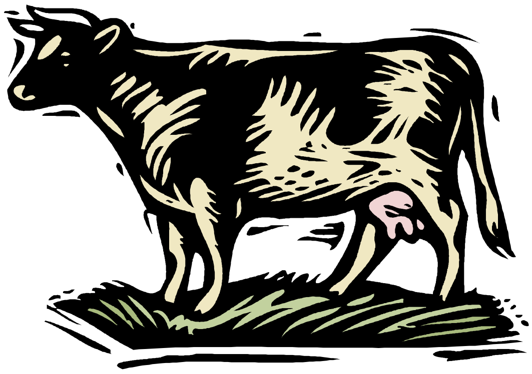

LaForge Biogaz Project

Greenhouse Gas Quantification Report

Prepared by Laforge Farms in conjunction with CSA Climate Change Services, Ottawa

1 General

1.1 Background

The New Brunswick Climate Change Action Plan 2007-2012 provides a greenhouse gas (GHG) emissions reduction target of 2.2 million tonnes (Mt) CO_2e from energy efficiency and renewable energy related activities (equalling 40% of the province's emission reduction targets). The NB Climate Change Action Plan 2007-2012 also states that the Climate Chang Secretariat of the Department of Environment aims to track and report on GHG trends and progress regarding the implementation of all climate change initiatives in this action plan. Furthermore the provincial authorities have decided to quantify the emission reductions according to the ISO 14064 framework.

This document quantifies the impact of the *Laforge Biogaz project* on GHG emission reductions. Since it is expected that the project involved will result in emission reductions below 25,000 tonnes of CO_2e, this specific quantification follows a track 2 quantification that is consistent with ISO 14064-2 principles. This is a simplified approach to estimating emissions that is meant to be transparent and help to demonstrate the credibility in terms of the emission reduction assertion associated with the project, with a level of rigour that is balanced by the availability of data and level of effort required. This quantification approach is also meant to provide a basis for project proponents who may want to later work to generate a more detailed emission reduction report that can be used for the purposes of third party verification.[1]

1.2 The Importance of Reporting Emission Reductions

Efforts have been undertaken to report the emission reductions accrued from this project so that the emission reduction assertion is viewed as credible and accurate. There are a number of reasons that underlie the need to adequately document and report efforts to reduce emissions.

- The basic premise of climate change policy is to take actions that lead to *real* reductions in GHG emissions to the atmosphere. In this respect, it is critical to understand what would have occurred in absence of the project, and to adequately describe what the project is and how it will reduce emissions relative to this "baseline". This in turn increases the rigour and transparency of an emission reduction assertion.
- It is important that there is accountability to how funds are invested and the environmental and economic benefits resulting from this investment. In this regards, it is important that estimates or measurements are provided of both the environmental and economic impacts of a project
- The emission reductions resulting from a project can ultimately be "retired" (i.e. used to reduce a company's or government's emissions), or sold into the carbon market (if not resulting from government funding). In terms of this latter option, how rigorous the emission reduction assertion is will help dictate the market price of the emission

[1] Third party verification is a key step in generating emission reductions that can be brought to market in the form of tradable emission reduction credits. The key areas that would require further development if the project proponent would wish to third party verify the quantification report would be to establish a monitoring plan and more rigorously assess the SSRs associated with the project.

reduction – i.e. offsets created from a high quality project will be deemed more valuable than for a project seen of lower quality.

1.3 ISO Principles Followed in Emission Reduction Estimation

The following principles from the ISO-14064 standards were followed in the estimation of emission reductions resulting from the implementation of this project:

Transparency: We have tried to make the estimation of emission reductions as transparent as possible by explaining all data sources used and providing all equations used in the estimation

Accuracy and rigour: We have followed or adapted best practices in order to help ensure accuracy and rigour in the emission estimations

Conservativeness: In order to not overestimate emission reductions, we have been conservative in our assumptions

Credible and complete: We have aimed to increase the credibility of the emission reduction assertion by making the process of quantification transparent, with an aim to accuracy and rigour, and being conservative in all assumptions. We have also sought to be complete in that all controlled, relevant and affected emissions have been properly accounted for in terms of the project activities.

1.4 Best practice guidance

Other than the requirements identified in ISO 14064-2 the following documents were used as a best practice guidance documents:

- *Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials,* Specified Gas Emitters Regulation[2]
- *Offset Project Methodology for Captured Methane End Use*, Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance[3]

1.5 Program and intended user

This quantification is intended to be used to:

- Provide a report that overviews the GHG reduction benefits of the Laforge Biogaz project, as well as the range of other socio-economic and environmental co-benefits associated with the project;
- Report to the Climate Change Secretariat on the greenhouse gas emissions reductions that have occurred due to this program as part of the Climate Change Action Plan 2007-2012 reporting requirements, and;
- Report back to the people of New Brunswick on the impact of the actions taken to reduce GHG emissions

[2] Specified Gas Emitters Regulation - Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials - http://environment.gov.ab.ca/info/posting.asp?assetid=7917&searchtype=asset&txtsearch=Quantification%20Protocol%20for%20the%20Anaerobic%20Decomposition%20of%20Agricultural%20Materials

[3] Climate Leaders - Offset Project Methodology for Captured Methane End Use - http://www.epa.gov/climateleaders/documents/resources/EndUseOffsetProtocol.pdf

This quantification does not take into account any other program requirements.

1.6 Project proponent

The project proponent is Laforge Hosltein LTD. The contact details of the project proponent are:

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2 Laforge Biogaz project

2.1 Current situation in Canada and in New Brunswick

Anaerobic digester (AD) systems produce electricity and heat from the biogas produced from organic inputs, as well as the possible by-product of nitrogen-rich organics that can be used as fertilizer. Because of these different by-products and potential revenue streams, farm-level AD systems represent a significant opportunity for Canadian farmers to capture new value from agricultural product and byproducts, as well as from off-farm organic inputs.

Although farm-based digesters are being increasingly found throughout Europe and other regions of the world, there were only a dozen or so farm-based digesters in Canada in 2005. The relatively low numbers of farm-based digesters in Canada compared to our European counterparts is reflective of the fact that in the past the environmental, energy, and economic benefits of this technology was under recognized and underdeveloped. Now, however, there appears to be a resurgence of interest in the possibilities and the multiple environmental and economic c0-benefits of farm-based anaerobic digesters in Canada. This is being driven in part by government policy and programs meant to reduce GHG emissions, efforts to improve energy security, alongside efforts to encourage green job creation and the creation of a green economy.[4,5,6]

New Brunswick has a large and diversified agricultural sector where farm-based anaerobic digesters could be implemented. This is especially true when considering that the sector is strongly vertically integrated. In particular, in New Brunswick there are field crop and livestock farms as well as food production and manufacturing facilities that produce organic wastes that could be used in digesters. Combined, there are approximately 2,776 farms with 100 processing plants in the province producing about $1.17 billion worth of agri-food and beverage products.[7] There are over 8,000 jobs in primary production and about 6,540 jobs in

[4] See http://www.omafra.gov.on.ca/english/engineer/facts/consider.htm for a list of some of the government programmes that exist for funding or fiscal-based incentives (e.g. tax rebates, etc).
[5] The province has funded approximately 47 farm-based feasibility studies for bioenergy projects, and has approximately 22 funded projects involving farm-based bioenergy project construction and implementation
[6] There are currently at least five anaerobic digesters processing agricultural wastes in Alberta (http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11290#Alberta)
[7] See Agriculture and Agri-Food 2007, available from http://www.gnb.ca/0168/30/reviewAgriculture2007.pdf

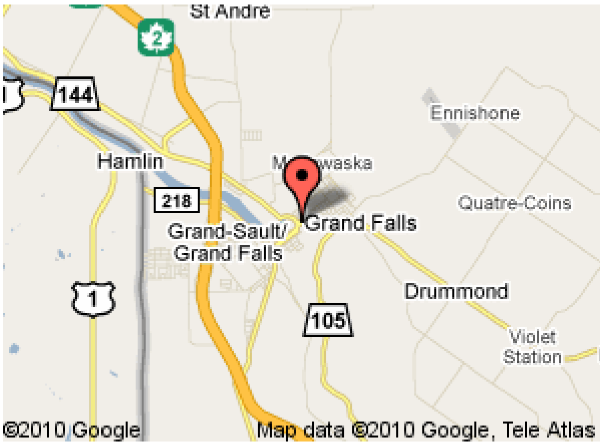
secondary packaging and processing activities, making the sector an important employment base in the province. In fact, New Brunswick enjoys one of the highest levels of value-added processing in Canada from its agriculture sector and its agri-products, which are currently exported to approximately 80 countries. More than 80 percent of the province's agriculture production is processed before reaching the market. Potatoes, dairy products, eggs and poultry and Greenhouse & Floriculture account for close to 60 percent of New Brunswick's total farm income of $444 million in 2007.

There are currently no known biodigesters operating on farms in New Brunswick. Thus, this project will act as an important pilot project that will act dually as part of the Province's actions to reduce climate change and also act as part of the Province's broader energy and economic policy. In particular, the project is identified in *An Action Plan for Self-sufficiency in Northern New Brunswick* in terms of a way New Brunswick could position itself as a regional energy hub. The New Brunswick Energy Minister, Jack Keir, provided this overview:

> "Through this innovative project, Laforge Holstein Ltd. is directly contributing to the development of renewable energy in New Brunswick and promoting long-term, sustainable growth in the energy sector…. (the) project captures many aspects of our vision for the energy hub."

2.2 Project description

Laforge Holstein Ltd. is a 600-acre dairy operation in Grand Falls, New Brunswick (see map) with 100 head of milking cows that produce 3,103 tonnes of manure a year.



This project involves building a Biogas Plant (digester) on the Laforge Holstein farm that will produce electricity from the combustion of biogas coming from the digester.[8] An important bi-product also resulting from the operation of the digester will be liquid organic waste that will be coming out of the digester. This organic material can in turn be used as nitrogen-rich fertilizer on potato land and grain production in the Grand Falls area.

2.2.1 Emission reductions associated with project

Emission reductions will result from three processes:

Improved manure management - GHG emissions will be reduced by capturing the methane gas that is normally emitted from manure storage tanks.

The generation of electricity from manure methane – the farm will be able to power its operations using the electricity generated from the combined heat and power plant being fuelled by biogas. In addition, the farm will be able to sell excess electricity back into the grid.

[8] Biogas is the product of a biological process called anerobic digestion. In the absence of oxygen, anerobic bacteria decompose organic matter and produce biogas that is primarily composed of (60 per cent) methane and carbon dioxide. Biogas can be compared to natural gas that is 99 per cent methane.

Transportation-related emissions associated with moving off-farm organic waste - the farm will offer a much closer destination for food manufacturers in terms of the waste they generate and ultimately would have to compost/send to landfills otherwise.

The feedstock for the digester will come from waste potato peel, french fries and vegetable oil from the McCain Foods Ltd. plant in Grand Falls and manure from local dairy farms. The liquid organic waste—a bi-product of the process—will be used as an organic fertilizer on potato and grain land in the area.

2.2.2 Co-benefits associated with project

The $2.35 million Laforge Bioenvironmental project will generate 2.5 million kWh/year of electricity—enough to run 200 homes. Initial estimates are that carbon dioxide reductions from reduced transportation will equal 26,000 tonnes per year.

The project will also lead to a reduction in landfill waste, the production of fertilizer and the mitigation of dairy farm odours for surrounding residents.

2.3 Project timeline

The project was approved for funding in March 2010, with work expected to commence in fiscal year 2010.

2.4 Description of technology

The digester installed at the Laforge diary farm is 1,500 cubic meters in volume, while the combined heat and power unit being implemented has a power rating of 360kW. The digester will process the dairy manure generated at Laforge farms as well as the organic wastes shipped to the farm, generating biogas which will be fed into a CHP unit to produce electricity and heat. The electricity will be used to first satisfy on site demand with all excess electricity sold to Énergie New Brunswick Power. The transformed manure, or digestate, will be used as fertilizer and land applied. The nutrients in digestate material are far more available for uptake by plant life when compared to untreated manure. Pathogen and odours will be reduced to negligible levels, if not completely eliminated.

The primary system feedstocks considered include dairy manure and off-farm organic wastes. Dairy manure would be entirely supplied from Laforge Farms while off-farm organics would be sourced from local generators.

The biogas system is expected to generate an additional source of revenue for Laforge Farms through the sale of electricity and receipt of tipping fees from off-farm materials shipped to the farm. In addition, revenues could also be recognized as a result from the reduced requirements to purchase fertilizers from outside suppliers or, alternatively, the sale of the digestate material as fertilizers to an outside source.

2.4.1 Biogas technology

Biogas technology involves the conversion of livestock manure and/or organic material into a nutrient fertilizer. The process significantly reduces odour and pathogen levels. GHG emissions are lowered by capturing the methane gas that is normally emitted from manure storage tanks. The methane is further used to produce green energy, replacing conventional electricity currently supplied on the grid.

Biogas consists of 5/8 CH_4 and 3/8 CO_2, or 63% methane and 37% carbon dioxide. Ammonia and Bicarbonate are dissolved in liquid form and remain in the effluent.
The production of biomass by anaerobic digestion is much lower compared to aerobic digestion. Digesting organic substrate anaerobically produces only about 10% new biomass. In other words: For every kilogram of biomass digested, 100 grams of new bacteria grows. The production of methane involves different processes: First, hydrolysis which includes the destruction of organic cells to create substances such as amino acids, fatty acids and sugars. Secondly, fermentation converts the products of hydrolysis into amino acids, propionate and LCFA. The third phase is methanisation, during which methane gas is produced from the products of fermentation. The first phase, hydrolysis, determines the required size of the bioreactor. The time requirement for the substrate to remain in the reactor depends on the digestibility of the substrate. Once the material is broken up, the following processes take place in a defined time period. A minimal retention time of 20 days should be maintained to avoid bacteria 'wash out', which means the growth of the bacteria is slower than its time in the digester.

2.4.2 Gas Production

Supposing that there are no Nitrate or Sulphate reactions in the anaerobic digester, which are quantitatively of minor importance, COD is not dismantled. This means the 100% of the reduced COD becomes methane in the biogas. COD is dismantled in the biogas engine through the burning of methane. Consequently, the methane production in the digester can be calculated using the COD content in the methane, which equals the COD extracted from the organic matter:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Converting 2 mol O_2 from biomass into CO_2 is producing 1 mol CH_4. 1 mol of gas at 35° Celsius at a pressure of 1 bar has a volume of 0.0253 m^3.

2 mol of fermented O_2 is equal to 64 grams COD, consequently 1 kilogram of fermented COD produces a volume of 0.395m^3 CH_4, or 0.626 m^3 biogas, having a methane content of 63%.

In other words, supposing the methane content is 63% in the biogas, each kilogram of COD reduced in the anaerobic digester theoretically produces 0.626m^3 biogas. In practice, farm based anaerobic digesters typically have a methane content between 50% and 60%. This lower methane content can possibly be explained by the composition of the substrate being different from the very simplified formula used above. However, the formula does give a good approximation.

COD laboratory results provide a projection of biogas production. However, only a small sample is analyzed and consequently inhomogeneous substrates are difficult to identify as a representative sample.

2.4.3 Co-Digestion

Co-digestion is the process of mixing various organic materials into an anaerobic digester. The primary advantage of using organic matter is the resulting boost in energy production. Most systems use a mixture of off-farm organics and manure as a means of ensuring stable biological activity within the digester. Some materials require thermal treatment prior to land application.

2.4.4 Biogas System Components

2.4.4.1 Storage & Mixing Pits

The collection pit is a storage facility sized to accommodate the even feeding of the digester. Its use is dependent upon the availability of the materials being delivered to the site. Typically, these substrates are delivered to the site where they are stored for a few days, depending on the delivery schedule. Since a typical truck hauls a volume of 35m^3, two 50m^3 storage pits will allow the accommodation of 1.5 truckloads in each tank and the storage of different substrates independently, avoiding unwanted reactions between the substrates before introducing them into the digester. The collection pit is also used to feed manure, other farm-based organic wastes, such as spoiled silage, and off-farm material. It is sized to accommodate incoming volumes accordingly. There will be a chopper pump in the collection pit for agitation and to pump the materials into the digester.

2.4.4.2 Anaerobic Digester

The Anaerobic Digester is the heart of the system. Here, biomass is decomposed with all gases released collected under a membrane installed over the liquid level. The substrates are maintained at a constant temperature of either 40^{o}C (Mesophilic) or 55 ^{o}C (Thermophilic). Mesophilic digestion is more stable than thermophilic, as thermophilic digesters are more susceptible to malfunctions and biological disturbances. That being said, thermophilic digestion is faster as it allows the same amount of digestion within a shorter period of time. The gas yield is similar regardless of which temperature is used.

The key to stable biogas production is the mixing of substrates. There are a variety of types of mixers on the market and malfunctions with a digester are most often related to the mixing technology employed. In selecting a mixer technology, key considerations are serviceability, reliability of the mechanical and electrical components and availability of replacement parts. Serviceability of the mixer includes the ability to replace or repair the mixer without having to empty the digester, which may not be possible during the winter months.

2.4.4.3 Desulphurisation

By injecting a small percentage of air into the digester, the H_2S is biologically converted to SO_4, which remains as a solid in the effluent. H_2S levels less than 200ppm are maintained with this technology, which is simple and economical. External H_2S removal systems exist, but are typically less cost effective. Substrates with excessive sulphur content may require additional sulphur removal from the biogas.

2.4.4.4 Gas Preparation

When being introduced into the engine, the moisture content of the biogas must be at defined, low levels. Proper demoisturization of the biogas improves engine life and performance of the engine. This can by achieved by cooling the gas down and removing water condensation before entering the turbo charger. A reliable and cost effective way for doing so is by installing a long enough gas pipe in the ground between the digester and the powerhouse, so that as the water cools, it is captured in a condensation trap.

Mechanical gas coolers are also available and are used typically in systems with 500 kW electrical capacities and more. A mechanical gas cooler consumes about 1% of the produced electricity.

2.4.4.5 Flare

Since biogas is a valuable fuel, there is no interest whatsoever to flare it. In addition, biogas flares are mandatory in a number of jurisdictions and countries. Consequently, there is a very limited market for biogas flares and the cost for flares is high.

According to Ontario regulations, biogas systems must have a connection for a portable flare in the event a co-generation unit is out of service for an extended period and there is no alternative means of disposing of the gas. Genesys Biogas includes such a connection in all of its digester designs should similar regulations exist or come into effect in New Brunswick.

2.4.4.6 Pasteurizer

When digesting certain organic wastes, government authorities in certain jurisdictions stipulate the need for thermal pre-treatment. The organic wastes proposed as a biogas system feedstock at Laforge Farms do not require pasteurization.

2.4.4.7 Co-generation Plant

Co-generation, also known as “combined heat and power” (CHP), is the simultaneous production of heat (usually in the form of hot water and/or steam) and electric power, utilizing one primary fuel source. Co-generation is a proven technology that has existed for over 100 years.

Co-generation plants for biogas systems are available from 100kW up to several MW of electrical capacity. The primary difference between natural gas and biogas is the low BTU content of the biogas due to its CO_2 content of up to 50%. This requires a higher volume gas flow through the engine for the same output. The variability of the CO_2 content in the biogas is a further challenge for biogas engines.

There are several manufacturers offering biogas engines, which are then configured to co-generation plants.

Large engines, over 300kW, are typically converted natural gas engines. Dual fuel systems are typically used for small-scale applications, in particular below 100kW and, especially for poor gas qualities, as sometimes found at landfill sites.

Gas engines typically require a minimum methane content of some 45% in the biogas.
Low methane contents are typically found in landfill systems and silage plants.
The overall efficiency of co-generation systems, including electrical power, low grade thermal and high grade thermal outputs, reach over 85%.

2.4.4.8 Solids Separator

The effluent of the digester can be run through a solid separator, typically a screw press, to extract the solids portion in order to use it for bedding. The liquid portion can then be land applied. In the case of Laforge Farms, the bedding produced through this process could replace the existing bedding.

Such a system would cost approximately $50,000, installed. Genesys Biogas recommends installing the anaerobic digester first, to ensure it is operating optimally, and then consider a solids separator at a later date.

2.4.4.9 Storage Pit

The effluent of the digester is to be stored initially before receiving further treatment (i.e. solid separation, land application). The storage facility should hold a volume of 240 days of production. Storage capacity needs to be built according to the volume of on and off-farm substrates to be received, please see Table 1.

Table 1 Storage requirements associated with on and off-farm material

	Cattle Manure (t per year)	Additional Material (t per year)	Total Feedstock (t per year)	Storage Required (m^3)
Current	3,103	-		2,040
Proposed	3,103	17,896	20,999	13,331

Organic material is created through photosynthesis, whereby solar energy is stored. Consumers of organic material use different methods to store the energy as a means of maintaining life and producing new products.

Energy cannot be created, only transformed. Once energy has been extracted from organic matter, the remains contain less energy than the original organic material. For example, when a mammal eats food, the end result is manure. The manure/organic matter left after food has been consumed has a lower energy value than the original food source. The material is transformed through the process of digestion.

Organic materials that have not undergone any form of digestion typically offer higher biogas yields than those which have previously been digested. Some materials from the processing industry are even more concentrated than the biomass from which they originated. Some of these products are beneficial to a digester, whereas others are not.

The costs of each organic material will vary; this is where co-digestion is beneficial.
For Laforge Farms, dairy manure, FOG and source-separated organics are considered as primary feedstock.

Depending on the nature of the substrates, long retention times for hydrolysis may be required. For materials with high-energy output, a shorter retention time may be possible.

Table 2 Substrates being considered for Laforge Farm

Substrate	Total Solids Content (%)	Digestibility (VS/TS)	Biogas Yield (m^3/ton)	Methane Content (%)
A. Dairy Manure (Liquid)[1]	12	85	21	60
B. Secondary Cake[1]	25	85	57	55
Secondary Cake[2]	10.5	52	13	61
C. Cooked Fries[1]	25	90	680	60
Cooked Fries[2]	27.6	99.2	81	52
D. Waste vegetable Oil[1]	95	92	874	68
Waste vegetable Oil[2]	20	96.0	276	51
E. Starch[1]	20	94	151	52
Starch[2]	65.1	98.8	760	50
F. Potato Peels[2]	12.1	87.9	43.5	51

[1] Literature Value
[2] Laboratory Sample Value

Roughly, one cubic meter of biogas will produce 1.8 - 2 kWh of electricity, depending on the methane content. The table below assumes that one cubic meter of biogas will produce 1.9 kWh of electricity.

Table 3 Methane and revenue (from electricity) potential from different feedstocks to digester

Substrate	Methane m^3/ ton	Value of Energy/ ton @ 9.17 Cents/ kWh
A. Dairy Manure (Liquid)	13	$ 2.26
B. Secondary Sludge (Cake)	13	$ 2.26
C. Cooked fries	81	$ 14.11
D. Waste vegetable Oil	276	$ 48.09
E. Starch	760	$ 132.41
F. Potato Peels	43.5	$ 7.58

2.5 GHG reductions strategy

There are three different sources of emission reductions associated with project, including:

- Emission reductions resulting from the management of manure methane, namely, the use of biogas in a combined heat and power unit
- Emission reductions resulting from the avoidance of electricity purchased from the fossil-fuel dominated grid as well as the sale of green electricity into the fossil-fuel dominated grid
- Emission reductions resulting from the avoidance of travel due to the fact that the farm is a closer destination for food waste generated by food manufacturers who would otherwise send this to a landfill and/or composter.

3 Identification of SSRs attributable to the project

Sources, sinks, and reservoirs (SSRs) are defined in order to determine the full breadth of emissions attributable to the project being implemented.[9] This relates to the project boundary,

[9] A source means any process or activity that releases a greenhouse gas into the atmosphere, whereas a sink means any process, activity or mechanism that removes a greenhouse gas from the atmosphere and a reservoir

or the activities which should be included in assessing the emission reductions resulting from a project. However, it is important to note that there are emissions that are not under the direct control of the project proponent, and that associated emission reductions are not necessarily owned by the project proponent unless are legal agreements with other stakeholders involved with these activities. For example, this is true in terms of project activities that might impact on electricity generation or in terms of project activities that might impact on the transportation characteristics of suppliers tied to the project. Both of these situations are relevant for the Laforge Biogaz project, and the approach for handling this is discussed in more detail in later sections.

The SSRs that are associated with the project were identified and are displayed in the figure below.

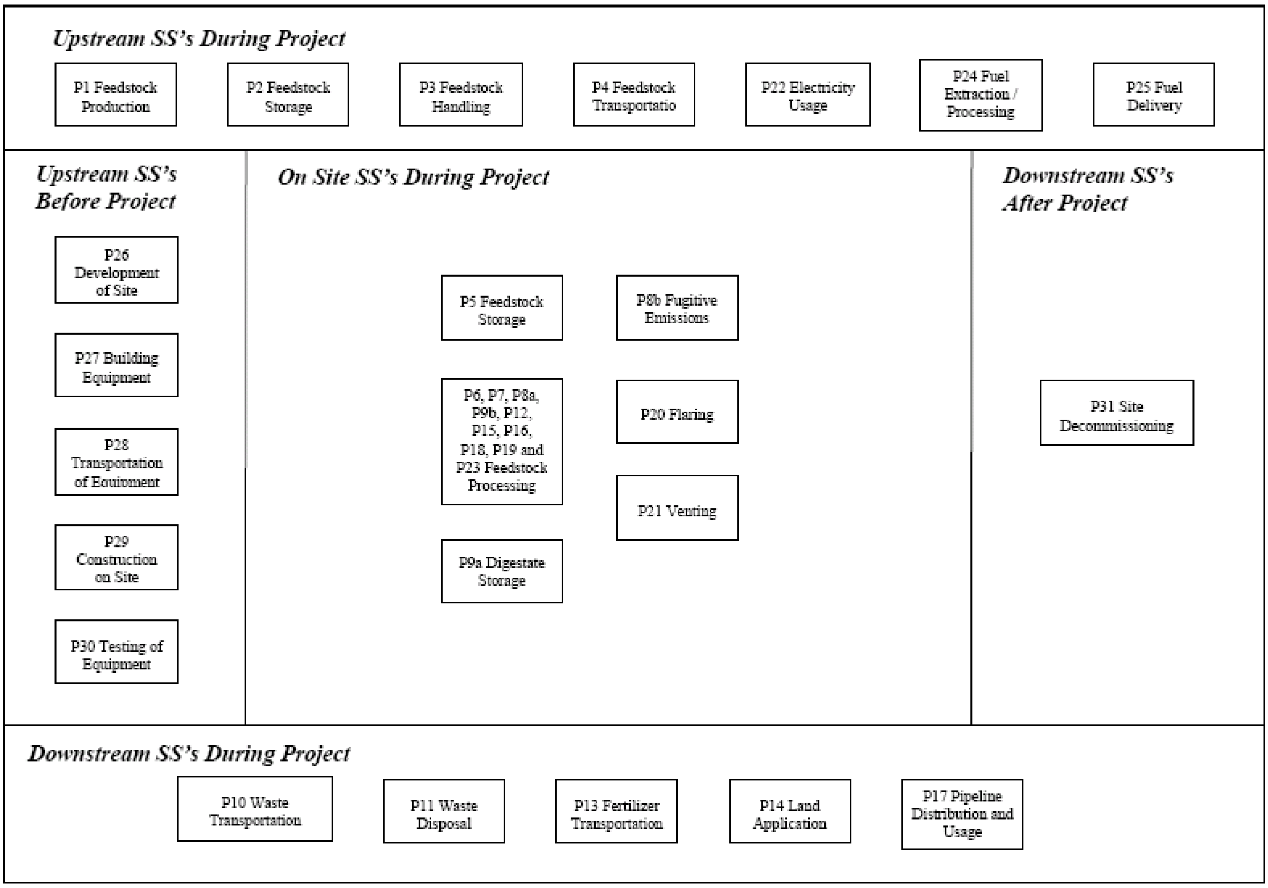


Figure 1 Sources, sinks and reservoirs identified for project[9]

Emissions that are "controlled" by the project proponent are those that are directly impacted by decisions and actions of the proponent. Alternatively, emissions that are "related" are those emission sources that are affected, but not necessarily controlled. For example, although a project proponent might increase energy efficiency in order to reduce electricity demand, emissions from electricity may still go up if the electricity generator produces more electricity from fossil fuels relative to clean energy sources. Finally, "affected" emissions are those related to market transformation that occurs as a result of the project activity happening. For

means a physical unit or component of the biosphere, geosphere or hydrosphere with the capability to store or accumulate GHGs (from http://www.ec.gc.ca/creditscompensatoires-offsets/default.asp?lang=En&n=7CAD67C6-1&offset=12&toc=show).

example, if the project activity is successful in encouraging other like entities to take up that activity, the market is transformed. Similarly, if the project activity helps establish best practices or influences the price of related services/materials, this can have a market impact.

The following table identifies, describes, and categorizes the SSRs according to if they are controlled, related, or affected by the project.

Table 4 Description of SSRs associated with project[10]

SSR	Description	Controlled, Related, Affected
Upstream during project operations		
P1 Feedstock Production	Agricultural materials are produced in a number ways. Farm animals produce manure as part of their digestive cycle. The composition of this manure is impacted by the ration they are fed. The ration is a function of the animal's life-stage, production target, climate and ration market dynamics. Other agricultural materials include dead-stock and materials from the harvesting and/or processing of various crops or agricultural products. Greenhouse gas emissions may be associated with the collection and processing of the feedstock using various mechanical farm equipment primarily powered by diesel and natural gas. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P2 Feedstock Storage	Feedstock may be stored at the farm site, in the animal pens, in windrows, piles or in enclosed containers. Greenhouse gas emissions may result from the anaerobic decomposition of these materials if storage conditions allow for an oxygen deficient atmosphere or from volatilization of nitrogen as nitrous oxide under aerobic conditions. The characteristics size, shape, composition and duration of storage are all pertinent to evaluate functional equivalence with the baseline condition.	Related
P3 Feedstock Handling	Feedstock may be handled and/or processed prior to transportation. This may involve the use of heavy equipment such as payloaders or excavators that operate using diesel or natural gas. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P4 Feedstock Transportation	Feedstock may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be	Related

[10] From Biogas Protocol

SSR	Description	Controlled, Related, Affected
	used to evaluate functional equivalence with the baseline condition.	
P22 Electricity Usage	Electricity may be required for operating the facility. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related
P24 Fuel Extraction / Processing	Each of the fuels used throughout the on-site component of the project will need to be sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related
P25 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there are no other delivery emissions as the fuel is already going to the commercial fuelling station. Distance and means of fuel delivery as well as the volumes of fuel delivered are the important characteristics to be tracked.	Related
Onsite SS's during Project Operation		
P5 Feedstock Storage	Feedstock may then be stored on site in piles or in enclosed containers. Greenhouse gas emissions may result from the anaerobic decomposition of these materials if storage conditions allow for an oxygen deficient atmosphere or from volatilization of nitrogen as nitrous oxide under aerobic conditions. The characteristics of these storage piles, in terms of size, shape, composition and duration of storage may all need to be tracked.	Controlled
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing	Feedstock may be handled and/or processed prior to being input to the anaerobic digester. This may involve the used of heavy equipment such as bull-dozers that operate using diesel or natural gas. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities for each of the energy inputs may all need to be tracked.	Controlled
	Regulations for handling dead stock may require specific processing. Specifically, this would address Special Risk Material (SRM) and may involve thermodynamic processes, or other mechanical processes. This may involve heating, cooling or processing using special equipment all of which would require either natural gas or diesel. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities for each of the energy inputs may all need to be tracked.	Controlled
	Greenhouse gas emissions may occur that are associated with the operation and maintenance of the anaerobic digestion facility. This may include running any auxiliary or monitoring systems. Quantities and types for each of the energy inputs	Controlled

SSR	Description	Controlled, Related, Affected
	would be tracked.	
	Greenhouse gas emissions may occur that are associated with the separation of the solid and liquid phases of the digestate. The mechanical process for separating the solid and liquid components is sometimes electrical system, which would be tracked.	Controlled
	Digestate may be converted to fertilizer through mechanical and amendment processes. This requires several energy inputs such as natural gas. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Effluent water may be treated through mechanical and chemical processes prior to discharge or reuse. This requires several energy inputs such as natural gas and diesel. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Effluent biogas will likely have a higher concentration of carbon dioxide and other impurities than may be acceptable to the pipeline operator. Mechanical equipment may be required to treat the biogas in order for the biogas to be suitable for inclusion in the pipeline system. This may require several energy inputs such as natural gas and diesel. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Co-generation systems may be required to produce thermal energy for distribution. The operation of this equipment may require several energy inputs such as natural gas or diesel. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Systems may be required to distribute the thermal energy to neighbouring sites. This may include pumps to circulate steam, hot oil or hot water. This equipment may require several energy inputs such as natural gas or diesel. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Thermal energy systems may be required to maintain the desired temperature for the anaerobic digester. This may include boilers or similar, which may require several energy inputs such as natural gas or diesel. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities and types for each of the energy inputs would be tracked.	Controlled
P8b Fugitive Emissions	Greenhouse gas emissions may also result from fugitive emissions associated with the operation of the anaerobic digestion facility. These emissions would primarily be methane emissions associated with leaks through valves, connections and equipment seals as many of the facility components operate under pressure. Quantities of fugitive emissions would need to be measured or estimated.	Controlled

SSR	Description	Controlled, Related, Affected
P9a Digestate Storage	Greenhouse gas emissions may also result if the digestate needs to be stored temporarily after being removed from digester and before further processing. Further anaerobic decomposition may occur resulting primarily in methane emissions. Quantities of digestate being stored, the emissions intensity and residency time would need to be measured or estimated.	Controlled
P20 Flaring	Flaring of the biogas may be required during upset conditions or during maintenance to the elements downstream of the anaerobic digester. Emissions of greenhouse gases would be contributed from the combustion of the biogas as well as from any natural gas used in flaring to ensure more complete combustion. Quantities of biogas being flared and the quantities of natural gas would need to be tracked.	Controlled
P21 Venting	Venting of the biogas may be required during upset conditions or during maintenance to the elements downstream of the anaerobic digester. Emissions of the methane under these circumstances would need to be considered. The duration of the venting condition, methane production rate and the volume of biogas in the digester at the time of venting would all need to be tracked.	Controlled
Downstream SS's during Project Operation		
P10 Waste Transportation	Waste materials may be transported to disposal sites by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
P11 Waste Disposal	Waste may be disposed of at a disposal site by transferring the waste from the transportation container, spreading, burying, processing, otherwise handling the waste using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gas or natural gas, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities and types for each of the energy inputs would be tracked.	Related
P13 Fertilizer Transportation	Fertilizer produced at the site will need to be transported to customers or distribution points by truck and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
P14 Land Application	The fertilizer produced at the site will then be land applied. This will require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas or natural gas, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P17 Pipeline Distribution and Usage	Biogas may be input to the pipeline system and distributed to customers at another point on the distribution system. This gas will be further processed or consumed by the consumer. The most reasonable fate would be combustion in a controlled manner as this relies on the highest emissions factors for the biogas. This quantity of biogas input to the pipeline system	Related

SSR	Description	Controlled, Related, Affected
	would need to be tracked.	
Others		
P26 Development of Site	The site of anaerobic digestion facility may need to be developed. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structure for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
P27 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
P28 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site will all need to be delivered to the site. Transportation may be completed by truck, barge and/or train. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
P29 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related
P30 Test of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test anaerobic digestion fuels or fossil fuels in order to ensure that the equipment runs properly. These activities will results in greenhouse gas emission associated with combustion of fossil fuels and the use of electricity.	Related
P31 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

The only source emissions that are directly controlled by the project proponent and included in the assessment of GHG emissions are those related to the management of the manure produced at the farm and the management of the organic wastes transported to the farm. However, emission reductions associated with the green electricity produced by the farm as well as emission reductions associated with the fertilizer produced from the biodigestor are also included since these are closely related to the project. Further, if the proponent chooses to, carbon clauses could be structured with both NB Power and the transportation companies that haul biowaste from the facility so that the farm might ultimately claim the reductions associated with the project.

4 Selection and justification of the baseline scenario

A baseline scenario is used to establish what the quantified emissions are in terms of what will occur under "business as usual" (BAU) conditions in respect of the project and the services it delivers. It is therefore important to establish what the baseline scenario is. The common practice is to identify multiple possibilities for the baseline scenario, and then to identify the one most likely to occur through the process of barrier analysis (see below).

The following scenarios were identified for the purposes of this project:

1. Continuing to manage manure in storage tanks on the Laforge farm
2. Building a digester that can be used to generate electricity through the use of a CHP plant (i.e. the project

A barrier test is used to help identify barriers to any of these scenarios occurring. A barrier test in a common technique used to help justify a baseline scenario and to substantiate the claim that a project is in fact additional to the business as usual.

Table 5 Barrier analysis of baseline scenarios

Possible baselines **Barriers**	**Scenario 1**	**Scenario 2**
Regulatory barriers	No barriers	No barriers
Common practice barriers	No barriers	Farm-based anaerobic digesters and not yet common practice in Canada or New Brunswick
Financial barriers	No barriers	The Laforge Digester project will entail a capital cost exceeding $2 million. This amount would make the project inaccessible if it were not for the help of government programs and funding.
Barriers due to the geographical location	No barriers	No barriers
Barriers due to public perception	No barriers	No barriers
Market barriers	No barriers	Since this project is essentially the first project of its kind in New Brunswick, there are market limitations in terms of expertise and technical skills, as well market barriers associated with available technology

Possible baselines Barriers	Scenario 1	Scenario 2
Technological barriers	No barriers	Similar to market barriers, this project has technological barriers due to the fact that some of the project equipment and know-how has to be imported from other jurisdictions.

The barriers analysis suggests that the baseline conditions are that of there is a continuation of the status quo; namely, a continuation of current practices. The assessment also indicates that the project is additional to the baseline; namely, that the project has enough barriers that would limit it from occurring if it were not for the carbon-related funding it has received.

5 Identification of SSR's attributable to the baseline

The following SSRs that are associated with the baseline were identified.

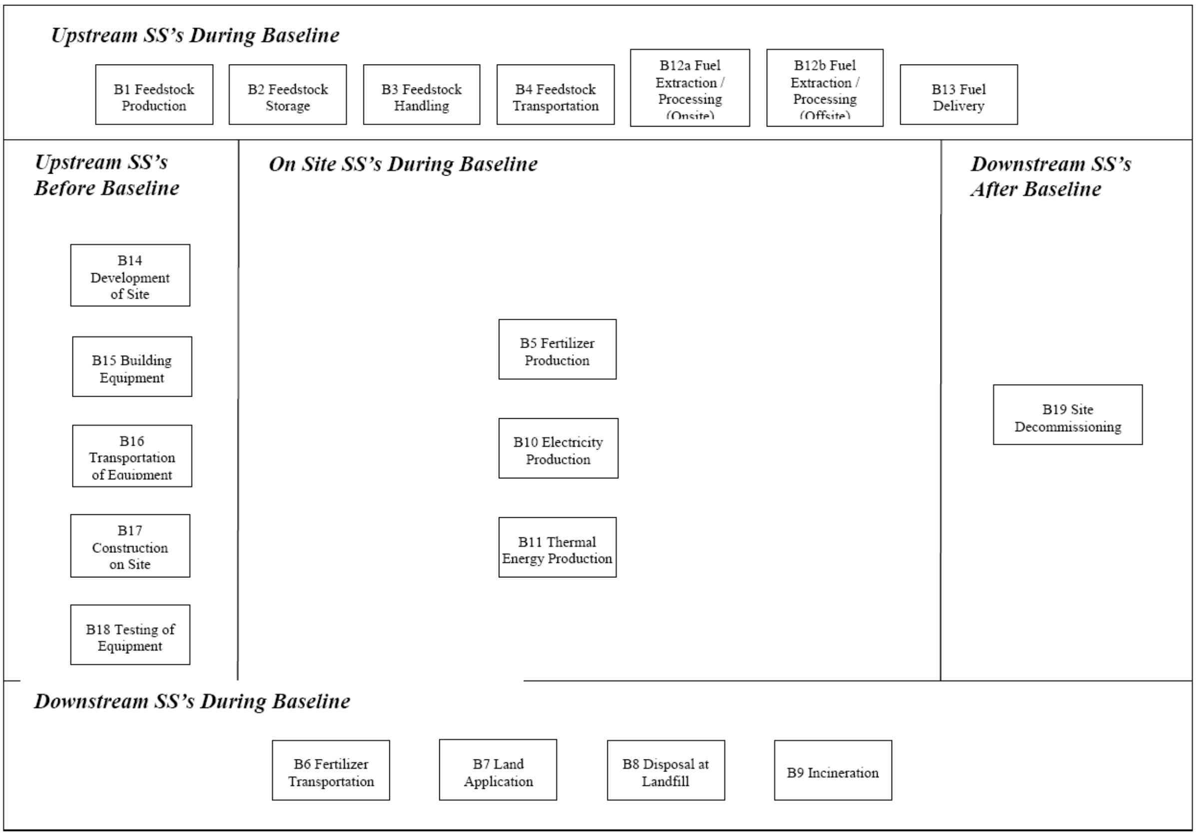


Figure 2 SSRs identified for the baseline

The following table names and details if the SSRs identified are related to controlled and then describes if there are differences between the SSRs in terms of the project and baseline.

Descriptions of each of the SS's and their classification as either 'controlled', 'related' or 'affected' is provided in the table below.

Table 6 Description of SSR's associated with the baseline[9]

SSR	Description	Controlled, Related, Affected
Upstream during project operations		
B1 Feedstock Production	Agricultural materials are produced in a number ways. Farm animals produce manure as part of their digestive cycle. The composition of this manure is impacted by the ration they are fed. The ration is a function of the animal's life-stage, production target, climate and ration market dynamics. Other agricultural materials include dead-stock and materials from the harvesting and/or processing of various crops or agricultural products. Greenhouse gas emissions may be associated with the collection and processing of the feedstock using various mechanical farm equipment primarily powered by diesel and natural gas. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
B2 Feedstock Storage	Feedstock may be stored at the farm site, in the animal pens, in windrows, piles or in enclosed containers. Greenhouse gas emissions may result from the anaerobic decomposition of these materials if storage conditions allow for an oxygen deficient atmosphere or from volatilization of nitrogen as nitrous oxide under aerobic conditions. The characteristics size, shape, composition and duration of storage are all pertinent to evaluate functional equivalence with the baseline condition.	Related
B3 Feedstock Handling	Feedstock may be handled and/or processed prior to transportation. This may involve the use of heavy equipment such as payloaders or excavators that operate using diesel or natural gas. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
B4 Feedstock Transportation	Feedstock may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
B12a Fuel Extraction / Processing (Onsite)	Each of the fuels used throughout the on-site component of the project will need to sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related
B12b Fuel Extraction / Processing (Offsite)	The biogas being input to the pipeline during the project condition offsets a volume of natural gas from the pipeline system. This volume of natural gas from the pipeline will need to sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the natural gas. The total volume of biogas input to the pipeline is considered under this SS and may need to be tracked.	Related

SSR	Description	Controlled, Related, Affected
B13 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there is no other delivery.	Related
Onsite SS's during Project Operation		
B5 Fertilizer Production	Fertilizer may be produced through a number of chemical, mechanical and amendment processes. This requires several energy inputs such as natural gas, diesel and electricity. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B10 Electricity Production	Electricity will be produced off-site to cover the electricity demand not being produced by the anaerobic digestion facility. This electricity will be produced at an emissions intensity as deemed appropriate by the Program Authority. Measurement of the gross quantity of electricity produced by the facility will need to be tracked to quantify this SS.	Related
B11 Thermal Energy Production	The production of thermal energy may be required to meet the demands of facilities being provided with thermal energy from the project site. This thermal energy may have been derived from waste heat recovery systems resulting in an energy burden on the systems from which the heat is being recovered or directly from combustion of fossil fuels. Energy requirements, fuel volumes and fuel types will need to be tracked.	Related
Downstream SS's during Project Operation		
B6 Fertilizer Transportation	Fertilizer produced at the site will need to be transported to customers or distribution points by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the project condition.	Related
B7 Land Application	Fertilizer and/or feedstock will then be land applied. This will require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas, natural gas or electricity, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B8 Disposal in Landfill	Some feedstock may be disposed of at a disposal site by transferring the material from the transportation container, spreading, burying, processing, otherwise handling the material using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gas, natural gas or electricity, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities and types for each of the energy inputs would be tracked. Residues may decompose in the disposal facility (typically a landfill site) resulting in the production of methane. A methane collection and destruction system may be in place at the disposal site. If such a system is active in the area of the	Related

SSR	Description	Controlled, Related, Affected
B9 Incineration	landfill where this material is being disposed, then this methane collection must be accounted for in a reasonable manner. Disposal site characteristics and mass disposed of at each site may need to be tracked as well as the characteristics of the methane collection and destruction system. Some feedstock may be incinerated at a disposal site. This will include combusting the materials with a fuel such as natural gas or diesel. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be contemplated and tracked to evaluate functional equivalence with the project condition.	Related
Others		
B14 Development of Site	The site may need to be developed under the baseline condition. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas and offices, etc., as well as structures to enclose, support and house any equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
B15 Building Equipment	Equipment may need to be built either on-site or off-site. This can include the baseline components for the storage, handling and processing of the agricultural material. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
B16 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site, will all need to be delivered to the site. Transportation may be completed by truck, barge and/or train. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
B17 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related
B18 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test agricultural materials or fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
B19 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

6 Selection of Relevant Project and Baseline SSR's

Each of the SS's from the project and baseline condition were compared and evaluated as to their relevancy using the guidance provided in Annex VI of the "Guide to Quantification Methodologies and Protocols: Draft", dated March 2006 (Environment Canada). The justification for the exclusion or conditions upon which SS's may be excluded is provided in **TABLE 2.3** below. All other SS's listed previously are included.

Table 7 Comparison of SSR's[9]

1. Baseline Options	2. Baseline (C, R, A)	2. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
Upstream SS's				
P1 Feedstock Production	N/A	Related	Exclude	Changes in livestock rations may yield differing energy values for manure. However, rations are typically tied to yield from the animal, availability, cost, etc. Further, the impacts of changes in feed regimes on enteric emissions from livestock are not sufficiently understood as to provide accuracy in measurement or estimation, in an economically efficient monitoring regime. Production of other feedstocks would likely be functionally equivalent as they are produced under normal operation. For these reasons, it is reasonable to exclude these SS's.
B1 Feedstock Production	Related	N/A	Exclude	
P2 Feedstock Storage	N/A	Related	Exclude	Under the majority of project and baseline configurations, the duration that the material is stored will be less under the project condition as compared to the baseline. This is reasonable given that collection will be planned in order to capture the material when it has a higher energy value. Further collection frequencies will be shorter to ensure more continual supply of feedstock to the anaerobic digestion system. As the duration of storage is shorter, it is reasonable to assume that these SS's may be excluded as the baseline emissions will exceed the project emissions.
B2 Feedstock Storage	Related	N/A	Exclude	
P3 Feedstock Handling	N/A	Related	Exclude	Excluded as under the majority of configurations, the project condition is equivalent to the baseline scenario.
B3 Feedstock Handling	Related	N/A	Exclude	
P4 Feedstock Transportation	N/A	Related	Include	N/A
B4 Feedstock Transportation	Related	N/A	Include	
P22 Electricity Usage	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practices are covered under proposed greenhouse gas regulations.
P24 Fuel Extraction / Processing	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practices are covered under proposed greenhouse gas

B12a Fuel Extraction / Processing (Onsite)	Related	N/A	Exclude	regulations.
B12b Fuel Extraction / Processing (Offsite)	Related	N/A	Exclude	Excluded as these SS's are not being considered for the project at this time as they are offsite.
P25 Fuel Delivery	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practices are covered under proposed greenhouse gas regulations.
B13 Fuel Delivery	Related	N/A	Exclude	
Onsite SS's				
P5 Feedstock Storage	N/A	Controlled	Exclude	As per the discussion for B2 and P2 Feedstock Storage, the storage of these materials is minimized in order to capture the highest energy value. Further, limited inventory of agricultural materials are maintained on site as should there be an up-set condition, having these materials on-site could bring forward storage issues such as odour. For these reasons, it is reasonable to exclude this SS.
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing	N/A	Controlled	Include all except P7, P19	Laforge will not be using any deadstock as outlined in P7. Laforge will not be distributing thermal energy to neighbouring sites as outlined in P19.
P8b Fugitive Emissions	N/A	Controlled	Exclude	Excluded as projects applying this protocol must meet the requirements of with Sections 10.2 through 10.4 of the Canadian Standards Association (CSA) Code for Digester Gas and Landfill Gas Installations CAN/CGA-B105-M93 which specifies the relevant leakage and pressure testing requirements providing reasonable assurance that fugitive emissions are immaterial.
P9a Digestate Storage	N/A	Controlled	Exclude	The digestate removed from the anaerobic digestion vessel(s) may continue to produce methane emissions if not aerated or nitrous oxide emissions if aerated. Separation of the solid and liquid components can serve to stabilize the digestate in order to minimize the continuation of the anaerobic digestion processes would continue outside of the digestion chamber. Under the condition that the digestate does not undergo active composting, the emissions from secondary storage are immaterial.
P20 Flaring	N/A	Controlled	Include	N/A
P21 Venting	N/A	Controlled	Include	N/A
B5 Fertilizer Production	N/A	Related	Include	N/A
B10 Electricity Production	Related	N/A	Include	N/A
B11 Thermal Energy Production	Related	N/A	Include	N/A
Downstream SS's				
P10 Waste Transportation	N/A	Related	Exclude	Excluded as quantity of waste and related emissions from its transport are negligible.

P11 Waste Disposal	N/A	Related	Exclude	Excluded as the waste is essentially inert and its disposal would not contribute to methane production, and would have no impact on methane collection and destruction systems.
P13 Fertilizer Transportation	N/A	Related	Exclude	Excluded as under the majority of configurations, the project condition is equivalent to the baseline scenario.
B6 Fertilizer Transportation	Related	N/A	Exclude	
P14 Land Application	N/A	Related	Exclude	The nitrogen stabilization in the project condition (P12 Land Application) is such that the amount of nitrous oxide released will be less and the amount of carbon that is biologically sequestered in the soil will be greater than in the baseline condition (B7 Land Application). As this involves complex data capture, management and calculation, involving considerable uncertainty, it is reasonable to exclude the emission reductions from this SS's.
B7 Land Application	Related	N/A	Exclude	
P17 Pipeline Distribution and Usage	N/A	Related	Exclude	Excluded as these SS's are not being considered for the project at this time as they are offsite.
B8 Disposal in Landfill	Related	N/A	Include	N/A (Note that only methane emissions will be included, and not emissions from transportation equipment as described in Table 6).
B9 Incineration	Related	N/A	Exclude	Laforge does/has not use(d) incineration practices to dispose of manure (feedstock).
Other				
P26 Development of Site	N/A	Related	Exclude	Emissions from site development are not material given the long project life, and the minimal site development typically required.
B12 Development of Site	Related	N/A	Exclude	Emissions from site development are not material for the baseline condition given the minimal site development typically required.
P27 Building Equipment	N/A	Related	Exclude	Emissions from building equipment are not material given the long project life, and the minimal building equipment typically required.
B13 Building Equipment	Related	N/A	Exclude	Emissions from building equipment are not material for the baseline condition given the minimal building equipment typically required.
P28 Transportation of Equipment	N/A	Related	Exclude	Emissions from transportation of equipment are not material given the long project life, and the minimal transportation of equipment typically required.
B14 Transportation of Equipment	Related	N/A	Exclude	Emissions from transportation of equipment are not material for the baseline condition given the minimal transportation of equipment typically required.
P29 Construction on Site	N/A	Related	Exclude	Emissions from construction on site are not material given the long project life, and the minimal construction on site typically required.
B15 Construction on Site	Related	N/A	Exclude	Emissions from construction on site are not material for the baseline condition given the minimal construction on site typically required.
P30 Testing of Equipment	N/A	Related	Exclude	Emissions from testing of equipment are not material given the long project life, and the minimal testing of equipment typically required.
B16 Testing of Equipment	Related	N/A	Exclude	Emissions from testing of equipment are not material for the baseline condition given the minimal testing of equipment typically required.

P31 Site Decommissioning	N/A	Related	Exclude	Emissions from decommissioning are not material given the long project life, and the minimal decommissioning typically required.
B17 Site Decommissioning	Related	N/A	Exclude	Emissions from decommissioning are not material for the baseline condition given the minimal decommissioning typically required.

7 Quantification of reductions of relevant SSRs

7.1 Approach for quantification of reductions of relevant SSRs

Emission reductions are estimated and quantified separately for each SSR based on the following formula:

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

7.1.1 Project Emissions

$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Feedstock Processing}} + \text{Emission}_{\text{Flaring}} + \text{Emissions}_{\text{Venting}} + \text{Emissions}_{\text{Transportation}}$

(i) For emissions related to the operation of the anaerobic digester, [P6, P8a, P9b, P12, P15m P16, P18, P23]

Project emissions associated with the operation of the anaerobic digester are estimated as a product of the volume of fuel combusted, whether it be biogas or a fossil fuel, and the different emission factors for that type of fuel (if biogas is used, the product must also include % CH_4, the methane composition in biogas). The operation of the digester may include pre-processing of the feedstock for digester use, general operation and maintenance of the anaerobic digestion facility (including thermal energy systems needed to maintain the desired temperature for the digester), treatment of the digestate (including separation of solid and liquid phases and conversion into fertilizer), effluent water treatment, effluent biogas treatment and operation of the CHP system. Quantities and types for each of the energy inputs would need to be tracked. CO_2 emissions from the operation of the anaerobic digester shall be determined as follows:

$\text{Emissions}_{\text{Feedstock Processing}}$ = (Vol. $\text{Biogas}_{\text{Combusted}}$ * % CH_4 * EF Biogas CH_4); (Vol. $\text{Biogas}_{\text{Combusted}}$ * %CH_4 *EF Biogas N_2O); (Vol. Fossil Fuel * EF Fuel_{CO2}); (Vol. Fossil Fuel * EF Fuel_{CH4}); (Vol. Fossil Fuel * EF Fuel_{N2O})

Where:

$\text{Emissions}_{\text{Feedstock Processing}}$ = Emissions related to the operation of the anaerobic digester, in kg CO_2; CH_4; N_2O
Vol. Biogas = Volume of biogas combusted, in m^3
% CH_4 = Methane composition in biogas
EF Biogas CH_4 = CH_4 emissions factor for biogas, kg CH_4 per m^3
Vol. Fossil Fuel = Any fossil fuel used for the operation of the anaerobic digester

(ii) For emissions related to flaring of biogas during upset conditions, P20

Project emissions associated with the flaring of biogas are estimated as a product of the volume of biogas flared, the methane content of the biogas and associated emission factors in addition to the product of any fossil fuel used in the flaring process (to ensure a more complete combustion) and its associated emission factors. Quantities of biogas and natural gas being flared would need to be tracked. CO_2 emissions from the flaring of biogas in upset conditions shall be determined as follows:

$Emissions_{Flaring}$ = (Vol.Biogas Flared * % CH_4 * EF $Biogas_{CH4}$); (Vol. Biogas Flared * % CH_4 * EF Biogas $_{N2O}$); Σ(Vol. Fuel * EF $Fuel_{CO2}$); Σ(Vol. Fuel * EF $Fuel_{CH4}$); Σ(Vol. Fuel * EF Fuel $_{N20}$)

$Emissions_{Flaring}$ = Emissions from flaring instances, in kg of CO_2; CH_4; N_2O
Vol. Biogas Flared = Volume of biogas being flared, in m^3
% CH_4 = Methane composition in biogas
EF $Biogas_{CH4}$ = CH_4 emissions factor for biogas, in kg CH_4 per m^3
EF $Biogas_{N20}$ = N_2O emission factor for biogas, in kg N_2O per m^3
Vol Fuel = Volume of each type of fuel used to supplement flare, in m^3
EF $Fuel_{CO2}$ = CO_2 emission factor for each type of fuel, in kg CO_2 per m^3
EF Fuel $_{CH4}$ = CH_4 emission factor for each type of fuel, in kg CH_4 per m^3
EF Fuel $_{N2O}$ = N_2O emission factor for each type of fuel, in kg N_2O per m^3

(iii) For the emissions related to the venting of biogas during upset conditions, P21

Project emissions associated with the venting of biogas are estimated as a product of the volume of biogas being stored at the time of venting, the flow from the biogas storage vessel, the duration of the venting condition and the methane composition of the biogas. The duration of the venting condition, methane composition of biogas and the volume of biogas in the digester at the time of venting would all need to be tracked. CO_2 emissions from the venting of biogas in upset conditions shall be determined as follows:

$Emissions_{Venting}$ = (Max. Storage $Vol._{Vessel}$ + Flow $Biogas_{Vessel}$ * $Time_{Venting}$)* % CH_4

$Emissions_{Venting}$ = Emissions from venting instances, in kg CH_4
Max. Storage $Vol._{Vessel}$ = Maximum volume of biogas stored in vessel at steady state, in m^3
Flow $Biogas_{Vessel}$ = Flow rate of biogas at steady state, in m^3/hr
$Time_{Venting}$ = Time that vessel is venting, days
% CH_4 = Methane composition in biogas

(iv) For emissions related to the transportation of organic waste, P4

Baseline and project emissions associated with the transportation of food waste by McCain's Inc. are estimated as a product of the tonnage expected to be transported to the Laforge Farm as part of the project, the distance that this waste is transported, and an emission factor representative of this transport. CO_2 emissions from the transportation of food waste shall be determined as follows:

$$Emissions_{Transportation} = Tonnes * Distance * EF_{WasteTransport}$$

Where:

Waste transport emissions = Emissions from the transportation of food waste, in kgs CO_2e
Tonnes = Amount of waste moved, in tonnes
Distance = Distance waste moved, in kilometres
$EF_{WasteTransport}$ = Emission factor of waste travel, in kgs CO_2e per tonne-kilometres

7.1.2 Baseline Emissions

$Emissions_{Baseline}$ = $Emissions_{Manure Disposal}$ + $Emissions_{Electricity}$ + $Emissions_{Thermal Heat}$ + $Emissions_{Transportation}$ + $Emissions_{Fertilizer Production}$

(i) *For manure management-related emission, $Emissions_{Manure Disposal}$, B8*

Note that N_2O emissions in the baseline are negligible and are therefore not included in calculations. According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the current method of manure management by Laforge has an emission factor of 0. N_2O is generally only emitted from more aerobic forms of manure management (e.g. windrows). At Laforge, manure is stored in a liquid state under a slated floor in the main barn.

From Environment Canada's National Inventory Report (2009)[11]:

The IPCC Tier 2 methodology is used to estimate CH_4 emission factors from manure management systems (IPCC 2000). The following equation is used to calculate CH_4 emissions from manure management for various categories of livestock in Canada.

$$Emissions_{Manure Disposal} = CH_{4MM} = \Sigma (N * EF_{(MM)})$$

Where:

CH_{4MM} = Emissions for dairy cattle
N = Dairy cattle count
$EF_{(MM)}$ = Emission factor for dairy cattle manure management

Table 8 CH_4 Emission Factors for Manure Management for Dairy Cattle, 2007

$EF_{(MM)}$ – kg CH_4/head/year			
Dairy Cows	Dairy Heifers	Bulls	Calves
24.5	18.7	3.3	1.5

These values take into account local diary industry factors. For details regarding the development of these emission factors, please refer to Environment Canada's National Inventory Report (2009).

Note that this method requires that *all* of the manure produced at the farm be used as feedstock. Laforge should include their heifers, bull and calves (not currently included in the quantification).

[11] See National Inventory Report 1990-2007, available from http://www.ec.gc.ca/pdb/GHG/inventory_e.cfm

(ii) For electricity-related emission, Emissions $_{Electricity}$, B10

Baseline emissions associated with electricity are based on the amount of electricity generated by the project-based digester-CHP unit in conjunction with the emission intensity of this electricity. For the baseline, it is assumed that this electricity was purchased from the grid, while for the project it is assumed that this electricity is zero carbon. The amount of electricity created in the project will need to be tracked. CO_2 emissions from the consumption of electricity shall be determined as follows:

$$Emissions_{Electricity} = ElecGen * EF_{Elec}$$

Where:

Electricity emissions = Emissions from electricity generation, in kg CO_2
ElecGen = Amount of electricity expected to be generated by the project-based CHP unit, in kWh
EF_{Elec} = Electricity emission factor, in kg CO_2e per kWh

(iii) For emissions related to the production of heat for the facility, B11

Baseline emissions associated with the production of thermal energy required to meet the demands of the facility are estimated as a product of the volume of fuel used to meet thermal energy requirements and the associated emission factors. This thermal energy was derived from the combustion of fossil fuels in the baseline. Energy requirements, fuel volumes and fuel types will need to be tracked. CO_2 emissions from the production of thermal energy shall be determined as follows:

$$Emissions_{Thermal\ Heat} = \Sigma\ (Vol.\ Fuel * EF\ Fuel_{CO2});\ \Sigma(Vol.\ Fuel * EF\ Fuel_{CH4});\ \Sigma(Vol.\ Fuel * EF\ Fuel_{N2O})$$

Where:

$Emissions_{Thermal\ Heat}$ = Emissions from thermal energy production, in kg of $C0_2$; CH_4; N_2O
Vol. Fuel = Volume of each type of fuel, in m^3
EF Fuel = Emission factor for each type of fuel used, in kg CO_2/m^3

(iv) For emissions related to the transportation of organic waste, B4

Baseline and project emissions associated with the transportation of food waste by McCain's Inc. are estimated as a product of the tonnage to be transported to the Laforge Farm as part of the project, the distance that this waste is transported, and an emission factor representative of this transport. CO_2 emissions from the transportation of food waste shall be determined as follows:

$$Emissions_{Transportation} = Tonnes * Distance * EF_{WasteTransport}$$

Where:

$Emissions_{Transport}$ = Emissions from the transportation of food waste, in kg CO_2e
Tonnes = Amount of waste moved, in tonnes
Distance = Distance waste moved, in km
$EF_{WasteTransport}$ = Emission factor for waste travel, in kg CO_2e per tonne-km

(v) For emissions related to fertilizer production, $Emissions_{Fertilizer\ Production}$, B5

Baseline emissions associated with the industrial production of inorganic/chemical fertilizer are estimated as a product of the amount of Nitrogen, Phosphorus or Pottasium based fertilizer produced and the emission factor for said production. The amount of N, P or K based fertilizer produced in the baseline is equivalent to the amount of these nutrients available in the anaerobic digester digestate in the project. The amount of nutrients available in the digestate is a product of the amount of feedstock used in the digester, the total solids proportion of that feedstock specimen and the % of TS from N, P or K. CO_2 emissions from the production of inorganic fertilizer shall be determined as follows:

$$Emissions_{Fertilizer\ Production} = (Fertilizer_N * EF_N) + (Fertilizer_P * EF_P) + (Fertilizer_K * EF_K)$$

$$Fertilizer = Waste * TS * Composition$$

Where:

$Emissions_{Fertilizer\ Production}$ = Emissions from the production of inorganic fertilizer, in kg CO_2
Fertilizer = Amount of inorganic Nitrogen, Phosphorus or Pottasium based fertilizer produced, in kg
EF = Emission factor for the production of inorganic Nitrogen, Phosphorus or Pottasium based fertilizer, in kg CO_2/kg
Waste = Amount of feedstock (food waste, manure) used in the digester, in kg
TS = Total solids content of feedstock specimen, in %
Composition = percent of total solids made up of Nitrogen, Phosphorus or Pottasium, in %

7.2 Data and monitoring plan

The following section overviews the data that will need to be collected/used in terms of monitoring the project and quantifying emissions from this activity.

Table 9 Data monitoring

Project/ Baseline SS	**Parameter/ Variable**	**Unit**	**Measured/Estimated**	**Method**	**Frequency**	**Justify measurement or estimation and frequency**
P6, P8a, P9b, P12, P15m P16, P18, P23 Feedstock Processing	$Emissions_{Multiple\ Sources}$ = (Vol. $Biogas_{Combusted}$ * % CH_4 * EF Biogas CH_4); (Vol. $Biogas_{Combusted}$ * %CH_4 *EF Biogas N_2O); (Vol. Fossil Fuel * EF $Fuel_{CO2}$); (Vol. Fossil Fuel * EF $Fuel_{CH4}$); (Vol. Fossil Fuel * EF $Fuel_{N2O}$)					
	$Emissions_{Multiple\ Sources}$	kg CO_2; CH_4; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Vol. $Biogas_{Combusted}$	m^3	Measured	Direct metering of volume of biogas being combusted. (Contingency method: Reconciliation of heat and power produced against volume of biogas required to produce	Continuous metering	Direct metering is standard practice. Frequency of metering is highest level possible.

Project/ Baseline SS	Parameter/ Variable	Unit	Measured/Estimated	Method	Frequency	Justify measurement or estimation and frequency
				that power.)		
	% CH_4	-	Measured	Direct measurement (Contingency method: Use previous year data, data that most accurately reflects current feedstock, or current year data retrospectively.)	Monthly or upon change in feedstock	Biogas composition should remain relatively stable during stead-state operation. Material change in feedstock would warrant additional measurement.
	EF $Biogas_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the biogas.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	EF $Biogas_{N2O}$	kg N_2O per m^3	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the biogas.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Vol. Fuel	m^3	Measured	Direct metering of reconciliation of volume in storage (including volumes received). (Contingency method: Reconciliation of volume of fuel purchased within a given time period.)	Continuous metering or monthly reconciliation	Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	EF $Fuel_{CO2}$	kg CO_2/ m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	EF $Fuel_{CH4}$	kg	Estimated	From Environment	Annual	Reference values

Project/ Baseline SS	**Parameter/ Variable**	**Unit**	**Measured/Estimated**	**Method**	**Frequency**	**Justify measurement or estimation and frequency**
		CH_4/ m^3		Canada reference documents.		adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	EF Fuel $_{N2O}$	kg N_2O/ m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P20 Flaring	Emissions$_{Flaring}$ = (Vol.Biogas Flared * % CH_4 * EF Biogas$_{CH4}$); (Vol. Biogas Flard * % CH_4 * EF Biogas $_{N2O}$); Σ(Vol. Fuel * EF Fuel$_{CO2}$); Σ(Vol. Fuel * EF Fuel$_{CH4}$); Σ(Vol. Fuel * EF Fuel $_{N20}$)					
	Emissions$_{Flaring}$	kg CO_2; CH_4; NO	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Vol. Biogas Flared	m^3	Measured	Direct metering of volume of biogas being flared. (Contingency method: Use volumetric calculation as per venting calculation: (Flow Biogas$_{Vessel}$ * Vol. Manure$_{Vessel}$ / Flow Manure$_{Vessel}$ + Flow Biogas$_{Vessel}$ * Time$_{Flaring}$))	Continuous metering	Direct metering is standard practise. Frequency of metering is highest level possible.
	% CH_4	-	Measured	Direct measurement (Contigency method: Use previous year data, data that most accurately reflects current feedstock, or current year data retrospectively.)	Monthly or upon change in feedstock.	Biogas composition should remain relatively stable during steady-state operation. Material changes in feedstock would warrant additional measurement.
	EF Biogas$_{N2O}$	kg N_2O/ m^3	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the biogas.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

Project/ Baseline SS	**Parameter/ Variable**	**Unit**	**Measured/Estimated**	**Method**	**Frequency**	**Justify measurement or estimation and frequency**
	Vol. Fuel	m^3	Measured	Direct metering or reconciliation of volume in storage (including volumes received) (Contingency method: Reconciliation of volume of fuel purchased within a given time period.)	Continuous metering or monthly reconciliation	Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	EF $Fuel_{CO2}$	kg CO_2/ m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	EF $Fuel_{CH4}$	kg CH_4/ m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	EF $Fuel_{N2O}$	kg N_2O/ m^3	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P21 Venting	$Emissions_{Venting}$ = (Max. Storage $Vol._{Vessel}$ + Flow $Biogas_{Vessel}$ * $Time_{Venting}$)* % CH_4					
	$Emissions_{Venting}$	kg CH_4	N/A	N/A	N/A	Quantity being calculated
	Max. Storage $Vol._{Vessel}$	m^3	Estimated	From facility engineering specifications	Annual	Reference values will remain consistent unless system is re-engineered (i.e. change to maximum storage volume from change in cap).
	Flow $Biogas_{Vessel}$	m^3/hr	Measured	Average flow rate of biogas from the digester at steady state for the preceding period. (Contingency method: Measure flow at current steady state operation.)	Weekly	Biogas flow rates are steady state; rates for the previous week should provide reasonable approximation of flow rate at time of venting.
	$Time_{Venting}$	days	Measured/Estimated	Number of partial or complete days of venting either measured or estimated from site records of energy production, witness	Continuous	Number of days in a year is an absolute value.

Project/ Baseline SS	Parameter/ Variable	Unit	Measured/Estimated	Method	Frequency	Justify measurement or estimation and frequency
				accounts, etc.		
	% CH_4	-	Measured	Direct measurement. (Contingency method: Use previous year data, data that most accurately reflects current feedstock, or current year data retrospectively.)	Annual or upon change in feedstock	Biogas composition should remain relatively stable during steady-state operation. Material changes in feedstock would warrant additional measurement.
P4 Feedstock Tranporation	$Emissions_{Transportation} = Tonnes * Distance * EF_{WasteTransport}$					
	$Emissions_{Transportation}$	kg CO_2e	N/A	N/A	N/A	Quantity being calculated
	Tonnes	tonnes	Measured	Direct measurments	Measurments every haul	
	Distance	km	Measured	Direct measurements	Measurements every haul	
	$EF_{Waste\ Transport}$	kg CO_2e per tonne - kilometres	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted as part of Environment Canada reporting on Canada's emissions inventory
B8 Manure Disposal	$Emissions_{Manure\ Disposal} = CH_{4MM} = \Sigma (N * EF_{(MM)})$					
	$Emissions_{Manure\ Disposal}$ (CH_{4MM})	kg CH_4	N/A	N/A	N/A	Quantity being calculated.
	N	head	Measured	Direct measurments	N/A	
	EF_{MM}	kg CH_4/head/year	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted as part of Environment Canada reporting on Canada's emissions inventory
B10 Electricity Production	$Emissions_{Electricity} = ElecGen * EF_{Elec}$					
	$Emissions_{Electricity}$	kg CO_2e	N/A	N/A	N/A	Quantity being calculated
	ElecGen	kWh	Measured	Direct metering	Continuous metering	Continuous direct metering with an electricity meter represents the industry practice and the highest level of detail. Uncertainty of the meters to be obtained from the manufacturers.
	EF_{Elec}	kg CO_2e per	Estimated	From Environment Canada reference documents	Annual	

Project/ Baseline SS	Parameter/ Variable	Unit	Measured/Estimated	Method	Frequency	Justify measurement or estimation and frequency
		kWh				
B11 Thermal Energy Produced	$Emissions_{Thermal\ Heat} = \Sigma$ (Vol. Fuel * EF $Fuel_{CO2}$); Σ(Vol. Fuel * EF $Fuel_{CH4}$); Σ(Vol. Fuel * EF $Fuel_{N2O}$)					
	$Emissions_{Thermal\ Heat}$	kg CO_2e	N/A	N/A	N/A	Quantity being calculated
	Vol. Fuel	m^3	Measured	Calculated relative to metered quantity of thermal energy delivered to the customer converted to an equivalent volume of fuel. (Contingency method: Calculated relative to metered quantity of Thermal Heat billed to the customer.)	Continuous metering	Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	EF $Fuel_{CO2}$	kg CO_2/ m^3	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted as part of Environment Canada reporting on Canada's emissions inventory.
	EF $Fuel_{CH4}$	kg CH_4/ m^3	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted as part of Environment Canada reporting on Canada's emissions inventory.
	EF $Fuel_{N2O}$	kg N_2O/ m^3	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted as part of Environment Canada reporting on Canada's emissions inventory.
B4 Transportation of Waste	$Emissions_{Transportation}$ = Tonnes * Distance * $EF_{WasteTransport}$					
	$Emissions_{Transportation}$	kg CO_2e	N/A	N/A	N/A	Quantity being calculated
	Tonnes	tonnes	Measured	Direct measurments	Measurements every haul	
	Distance	km	Measured	Direct measurements	Measurements every haul	
	$EF_{Waste\ Transport}$	kg CO_2e per tonne - kilometres	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted as part of Environment Canada reporting on Canada's emissions inventory
B5 Fertilizer Production	$Emissions_{Fertilizer\ Production} = (Fertilizer_N * EF_N) + (Fertilizer_P * EF_P) + (Fertilizer_K * EF_K)$ Fertilizer = Waste * TS * Composition					
	$Emissions_{Fertilizer\ Production}$	kg	N/A	N/A	N/A	Quantity being

Project/ Baseline SS	Parameter/ Variable	Unit	Measured/Estimated	Method	Frequency	Justify measurement or estimation and frequency
		CO_2				calculated
	Fertilizer	kg	N/A	N/A	N/A	Quantity being calculated
	EF	kg CO_2/kg fertilizer	Estimated	From a credible source.	Annual	
	Waste	kg	Measured	Direct measurments of the type and amount of feedstock being used in the digester.	Measurements at every collection of manure, unloading of food waste	
	TS	%	Estimated	Chemical labratory analysis	Annual	A chemical analysis of the food waste and manure should be done annually or when there is a change in the quality of these products.
	Composition	%	Estimated	Chemical labratory analysis	Annual	A chemical analysis of the food waste and manure should be done annually or when there is a change in the quality of these products.

8 Estimated emissions and emission reductions

As outlined in section 7.1, the emission reductions for the project will be quantified as follows:

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

Initial estimates are that baseline emissions are as follows:

Emission Source	GHG emissions (kg CO_2e/year)
Manure Disposal	51,450
Electricity*	481,800
Thermal Heat	0
Transportation	1,397,648
Fertilizer Production	687,322
Total Baseline GHG Emissions	**2,618,220**

* It is assumed that the electricity produced by Laforge farm will represent the needs of about 50 houses in New Brunswick. It is further assumed that a house in New Brunswick requires about 12,000 kWh of electricity per year.

Initial estimates are that project emissions are as follows:

Emission Source	GHG emissions (kg CO_2e)
Feedstock Processing	0
Flaring	0
Venting	0
Transportation	27,476
Total Project GHG Emissions	**27,476**

Initial estimates of emission reductions are as follows:

	GHG emissions (kg CO_2e)
Annual Baseline Emissions	2,618,220
Project Emissions	27,476
Annual Emission Reduction (kgs CO_2e)	2,590,743

9 Data Quality Management

In general, data quality management must include sufficient data capture such that the mass and energy balances may be easily performed with the need for minimal assumptions and use of contingency procedures (within Table 8). The data should be of sufficient quality to fulfill the quantification requirements and be substantiated by company records for the purpose of verification.

The project proponent shall establish and apply quality management procedures to manage data and information. Written procedures should be established for each measurement take outlining responsibility, timing and record location requirements. The greater the rigour of the management system for the data, the more easily an audit will be to conduct for the project.

9.1 Record Keeping

Record keeping practices should include :

- Electronic recording of values of logged primary parameters for each measurement interval ;
- Printing of monthly back-up hard copies of all logged data ;
- Written logs of operations and maintenance of the project system including notation of all shut downs, start ups and process adjustments ;

- Retention of copies of logs and all logged data for a period of 7 years ; and
- Keeping all records available for review by a verification body.

9.2 Quality Assurance and Quality Control

QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly These include, but are not limited to :

- Protecting monitoring equipment (sealed meteres and data loggers) ;
- Protecting records of monitored data (hard copy and electronic storage) ;
- Checking data integrity on a regular and periodic basis (manual assessment, comparing redundant metered data, and detection of outstanding data/records) ;
- Comparing current estimates with previous estimates as a ‘reality check’ ;
- Provide sufficient training to operators to perform maintenance and calibration of monitoring devices ;
- Establish minimum experience and requirements for operators in charge of project and monitoring ; and
- Performing recalculations to make sure no mathematical errors have been made.

10 Verification Statement

Since this is a track 2 project and emission reductions are not expected to be brought to market, a verification statement is not required.