	0	2

Manufacturing	Electricity kWh	Coal tonne	Natural Gas m3	Oil L	Gasoline L	
Par tonne de matières	1027.78	0.00	0.14	0.00	0.00	---
Consommation totale	29066598.31	0.00	4059.12	0.00	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	34.88	0.00	7.66	0.00	0.00	42.54
Emissions CH4 tCH4	0.00	0.00	0.00	0.00	0.00	0.00
Emissions N2O tN2O	0.00	0.00	0.00	0.00	0.00	0.00
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	35	0	8	0	0	43
Emissions CH4 tCO2e	0	0	1	0	0	1
Emissions N2O tCO2e	0	0	1	0	0	1
Émissions totales tCO2e	35	0	10	0	0	45

Transportation	Electricity kWh	Coal tonne	Natural Gas m3	Diesel L	Gasoline L	
Par tonne de matières	0.00	0.00	0.00	10.44	0.00	---
Consommation totale	0.00	0.00	0.00	295363.08	0.00	---
Émissions par gaz						TOTAL
Emissions CO2 tCO2	0.00	0.00	0.00	791.87	0.00	791.87
Emissions CH4 tCH4	0.00	0.00	0.00	0.04	0.00	0.04
Emissions N2O tN2O	0.00	0.00	0.00	0.02	0.00	0.02
Émissions en TCO2e						TOTAL
Emissions CO2 tCO2e	0	0	0	792	0	792
Emissions CH4 tCO2e	0	0	0	2	0	2
Emissions N2O tCO2e	0	0	0	8	0	8
Émissions totales tCO2e	0	0	0	802	0	802

Aggregates - Baseline scenario

Baseline scenario - landfill	
Transportation	Diesel mobile L
Par tonne de matières	8.138334457
Consommation totale	4183170.69
Émissions par gaz	
Emissions CO2 tCO2	11215.08
Emissions CH4 tCH4	0.59
Emissions N2O tN2O	0.34
Émissions en TCO2e	
Emissions CO2 tCO2e	11215
Emissions CH4 tCO2e	14
Emissions N2O tCO2e	102
Émissions totales tCO2e	11331

Aggregates - Project scenario

Project scenario - recycling and landfill	
Virgin inputs, process	Diésel mobile, L
Par tonne de matières	-24.41500337
Consommation totale	-8167413.07
Émissions par gaz	
Emissions CO2 tCO2	-21896.83
Emissions CH4 tCH4	-1.14
Emissions N2O tN2O	-0.67
Émissions en TCO2e	
Emissions CO2 tCO2e	-21897
Emissions CH4 tCO2e	-29
Emissions N2O tCO2e	-200
Émissions totales tCO2e	-22126

Virgin inputs, transportation	Diésel mobile, L
Par tonne de matières	-20.34583614
Consommation totale	-6806177.555
Émissions par gaz	
Emissions CO2 tCO2	-18247.36
Emissions CH4 tCH4	-0.95
Emissions N2O tN2O	-0.56
Émissions en TCO2e	
Emissions CO2 tCO2e	-18248
Emissions CH4 tCO2e	-24
Emissions N2O tCO2e	-167
Émissions totales tCO2e	-18439

Recycling production	Diésel fixe, L
Par tonne de matières	11.97128745
Consommation totale	4004687.119
Émissions par gaz	
Emissions CO2 tCO2	11024.90
Emissions CH4 tCH4	0.02
Emissions N2O tN2O	0.12
Émissions en TCO2e	
Emissions CO2 tCO2e	11025
Emissions CH4 tCO2e	1
Emissions N2O tCO2e	37
Émissions totales tCO2e	11063

Landfill / Storage	Diésel mobiel, L
Par tonne de matières	8.138334457
Consommation totale	1460699.668
Émissions par gaz	
Emissions CO2 tCO2	3916.14
Emissions CH4 tCH4	0.20
Emissions N2O tN2O	0.12
Émissions en TCO2e	
Emissions CO2 tCO2e	3917
Emissions CH4 tCO2e	6
Emissions N2O tCO2e	36
Émissions totales tCO2e	3959