SPECIFIED GAS EMITTERS REGULATION

QUANTIFICATION PROTOCOL FOR NON-INCINERATION THERMAL WASTE CONVERSION

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Version 1.0

Alberta

ALBERTANS & CLIMATE CHANGE

Disclaimer:

The information provided in this document is intended as guidance only and is subject to revisions as learnings and new information comes forward as part of a commitment to continuous improvement. This document is not a substitute for the law. Please consult the *Specified Gas Emitters Regulation* and the legislation for all purposes of interpreting and applying the law. In the event that there is a difference between this document and the *Specified Gas Emitters Regulation* or legislation, the *Specified Gas Emitters Regulation* or the legislation prevail.

All Quantification Protocols approved under the *Specified Gas Emitters Regulation* are subject to periodic review as deemed necessary by the Department, and will be re-examined at a minimum of every 5 years from the original publication date to ensure methodologies and science continue to reflect best-available knowledge and best practices. This 5-year review will not impact the credit duration stream of projects that have been initiated under previous versions of the protocol. Any updates to protocols occurring as a result of the 5-year and/or other reviews will apply at the end of the first credit duration period for applicable project extensions.

Any comments, questions, or suggestions regarding the content of this document may be directed to:

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1.0 Project and Methodology Scope and Description

This quantification protocol is written for the non-incineration thermal waste management facility or project developer, hereafter referred to as the BioEnergy Facility. Some familiarity with, or general understanding of the operation of a municipal solid waste facility is expected.

The opportunity for generating carbon offsets with this protocol arises mainly from the indirect reductions of greenhouse gas (GHG) emissions from displacing a portion of fossil fuels with municipal solid waste. However, some opportunities from reduced feedstock transportation, or onsite heat/power production are allowed in the flexibility of this protocol.

1.1 Protocol Scope and Description

This protocol quantifies the emission reductions from the avoidance of fossil fuel consumption, replaced by municipal solid waste on an equivalent energy potential basis. It also specifically includes reductions in GHG emissions due to any heat/power production and electricity generation related to the process, and from the avoidance of landfilling any organic materials which may be diverted for conversion to Biofuel.

Biofuel is defined as the synthetic fuel gas (syngas) created from the conversion of waste. BioEnergy is defined to include electricity, and heat / power produced from the Biofuel. **FIGURE 1.1** offers a process flow diagram for a typical project. Slag is a useful by-product of the production of Biofuel. There is also a very small amount of residue left over from the Biofuel production process.

Protocol Approach:

The Non-Incineration Thermal Waste Management Protocol is not intended to be prescriptive, but instead serve as a generic 'recipe' for project developers (i.e. BioEnergy facility owners/operators) to follow in order to meet the measurement, monitoring and GHG quantification requirements.

Since this Protocol is one of the first in the Alberta Offset System that represents a technological process that can be considered a "new market entrant", Project Developers applying this protocol will need to submit technology performance assessments (i.e. based on pilot or demonstration sites) along with their project documentation (see Protocol Applicability section for more detail).

The baseline condition for the Non-Incineration Thermal Waste Management Protocol is that the municipal solid waste is being collected, handled and disposed of in a landfill (controlled or uncontrolled) such that anaerobic decomposition of the organic fraction would typically occur. The baseline also includes the use of fossil fuels by downstream users (calculated on an equivalent energy potential basis), the production of heat/power using fossil fuels at facilities that rely on heat/power from the BioEnergy facility, and the generation of electricity by other facilities to cover the net generation capacity of the BioEnergy facility. **FIGURE 1.2** offers a process flow diagram for a typical baseline configuration.

FIGURE 1.1: Process Flow Diagram for Project Condition

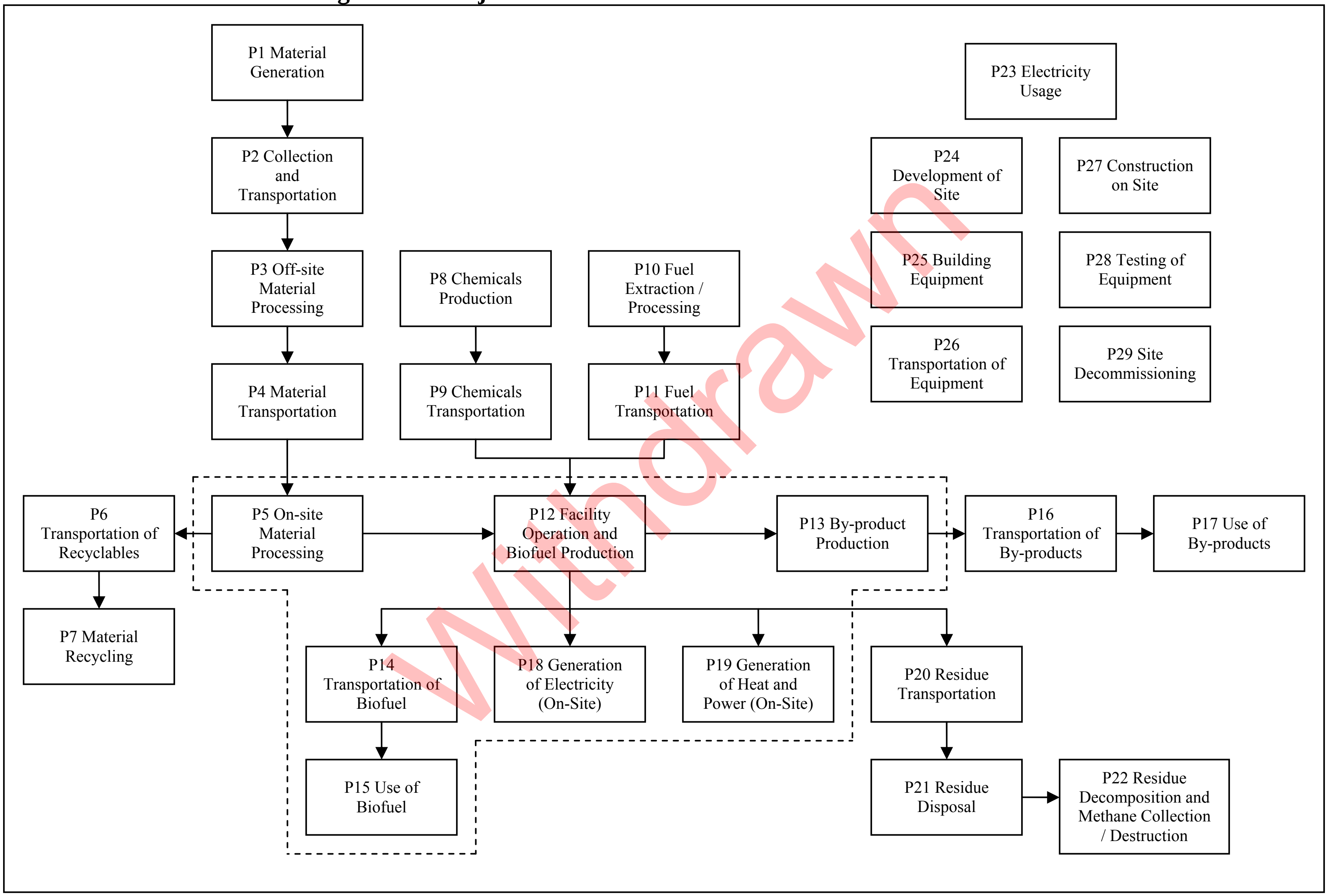
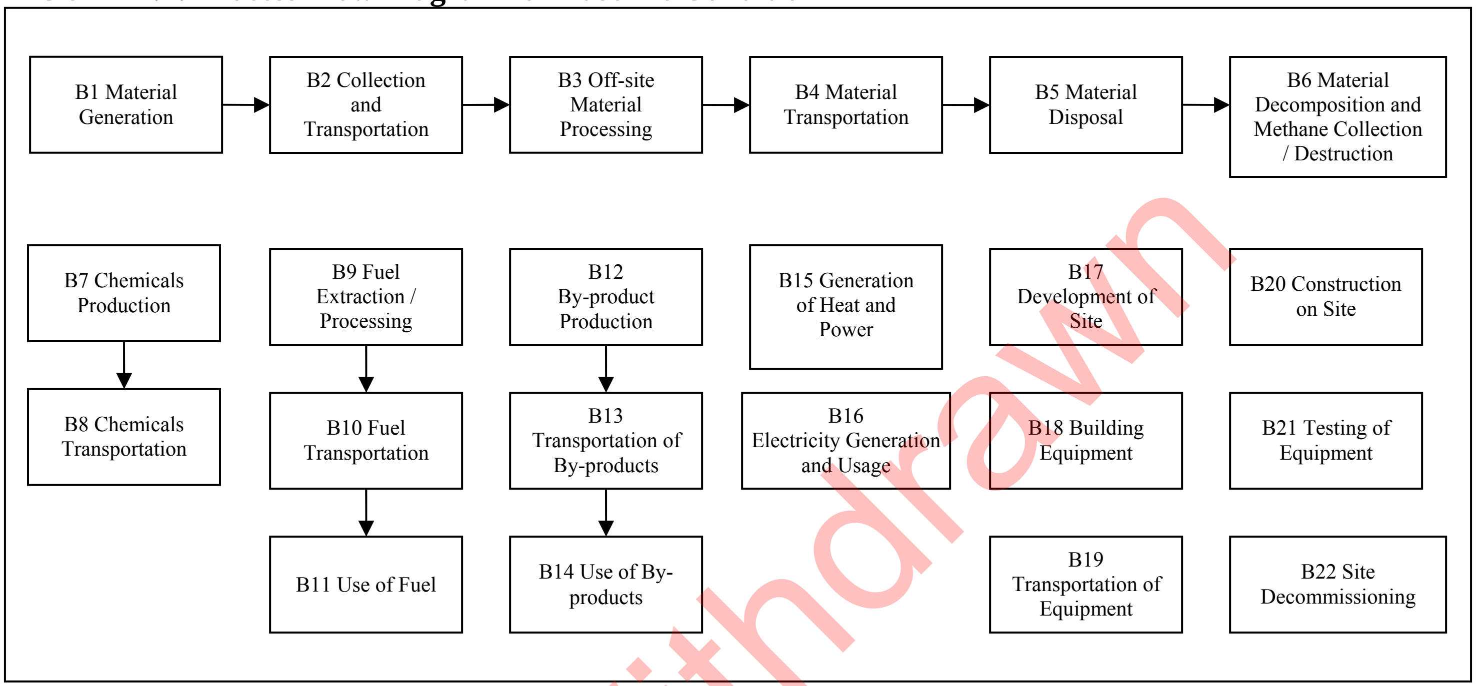


FIGURE 1.2: Process Flow Diagram for Baseline Condition



Protocol Applicability:

The boundary of the non-incineration thermal waste management protocol encompasses the production of feedstocks, production of BioEnergy, and the end use of fuel and by-products. To demonstrate that a project meets the requirements under this protocol, the project developer must provide evidence that:

1. Measurement of waste stream composition will be conducted quarterly and following any changes in source or composition that may materially influence waste stream composition to assess the percent plastics by waste and any other characteristics required to estimate the Carbon Dioxide Emission Factor for the non-biogenic component of the feedstock,
2. The material being diverted to the BioEnergy facility, that is being claimed as diverted from landfill, would otherwise be landfilled as confirmed by disposal records or other means;
3. The BioEnergy facility must be in compliance with all required permits, including regulations regarding storage of waste on site;
4. Additional information outlining the technology performance assessments must be included in the Offset Project Plan. The Offset Project Plan is appended to the final Project Report when a GHG Assertion is being made[1] and is included in the Project Documentation submitted to Alberta Environment.
5. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol;
6. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System. [Of particular note:
    - [The BioEnergy project must have received the first batch of feedstock that is not for a testing phase, on or after January 1, 2002 as indicated by facility records;]
    - [The project may generate emission reduction offsets for a period of 8 years unless an extension is granted by Alberta Environment, as indicated by facility and offset system records. Additional credit duration periods require a reassessment of the baseline condition; and,]
    - [Ownership of the emission reduction offsets must be established as indicated by facility records.]

[1] Note – the verifier is not expected to review technology performance – the additional information on 'new market entrants' being collected is to enhance the understanding of the technology by the Alberta Government, in the context of the provincial offset system.

Protocol Flexibility:

Flexibility in applying the quantification protocol is provided to project developers in 7 (seven) ways:

1. The heat and power production component of the process may be dealt with outside the scope of the protocol as part of a *Waste Heat Recovery* protocol. However, the project developer must justify the separation of this component of the project to ensure that the emission reductions are properly quantified between the two projects and that double counting does not occur;
2. The heat and power production component of the project may provide some or all of the heat and power requirements for the facility. Flexibility is provided in terms of allowing the broadening of the project scope to include existing, new, or retrofitted supplementary heating both on and off site to meet the project energy load;
3. In cases where the project developer wishes to quantify the emission reduction from reduced transportation requirements, then the GHG sources for the corresponding transportation related element(s) in project and baseline must be quantified (e.g. B4 and P4). Suitable equations are provided in the Appendix to the *Alberta Environment Gas Protocol: Energy from Biomass*;
4. Site specific emission factors may be substituted for the generic emission factors indicated in this protocol document. The methodology for generation of these emission factors must ensure accuracy;
5. In particular site specific emissions factors for non-biogenic waste may be calculated from a mass balance and substituted for those indicated in this protocol document. The methodology for generation of these emission factors is discussed briefly in Appendix C;
6. In cases where the diversion of feedstocks from landfill cannot be verified, the diversion of feedstocks from landfill components of the project may be ignored in both the baseline and project conditions; and
7. For projects with a dedicated end-user of some or all of the electricity generation, where the non-incineration thermal waste management facility is connected by a dedicated line to that facility, site specific electricity generation emission factors may be substituted for the generic grid emission factors indicated in this protocol document. The methodology for generation of these emission factors must be sufficiently robust as to ensure reasonable accuracy.

If applicable, the proponent must indicate and justify why flexibility provisions have been used.

1.2 Glossary of New Terms

BioEnergy: A term for use in this protocol which encompasses the electricity or heat / power produced from the Biofuel.

Biofuel: A term for use in this protocol which describes the synthetic fuel gas produced from the conversion of waste.

Landfill: A landfill is a site at which materials are stored where they can undergo anaerobic decomposition. This may include the materials being buried, piled, mixed with other waste materials, or otherwise. Landfills classified as either controlled or uncontrolled are included in this definition. The designation of controlled or uncontrolled refers to the level of permitting and technical controls in place at the disposal site. Uncontrolled landfills may exist where although there is no expressly stated goal to leave the materials in place, there is a track record of material residing in that place for extended periods (greater than 10 years) and there are no plans or regulatory requirements for the material to be transferred to another disposal site.

2.0 Quantification Development and Justification

The following sections outline the quantification development and justification.

2.1 Identification of Sources and Sinks (SSs) for the Project

SSs were identified for the project by reviewing the seed document, relevant process flow diagrams, and discussions with project developers. This process confirmed that the SSs in the process flow diagrams covered the full scope of eligible project activities under the protocol.

Based on the process flow diagrams provided in **FIGURE 1.1**, the project SSs were organized into life cycle categories in **FIGURE 2.1**. Descriptions of each of the SSs and their classification as controlled, related or affected are provided in **TABLE 2.1.**

FIGURE 2.1: Project Element Life Cycle Chart

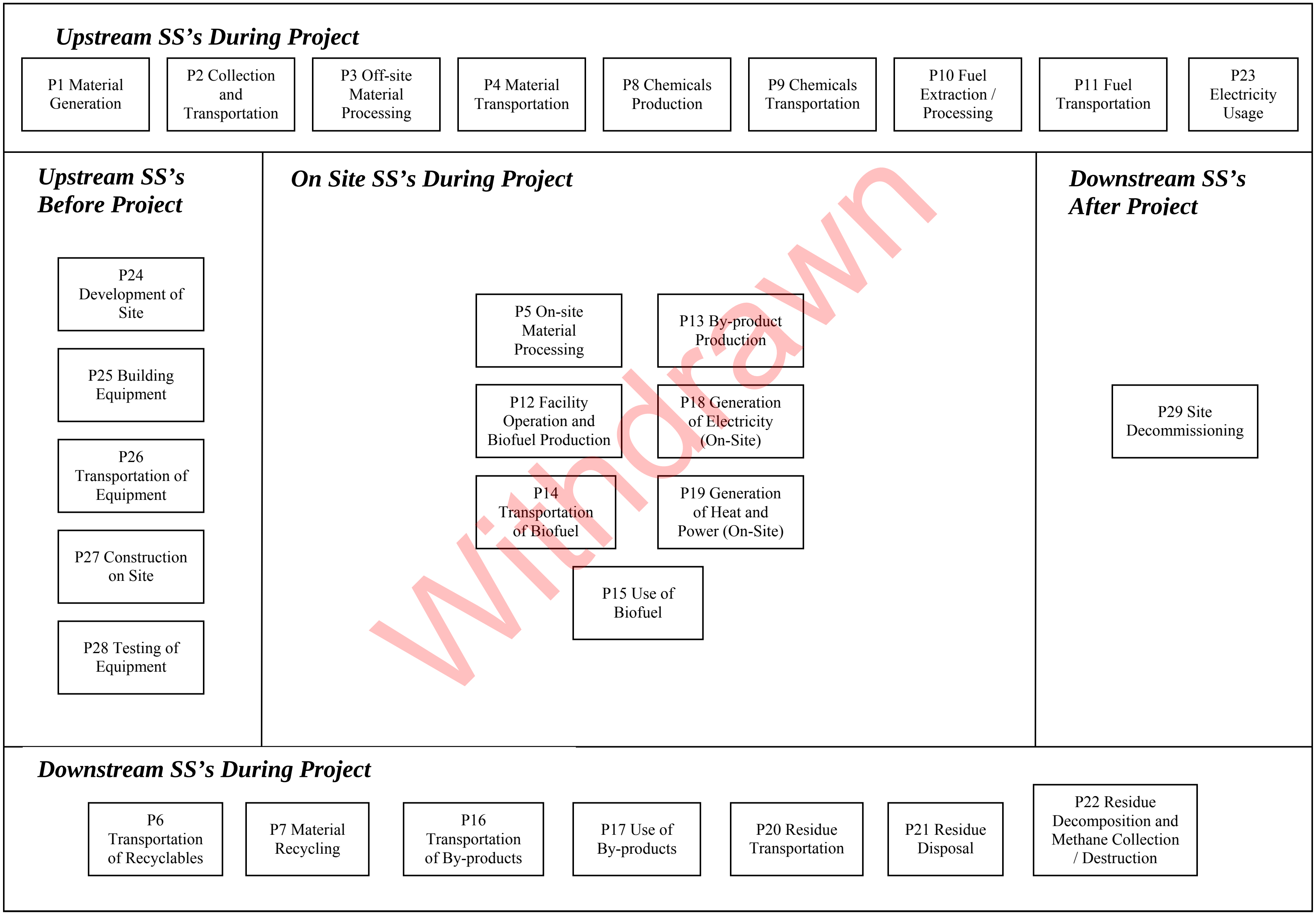


TABLE 2.1: Project SSs

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SSs during Project Operation		
P1 Material Generation	Materials are produced in a number ways, depending on the source of these materials. Quantities for each of the energy inputs related to the materials would be contemplated to evaluate functional equivalence with the project condition.	Related
P2 Collection and Transportation	Materials are collected and transported to the off-site material processing station by truck. 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 truck, number of loads and distance travelled would be tracked.	Related
P3 Off-site Material Processing	Materials may be processed by using a series of mechanical processes, heavy equipment and conveyors. This equipment would be fuelled by diesel, gasoline, or natural gas resulting in GHG emissions, or electricity. Quantities and types for each of the energy inputs would be tracked.	Related
P4 Material Transportation	Materials are transported by truck from the material processing station to the project site. 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 truck, number of loads and distance travelled would be tracked.	Related
P8 Chemicals Production	Chemical production may include several material and energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P9 Chemicals Transportation	Chemicals are transported to the project site by truck. 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 truck, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
P10 Fuel Extraction and Processing	Each of the fuels used throughout 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 SSs are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related
P11 Fuel Transportation	Each of the fuels used throughout 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 sites is captured under other SSs and there is no other delivery.	Related

P23 Electricity Usage	Electricity may be required for operating the facility or to compensate for any net reduction in electricity output from the project facility as compared to the baseline. 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
Onsite SSs during Project Operation		
P5 On-site Material Processing	Materials may be processed using a series of mechanical processes, heavy equipment and conveyors. This equipment would be fuelled by diesel, gasoline, or natural gas resulting in GHG emissions, or electricity. Quantities and types for each of the energy inputs would be tracked.	Controlled
P12 Facility Operation and Biofuel Production	Greenhouse gas emissions may occur that are associated with the operation and maintenance of the project site. This may require any number of mechanical processes including those related to processing inputs and generating outputs (including the biofuel) for downstream use. The operation of the facility could require the combustion of fossil fuels precipitating greenhouse gas emissions. Volumes and types of the fossil fuels are the important characteristics to be tracked.	Controlled
P13 By-product Production	Biochemical feedstocks may be generated that would serve to offset petrochemical feedstocks. This may result from chemical, biological and mechanical processes used in the production of the biochemicals. All relevant characteristics of these processes would be tracked.	Controlled
P14 Transportation of Biofuel	Biofuel will be transported across the project site or off-site by truck or pipeline. 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 truck, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition. Where pipeline is used, the greenhouse gas emissions associated with compression power, if compression is required, would be tracked.	Controlled
P15 Use of Biofuel	The biofuel produced at the facility is used as a fuel source, either on- or off-site as a source of energy. This may be part of the generation of electricity or heat and power. The carbon dioxide emissions may be both biogenic and non-biogenic, and there are also methane and nitrous oxide emissions from the biofuel combustion. The biogenic emissions of carbon dioxide would not need to be tracked. The mass and composition of the incoming waste stream would need to be tracked as well as the heating value and flow rate of the biofuel.	Controlled
P18 Electricity Production (On-Site)	Electricity may be generated from the biofuel or supplementary fossil fuels to meet internal project demand or for export from the project site. The generation of this electricity may yield incremental greenhouse gas emissions from the combustion of supplementary fossil fuels. The emissions from the combustion of the biofuel would be captured under P15. Quantities and types for each of the fossil fuel inputs would be tracked.	Controlled
P19 Generation of Heat and Power (On-Site)	The generation of heat and power from the biofuel or supplementary fossil fuels may occur at the project site for sale to other facilities. This generation could require the combustion of supplementary fossil fuels precipitating greenhouse gas emissions. The emissions from the combustion of the biofuel would be captured under P15. Quantities and types for each of the fossil fuel inputs would be tracked.	Controlled

Downstream SSs during Project Operation		
P6 Transportation of Recyclables	Recyclables mixed in with the municipal solid waste feedstock would need to be transported to an off-site recycling facility by truck. 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 truck, number of loads and distance travelled would be used to evaluate the emissions.	Related
P7 Material Recycling	Materials recovered at the facility will be transported for recycling. These materials may be refurbished, processed or otherwise disposed of using a variety of equipment and processes. This may require any number of mechanical processes. All relevant characteristics of these processes would be tracked.	Related
P16 By-product Transportation	By-product feedstocks will be transported from the project site by truck to disposal or re-processing sites. 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 truck, number of loads and distance travelled would be tracked.	Related
P17 Use of By-product	By-product feedstocks from the BioEnergy process may become inputs to other petrochemical processes. Any energy inputs (i.e. use of fossil fuels) associated with their downstream use would need to be captured.	Related
P20 Residue Transportation	Residues will be transported by truck from the project site to disposal or re-processing sites. 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 truck, number of loads and distance travelled would be tracked.	Related
P21 Residue Disposal	Residue may be handled at a disposal site by transferring the waste from the transportation container, spreading, burying, processing, or otherwise dealing with the waste using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gasoline 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 may need to be tracked.	Related
P22 Residue Decomposition and Methane Collection / Destruction	Waste 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 landfill where this waste 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.	Related
Other		
P24 Development of Site	The site of the 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 structures 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

P25 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
P26 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 will 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
P27 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 emissions from the use of fossil fuels and electricity.	Related
P28 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test BioEnergy 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
P29 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

2.2 Identification of Baseline

The baseline condition for the projects applying this protocol is that the municipal solid waste is being collected, handled and disposed of in a landfill (controlled or uncontrolled) such that anaerobic decomposition would typically occur. The baseline also includes the use of fossil fuels by downstream users (calculated on an equivalent energy potential basis), the production of heat/power using fossil fuels at facilities that rely on heat/power from the BioEnergy facility, and the generation of electricity by other facilities to cover the net generation capacity of the BioEnergy facility.

The approach to quantifying the baseline will be projection-based as there are suitable models for the applicable baseline condition that can provide reasonable certainty. The projection-based baseline scenario for this protocol is dynamic as the emissions profile for the baseline activities would change materially, year over year, relative to the mass of material processed under the project condition.

The baseline condition is defined, including the relevant SSs and processes, as shown in **FIGURE 1.2**. More detail on each of these SSs is provided in Section 2.3, below.

2.3 Identification of SSs for the Baseline

Based on the process flow diagrams provided in **FIGURE 1.2**, the project SSs were organized into life cycle categories in **FIGURE 2.2**. Descriptions of each of the SSs and their classification as either ‘controlled’, ‘related’ or ‘affected’ is provided in **TABLE 2.2.**

FIGURE 2.2: Baseline Element Life Cycle Chart

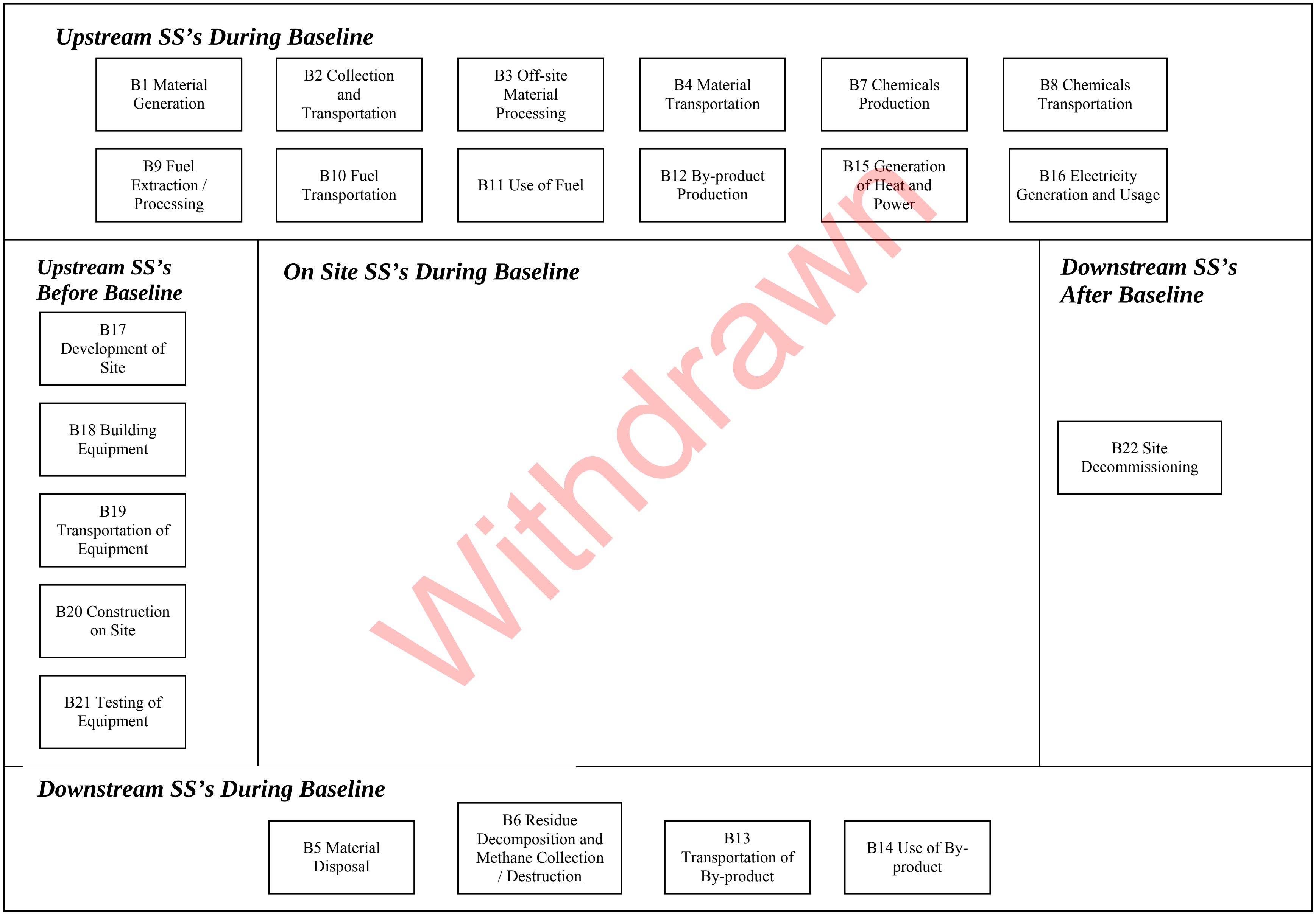


TABLE 2.2: Baseline SSs

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SSs during Baseline Operation		
B1 Material Generation	Materials are produced in a number ways, depending on the source of these materials. Quantities for each of the energy inputs related to the organic materials would be contemplated to evaluate functional equivalence with the project condition.	Related
B2 Collection and Transportation	Materials will be collected and transported to the off-site material processing station by truck. The related energy inputs for fuelling this equipment are captured under this SS, for the purpose of calculating the resulting greenhouse gas emissions. Type of truck, number of loads and distance travelled would be used to evaluate functional equivalence with the project condition.	Related
B3 Off-site Material Processing	Materials may be processed using a series of mechanical processes, heavy equipment and conveyors. This equipment would be fuelled by diesel, gasoline, or natural gas resulting in GHG emissions, or electricity. Quantities and types for each of the energy inputs would be tracked.	Related
B4 Material Transportation	Materials will be transported by truck from the material processing station to the baseline disposal facility. 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 truck, number of loads and distance travelled would need to be tracked.	Related
B7 Chemicals Production	Chemical production may include several material and energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B8 Chemicals Transportation	Chemicals will be transported to the project site by truck. 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 truck, number of loads and distance travelled would be used to evaluate functional equivalence with the project condition.	Related
B9 Fuel Extraction and Processing	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 SSs are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related
B10 Fuel Transportation	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 SSs and there is no other delivery.	Related

B11 Use of Fuel	Equivalent amounts of fossil fuels may be consumed to cover the same energy content as the bioenergy generated that is not used for generation of electricity or heat and power. This generation could require the combustion of fossil fuels precipitating greenhouse gas emissions. Volumes and types of fuels are the important characteristics to be tracked.	Related
B12 By-product Production	By-products, such as slag, may need to be offset by the production of these materials elsewhere. This may result from chemical, biological and mechanical processes used in the production of the petrochemicals. All relevant characteristics of these processes would need to be tracked.	Related
B15 Generation of Heat and Power	The generation of heat and power may be required at other facility sites to offset the heat and power provided under the project condition. This generation could require the combustion of fossil fuels resulting in greenhouse gas emissions. Volumes and types of fuels are the important characteristics to be tracked.	Related
B16 Electricity Generation and Usage	Electricity will be produced off-site to match the net electricity being produced at the bioenergy facility. This electricity will be produced at an emission's intensity as deemed appropriate by the Program Authority. Measurement of the net quantity of electricity produced by the bioenergy facility will need to be tracked to quantify this SS. Measurement must occur downstream of any electricity storage and transmission systems at the point where the electricity is tied into the electricity grid to account for on-site losses and parasitic loads.	Related
Onsite SSs during Baseline Operation		
	None	
Downstream SSs during Baseline Operation		
B5 Material Disposal	Material may be handled at a disposal site by transferring the material from the transportation container, spreading, burying, processing, otherwise handling the residue using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gasoline 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 may need to be tracked.	Related
B6 Material Decomposition and Methane Collection / Destruction	Material 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 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.	Related
B13 Transportation of By-product	By-product may be transported from the production site by truck to disposal or re-processing sites. 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 need to be tracked.	Related
B14 Use of By-product	By-product is used as a building and construction material. Mass and properties of by-product materials would need to be tracked.	Related

Other		
B17 Development of Site	The site of the material processing and disposal facilities 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 structures 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
B18 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
B19 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 train, truck, by some combination, or even by courier. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
B20 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
B21 Testing 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 result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
B22 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

2.4 Selection of Relevant Project and Baseline SSs

Each of the SSs 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 SSs may be excluded is provided in **TABLE 2.3** below. All other SSs listed previously are included.

TABLE 2.3: Comparison of SSs

1. Identified SS	2. Baseline (C, R, A)	3. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
Upstream SSs				
P1 Material Generation	N/A	Related	Exclude	Excluded as emissions in the baseline and project scenarios are equivalent.
B1 Material Generation	Related	N/A	Exclude	
P2 Collection and Transportation	N/A	Related	Exclude	Excluded as emissions in the baseline and project scenarios are equivalent.
B2 Collection and Transportation	Related	N/A	Exclude	
P3 Off-site Material Processing	N/A	Related	Exclude	Excluded as emissions in the baseline and project scenarios are equivalent.
B3 Off-site Material Processing	Related	N/A	Exclude	
P4 Material Transportation	N/A	Related	Exclude	Excluded as emissions in the baseline and project scenarios are equivalent.
B4 Material Transportation	Related	N/A	Exclude	
P8 Chemicals Production	N/A	Related	Exclude	Excluded as this SS is not relevant to the project as the emissions from this practice are covered under proposed greenhouse gas regulations.
B7 Chemicals Production	Related	N/A	Exclude	
P9 Chemicals Transportation	N/A	Related	Exclude	Excluded as emissions in the baseline and project scenarios are equivalent.
B8 Chemicals Transportation	Related	N/A	Exclude	
P10 Fuel Extraction / Processing	N/A	Related	Include	N/A
B9 Fuels Extraction / Processing	Related	N/A	Include	N/A
P11 Fuel Transportation	Related	N/A	Exclude	Excluded as emissions in the baseline and project scenarios are equivalent.
B10 Fuel Transportation	N/A	Related	Exclude	
B11 Use of Fuel	N/A	Related	Include	N/A
B12 By-product Production	N/A	Related	Exclude	Excluded as it is conservative to exclude sources of GHG emissions from the baseline condition.
B15 Generation of Heat and Power	N/A	Related	Include	N/A
B16 Electricity Generation and Usage	Related	N/A	Include	N/A

P23 Electricity Usage	Related	N/A	Exclude	Excluded as these SSs are not relevant to the project as the emissions from these practices are covered under proposed greenhouse gas regulations.
Onsite SSs				
P5 On-Site Material Processing	N/A	Controlled	Include	N/A
P12 Facility Operation and Biofuel Production	N/A	Controlled	Include	N/A
P13 By-product Production	N/A	Controlled	Include	N/A
P14 Transportation of Biofuel	N/A	Related	Exclude	Excluded as the emissions from transportation are negligible and likely greater under the baseline condition (comparing SS P11 and P14 with SS B10).
P15 Use of Biofuel	N/A	Related	Include	Biogenic CO_2 emissions are excluded.
P18 Generation of Electricity (On-Site)	N/A	Controlled	Include	N/A
P19 Generation of Heat and Power (On-Site)	N/A	Controlled	Include	N/A
Downstream SSs				
P6 Transportation of Recyclables	N/A	Related	Exclude	Excluded as the emissions from transportation are immaterial and likely greater under the baseline condition.
P7 Material Recycling	N/A	Related	Exclude	Excluded as recycling of these materials provides a net reduction in GHG emissions relative to producing new materials and cannot be included for credits as it is outside of project boundaries.
P16 Transportation of By-product	N/A	Related	Exclude	Excluded as emissions are likely functionally equivalent in the project and baseline conditions.
B13 Transportation of By-Product	Related	N/A	Exclude	
P17 Use of By-product	N/A	Related	Exclude	Excluded as emissions are likely functionally equivalent in the project and baseline conditions.
B14 Use of By-product	Related	N/A	Exclude	
P20 Residue Transportation	N/A	Related	Exclude	Excluded as the emissions from transportation are likely greater under the baseline condition.
P21 Residue Disposal	N/A	Related	Exclude	Excluded as emissions from disposal are likely greater under the baseline condition.
B5 Material Disposal	Related	N/A	Exclude	
P22 Residue Decomposition and Methane Collection / Destruction	Related	N/A	Exclude	Excluded as residue from thermal treatment process is inert. The disposal of other materials separated and sent back to landfill upstream of the thermal treatment unit would be functionally equivalent to the baseline landfill disposal practice.

B6 Residue Decomposition and Methane Collection / Destruction	N/A	Related	Include	N/A
Other				
P24 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.
B17 Development of Site	Related	N/A	Exclude	
P25 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.
B18 Building Equipment	Related	N/A	Exclude	
P26 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.
B19 Transportation of Equipment	Related	N/A	Exclude	
P27 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.
B20 Construction on Site	Related		Exclude	
P28 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.
B21 Testing of Equipment	Related	N/A	Exclude	
P29 Site Decommissioning	N/A	Related	Exclude	Emissions from decommissioning are not material given the long project life, and the minimal decommissioning typically required.
B22 Site Decommissioning	Related	N/A	Exclude	

2.5 Quantification of Reductions, Removals and Reversals of Relevant SSs

2.5.1 Quantification Approaches

Quantification of the reductions, removals and reversals of relevant SSs for each of the greenhouse gases will be completed using the methodologies outlined in **TABLE 2.4**, below. A listing of relevant emission factors is provided in **Appendices A, B, C, and D**. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

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

$$\begin{aligned}\text{Emissions}_{\text{Baseline}} = {} & \text{Emissions}_{\text{Decomposition, Collection and Destruction}} \\ & + \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Use of Fuel}} \\ & + \text{Emissions}_{\text{Generation of Heat and Power}} + \text{Emissions}_{\text{Electricity Generation and Usage}}\end{aligned}$$

$$\begin{aligned}\text{Emissions}_{\text{Project}} = {} & \text{Emissions}_{\text{Fuel Extraction / Processing}} \\ & + \text{Emissions}_{\text{BioEnergy Operations}} + \text{Emissions}_{\text{Use of Biofuel}} \\ & + \text{Emissions}_{\text{Elec Gen}} + \text{Emissions}_{\text{Gen Heat and Power}}\end{aligned}$$

Where:

$\text{Emissions}_{\text{Baseline}}$ = sum of the emissions under the baseline condition.

- $\text{Emissions}_{\text{Decomposition, Collection and Destruction}}$ = emissions under SS B6 Residue Decomposition and Methane Collection / Destruction
- $\text{Emissions}_{\text{Fuel Extraction / Processing}}$ = emissions under SS B9 Fuel Extraction and Processing
- $\text{Emissions}_{\text{Use of Fuel}}$ = emissions under SS B11 Use of Fuel
- $\text{Emission}_{\text{Generation of Heat and Power}}$ = emissions under SS B15 Generation of Heat and Power
- $\text{Emissions}_{\text{Electricity Generation and Usage}}$ = emissions under SS B16 Electricity Generation and Usage

$\text{Emissions}_{\text{Project}}$ = sum of the emissions under the project condition.

- $\text{Emissions}_{\text{Fuel Extraction / Processing}}$ = emissions under SS P10 Fuel Extraction and Processing
- $\text{Emissions}_{\text{BioEnergy Operations}}$ = emissions under SS P5 On-Site Material Processing, P12 Facility Operation and Biofuel Production, and P13 By-product Production
- $\text{Emissions}_{\text{Use of Biofuel}}$ = emissions under SS P15 Use of Biofuel
- $\text{Emissions}_{\text{Elec Gen}}$ = emissions under SS P18 Generation of Electricity (On-Site)
- $\text{Emissions}_{\text{Gen Heat and Power}}$ = emissions under SS P19 Generation of Heat and Power (On-Site)

TABLE 2.4: Quantification Procedures

1. Project / Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SSs						
P10 Fuel Extraction and Processing	$Emissions_{Fuel\ Extraction\ /\ Processing} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$					
	$Emissions_{Fuel\ Extraction\ /\ Processing}$	kg of CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Volume of Fuel Combusted for P6, P5, P12, P13, P18, and P19 / Vol. Fuel	L/ m^3/ other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Fossil Fuel Including Production and Processing / EF $Fuel_{CO2}$	kg CO_2 per L/ m^3/ other	Estimated	Values Provided in Appendix B	Annual	Reference values from the Canadian Association of Petroleum Producers report.
	CH_4 Emissions Factor for Fossil Fuel Including Production and Processing / EF $Fuel_{CH4}$	kg CH_4 per L/ m^3/ other	Estimated	Values Provided in Appendix B	Annual	Reference values from the Canadian Association of Petroleum Producers report.
	N_20 Emissions Factor for Fossil Fuel Including Production and Processing / EF $Fuel_{N2O}$	kg N_2O per L/ m^3/ other	Estimated	Values Provided in Appendix B	Annual	Reference values from the Canadian Association of Petroleum Producers report.
P5 On-Site Material Processing, P12 Facility Operation and Biofuel Production, and P13 By-product Production	$Emissions_{Bioenergy\ Operations} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2});\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$					
	$Emissions_{Bioenergy\ Operations}$	kg of 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 SSs. Methane production is taken to be zero as the by-product of bioenergy production is inert.

	Volume of Each Type of Fossil Fuel / Vol. Fuel $_i$	L/ m^3/ other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Combustion of Each Type of Fossil Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Combustion of Each Type of Fossil Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Combustion of Each Type of Fossil Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P15 Use of Biofuel	Emissions $_{Use\ of\ Biofuel}$ = (Mass $_{waste}$ * EF MSW $_{Non\text{-}biogenic\ CO2}$; Heat Value $_{Biofuel}$ * EF $_{CH4}$; Heat Value $_{Biofuel}$ * EF $_{N20}$					
	Emissions $_{Use\ of\ BioEnergy}$	kg of CO_2 ; N_2O	N/A	N/A	N/A	Quantity being calculated. Methane production is taken to be zero as the as it is not produced in this process.
	Mass of waste / Mass $_{waste}$	kg waste	Measured	Direct metering or reconciliation of mass produced.	Continuous	Frequency of metering is highest level possible.
	CO_2 Emissions Factor for MSW / EF MSW $_{Non\text{-}biogenic\ CO2}$	kg CO_2 per kg waste	Calculated	Calculation methodology provided in Appendix C	Annual	Reference value from the US EPA MSW non-biogenic emissions factor for plastics.
	Lower heating value of the biofuel / Heat Value $_{Biofuel}$	TJ	Measured	Direct metering	Continuous	Frequency of metering is highest level possible.

	CH_4 Emissions Factor for Derived Gases / EF $_{CH4}$	kg CH_4 per TJ	Estimated	From IPCC guidance documents noted in Appendix C.	Annual	Reference value adjusted periodically as part of IPCC review cycles.
	N_2O Emissions Factor for Derived Gases / EF $_{N2O}$	kg N_2O per TJ	Estimated	From IPCC guidance documents noted in Appendix C.	Annual	Reference value adjusted periodically as part of IPCC review cycles.
P18 Electricity Generation	Emissions $_{Elec\ Gen}$ = ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$); ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N20}$)					
	Emissions $_{Elec\ Gen}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated.
	Volume of Each Type of Fossil Fuel for Electricity Generation / Vol. Fuel $_i$	L/ m^3/ other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Combustion of Each Type of Fossil Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L/ m^3/ other	Estimated and Measured	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Combustion of Each Type of Fossil Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Combustion of Each Type of Fossil Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

P19 Generation of Heat and Power	$Emissions_{Gen\ Heat\ and\ Power} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$					
	$Emissions_{Gen\ Heat\ and\ Power}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated.
	Volume of Each Type of Fossil Fuel Consumed to Generate Heat and Power / $Vol.\ Fuel_i$	L/ m^3/ other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Combustion of Each Type of Fossil Fuel / $EF\ Fuel_{i\ CO2}$	kg CO_2 per L/ m^3/ other	Estimated and Measured	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Combustion of Each Type of Fossil Fuel / $EF\ Fuel_{i\ CH4}$	kg CH_4 per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Combustion of Each Type of Fossil Fuel / $EF\ Fuel_{i\ N2O}$	kg N_2O per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
Baseline SSs						
B6 Residue Decomposition and Methane Collection / Destruction	$Emissions_{Decomposition,\ Collection\ and\ Destruction} = (Mass_{Residue\ Disposed} * MCF * DOC * DOC_F * F * 16/12) * (1 - R) * (1 - OX)$					
	$Emissions_{Decomposition,\ Collection\ and\ Destruction}$	kg of CH_4	N/A	N/A	N/A	Quantity being calculated.
	Mass of Residue Material Sent for Disposal (wet) / $Mass_{Residue\ Disposed}$	kg	Measured	Direct measurement of mass of residue sent for disposal.	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.

	Methane Correction Factor / MCF	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix A.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Degradable Organic Carbon / DOC	-	Estimated	Calculated based on Environment Canada guidelines, provided in Appendix A.	Annual	Values calculated based on equations published by Environment Canada.
	Fraction of Degradable Organic Carbon Dissimilated / DOC_F	kg C / kg waste	Estimated	Calculated based on Environment Canada guidelines, provided in Appendix A.	Annual	Values calculated based on values published by Environment Canada. Reference values adjusted periodically as part of internal Environment Canada review of its methodologies.
	Fraction of CH_4 in Landfill Gas / F	-	Estimated	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Fraction of CH_4 Recovered at Landfill / R	-	Estimated	Based on an affirmation from the landfill operator or from landfill gas collection system engineering design efficiency if site-specific data is available to the project developer. If site specific data is not available or if biomass wastes are diverted from multiple landfills within a large area the project developer may use a regional average percentage of landfill methane collected in the region.	Annual	Percentage of methane collected and destroyed at the landfill sites where the materials were previously sent. In cases where biomass is sourced from a large area and diverted from multiple landfills the project developer may use a regional average based on landfill gas capture data from the National GHG Inventory or other relevant sources.
	Oxidation Factor / OX	-	Estimated	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC

						review of its methodologies.
B9 Fuel Extraction and Processing	Emissions $_{Fuel\ Extraction\ /\ Processing}$ = ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)					
	Emissions $_{Fuel\ Extraction\ /\ Processing}$	kg of CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Volume of Fossil Fuel Combusted for B11 and B15 / Vol. Fuel	L/ m^3/ other	Measured	Based on equivalent heat and power demand with the most likely fuel.	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Fossil Fuel Including Production and Processing / EF Fuel $_{CO2}$	kg CO_2 per L/ m^3/ other	Estimated	Values Provided in Appendix C	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Fossil Fuel Including Production and Processing / EF Fuel $_{CH4}$	kg CH_4 per L/ m^3/ other	Estimated	Values Provided in Appendix C	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Fossil Fuel Including Production and Processing / EF Fuel $_{N2O}$	kg N_2O per L/ m^3/ other	Estimated	Values Provided in Appendix C	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B11 Use of Fuel	Emissions $_{Use\ of\ Fuel}$ = ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$); ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N20}$)					
	Emissions $_{Use\ of\ Fuel}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated.
	Volume of Each Type of Fossil Fuel offset with Bioenergy / Vol. Fuel $_i$	L/ m^3/ other	Measured	Based on equivalent heat and power demand with the most likely fuel.	Monthly	Represents most reasonable means of estimation.

	CO_2 Emissions Factor for Combustion of Each Type of Fossil Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Combustion of Each Type of Fossil Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Combustion of Each Type of Fossil Fuel / EF Fuel $_{i\ N2O}$	kg N2O per L/ m^3/ other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B15 Generation of Heat and Power	$Emissions_{Gen\ Heat\ and\ Power} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$					
	Emissions $_{Thermal\ Heat}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated.
	$Vol.\ Fuel_i = (Heat\ Load * \%_i) / (NCV_{fuel\ i} * \%_{eff})$					
	Equivalent Volume of Each Type of Fossil Fuel Offset/ Vol. Fuel $_i$	L, m^3 or other	N/A	Calculated relative to metered quantity of thermal energy delivered to the end user by the project facility and converted to an equivalent volume of fossil fuel.	Monthly	Quantity being calculated.
	Heat Load Produced under the Project Condition / Heat Load	GJ	Measured	Direct metering of quantity of thermal energy delivered to the end user.	Monthly	Represents the baseline quantity of thermal energy that is being offset by the heat load produced from the operation of the project facility.
	Percentage of Each Type of Fuel Offset / % $_i$	%	Estimated	Based on recorded fossil fuel consumption in one or more years prior to the implementation of project.	Monthly	Represents most reasonable means of estimation.

	Net Calorific Value of Each Type of Fuel being Offset by the Project / NCV $fuel_i$	GJ per L, m^3 or other	Estimated	Reference value.	N/A	Reference value.
	Percentage Efficiency of the Thermal Energy Heating System / $\%_{eff}$	%	Measured or Estimated	Directly metered or estimated from manufacturer's specifications.	Annual	Represents the most reasonable means of estimation.
	CO_2 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ CO2}$	kg CO_2 per L, m^3 or other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ CH4}$	kg CH_4 per L, m^3 or other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_2O Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ N2O}$	kg N2O per L, m^3 or other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B16 Electricity Generation and Usage	$Emissions_{Electricity\ Generation} = Electricity * EF_{Elec}$					
	$Emissions_{Electricity}$	kg of CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Net of Electricity Exported from the Project Site minus Electricity Imported from the Grid / Electricity	kWh	Measured	Direct metering	Continuous metering	Continuous direct metering represents the industry practice and the highest level of detail.
	Emissions Factor for Electricity / EF_{Elec}	kg of CO_2e per kWh	Estimated	From Alberta Environment Offset Project Guidance Document.	Annual	Reference values adjusted periodically.

2.5.2. Contingent Data Approaches

Contingent means for calculating or estimating the required data for the equations outlined in section 2.5.1 are summarized in **TABLE 2.5.** below.

2.6 Management of Data Quality

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. 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 task 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.

2.6.1 Record Keeping

Record keeping practises should include:

a. Electronic recording of values of logged primary parameters for each measurement interval;
b. Printing or secured storage of monthly back-up hard copies of all logged data;
c. Written logs of operations and maintenance of the project system including notation of all shut-downs, start-ups and process adjustments;
d. Retention of copies of logs and all logged data for a period of 7 years; and
e. Keeping all records available for review by a verification body.

2.6.2 Quality Assurance/Quality Control (QA/QC)

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:

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

TABLE 2.5: Contingent Data Collection Procedures

1. Project / Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Contingency Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SSs						
P10 Fuel Extraction and Processing	Volume of Fuel Combusted for P6, P5, P12, P14, P19, and P20 / Vol. Fuel	L/ m^3/ other	Measured	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P5 On-Site Material Processing, P12 Facility Operation and Biofuel Production, and P13 By-product Production	Volume of Each Type of Fuel for Unit Operation / Vol. $Fuel_i$	L/ m^3/ other	Measured	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P15 Use of Biofuel	Mass of Waste	kg	Estimated	Interpolation of previous and following measurements taken.	Continuous Metering.	Mass of waste should remain relatively similar during steady-state operation. Interpolating the mass of waste provides a reasonable estimate when the more accurate and precise method cannot be used.
	Lower heating value of the biofuel / Heat $Value_{Biofuel}$	TJ	Estimated	Interpolation of previous and following measurements taken.	Continuous Metering.	Lower heating value of biofuel should remain relatively similar during steady-state operation. Interpolating the lower heating value provides a reasonable estimate when the more accurate and precise method cannot be used.
P18 Electricity Generation	Volume of Each Type of Fossil Fuel for Electricity Generation / Vol. $Fuel_i$	L/ m^3/ other	Measured	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

P19 Generation of Heat and Power	Volume of Each Type of Fossil Fuel Consumed to Generate Heat and Power / Vol. Fuel $_i$	L/ m^3/ other	Measured	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
Baseline SSs						
B6 Residue Decomposition and Methane Collection / Destruction	Mass of Residue Material Sent for Disposal (wet) / Mass $_{Residue\ Disposed}$	kg	Estimated	Reconciliation with mass of material disposed of at disposal sites.	Continuous metering or monthly reconciliation.	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B9 Fuel Extraction and Processing	Volume of Fuel Combusted for B11 and B15 / Vol. Fuel	L/ m^3/ other	Measured	Reconciliation as per B14 and B16 contingency methods.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B11 Use of Fuel	Volume of Each Type of Fuel offset with Biofuel / Vol. Fuel $_i$	L/ m^3/ other	Measured	Reconciliation of volume of biofuels sold within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B15 Generation of Heat and Power	Heat Load Produced under the Project Condition / Heat Load	GJ	Estimated	Reconciliation of typical heat loads in the project condition based on quantity of fuel consumed and typical net calorific value of fuel used (NCV) and average conversion efficiency	Monthly	Represents the baseline quantity of thermal energy that is being offset by the heat load produced from the operation of the project facility.

	Percentage of Each Type of Fuel Offset / $\%_i$	%	Estimated	Based on conservative values for relevant industry practice at the site where the heat/ power would be consumed.	Monthly	Provides reasonable estimate of the parameter, when there is insufficient historical data available.
B16 Electricity Generation and Usage	Net of Electricity Exported from the Project Site minus Electricity Imported from the Grid / Electricity	kWh	Measured	Reconciliation with power sales agreements covering the same period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

APPENDIX A:

Parameters for Calculations of Avoided Methane Emissions Due to Diversion of Waste from Landfills

Methane Generation Potential of Waste Materials

The following calculation methodologies were collected according to the information outlined in the "National Inventory Report – Greenhouse Gas Sources and Sinks in Canada, 1990-2004", Environment Canada, April 2006.

The methane generation potential of different waste materials disposed of in landfill depends on a number of factors including the composition of the waste and the type of landfill. The methane generation potential is calculated according to the equation below.

$$L_0 = MCF * DOC * DOC_F * F * 16/12 * 1000 \text{ kg } CH_4/\text{t } CH_4$$

Where:
- L_O = CH_4 generation potential (kg CH_4/ t waste)
- MCF = CH_4 correction factor (fraction)
- DOC = degradable organic carbon (t C/t waste)
- DOC_F = fraction DOC dissimilated
- F = fraction CH_4 in landfill gas
- 16/12 = stoichiometric factor

The methane correction factor is determined based on the physical characteristics of the landfill that the waste being disposed as shown in Table B.1, below. According to the IPCC Guidelines, the MCF for managed landfill sites has a value of 1.0. The method used to determine the degradable organic carbon is discussed in detail below. The Environment Canada default DOC_F value of 0.77 was used for all waste types except for wood wastes where a value of 0.5 was used representing the low end of the range of wastes high in lignin as used by Environment Canada. The fraction of CH_4 (F) emitted from a landfill ranges from 0.4 to 0.6 and was assumed to be 0.5.

TABLE A1: Landfill Type-Based Factors

	Mixed-Waste Landfills				**Wood Waste Landfills**
Parameter	**Managed**	**Unmanaged – Deep (>= 5m waste)**	**Unmanaged – Shallow (< 5m waste)**	**Uncategorized**	
Methane Correction Factor (MCF)	1.0	0.8	0.4	0.6	0.8[a]
Fraction of degradable organic carbon (DOC)	See below				0.3
Fraction of degradable organic carbon dissimilated (DOC_F)	0.77				0.5
Fraction of CH_4 in landfill gas (F)	0.5				

a - the default condition for a wood waste landfill is an unmanaged, deep landfill (Environment Canada, 2006). This parameter may be changed if the emissions are being calculated for an alternate type of wood waste landfill.

Calculation of DOC

Estimates of the degradable organic carbon (DOC) present in a waste stream can be calculated using the following equation based on the biodegradable portion of the waste stream:

DOC = (0.4 * A) + (0.17 * B) + (0.15 * C) + (0.3 * D)

Where:
A = fraction of MSW that is paper and textiles
B = fraction of MSW that is garden or park waste
C = fraction of MSW that is food waste
D = fraction of MSW that is wood or straw

The fractions A through D can be determined from a waste audit if mixed wastes are utilized in the project activity while source segregated waste streams can be classified according to the above descriptions. Note that the DOC value should only be calculated using the fractions of the waste that was destined for landfill in the baseline scenario and other materials used as feedstocks should not be considered when determining the values for the fractions A through D.

If site-specific waste characterization data is not available, Environment Canada default values may be used. The default DOC values in the following table were calculated using average Lo values for each province published by Environment Canada (2006).

TABLE A2: Estimates of DOC by Province

Province	Lo (value after 1990)	DOC (calculated)
British Columbia	108.8	0.21
Alberta	100.0	0.19
Saskatchewan	106.8	0.21
Manitoba	92.4	0.18
Ontario	90.3	0.18
Quebec	127.8	0.25
New Brunswick	117.0	0.23
Prince Edward Island	117.0	0.23
Nova Scotia	89.8	0.17
Newfoundland and Labrador	102.2	0.20
Northwest Territories and Nunavut	117.0	0.23
Yukon	117.0	0.23

APPENDIX B:

Emission Factors for Fuel Production and Processing

Emission Factors for Fuel Production and Processing

All values interpreted from volume 1 of the technical report: A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H2S) Emissions by the Upstream Oil and Gas Industry dated September 2004 completed by Clearstone Engineering Ltd. on behalf of the Canadian Association of Petroleum Producers (CAPP).

Table B1: Emission Factors for Gasoline and Diesel Production

	Approximate Proportionate Amount in Year of Emission Factor Generation		Emission Factors			
			CO_2	CH_4	N_2O	Units
Light / Medium Crude Oil Production	55,588	10^3 m^3 / yr	86.3	4.41	0.0038	t / 10^3 m^3
Heavy Crude Oil Cold Production	30,924	10^3 m^3 / yr	75	25.1	0.0033	t / 10^3 m^3
Heavy Crude Oil Thermal Production	10,589	10^3 m^3 / yr	594.2	3.75	0.009	t / 10^3 m^3
Weighted Average			0.1381	0.0109	4.208E-6	kg / L

Table B2: Emission Factors for Natural Gas and NGL's

	Emission Factors			
	CO_2	CH_4	N_2O	Units
Natural Gas Production	0.043	0.0023	0.000004	t / 10^3 m^3
Natural Gas Processing	0.090	0.0003	0.000003	t / 10^3 m^3
Petroleum Liquids Transportation	0.092	0.013	0.0	t / 10^3 m^3

APPENDIX C:

Emission Factors for Municipal Solid Waste (MSW)

Emission Factors for Municipal Solid Waste (MSW)

Biogenic CO_2 Emission Factor for Municipal Solid Waste (MSW)

The biogenic CO_2 emission factor for thermal destruction of MSW is not included as biogenic CO_2 emissions are considered part of the natural carbon balance and it will not add to atmospheric concentrations of carbon dioxide.

Non-Biogenic CO_2 Emission Factor for Municipal Solid Waste (MSW)

The non-biogenic CO_2 emission factor for thermal destruction of MSW is interpreted from the U.S. Environmental Protection Agency (EPA) technical report: Voluntary Reporting of Greenhouse Gases Program dated 1997. This report estimates that the CO_2 emission factor for the non-organic portion of the MSW, primarily the plastics, is 2.8795 $kg_{CO2} / kg_{plastic\ waste}$. Using this information an emission factor for non-biogenic emissions from MSW can be estimated by multiplying the EPA value by the proportion of plastic waste to overall waste at the site as;

$$EF\ MSW_{Non\text{-}biogenic\ CO2} = 2.8795\ (kg_{CO2} / kg_{plastic\ waste}) * \%\ Plastics\ Content\ of\ Waste$$

Where: $EF\ MSW_{Non\text{-}biogenic\ CO2}$ = CO_2 emissions (kg_{CO2} / kg_{waste})
% Plastics Content of Waste = Plastics component of the waste stream ($kg_{plastics} / kg_{waste}$)

Alternatively a site-specific non-biogenic CO_2 emission factor may be calculated as outlined in the flexibility mechanism by performing a mass balance as follows:

$$EF\ MSW_{Non\text{-}biogenic\ CO2} = C * Plastics * 44/12$$

Where: $EF\ MSW_{Non\text{-}biogenic\ CO2}$ = CO_2 emissions (kg_{CO2} / kg_{waste})
C = Concentration of carbon in plastics fraction (%)
% Plastics Content of Waste = Plastics component of the waste stream ($kg_{plastics} / kg_{waste}$)
44/12 = The molecular weight conversion factor from C to CO_2

CH_4 and N_2O Emission Factors for Derived Gases

Based on its composition, the biofuel may reasonably considered as analogous to a derived gas stream. As per Table 2.2 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the coefficients for CH_4 and N_2O emission factors for derived gases are 1.0 kg of CH_4 per TJ of biofuel and 0.1 kg N_20 per TJ of biofuel, respectfully, regardless of the source, type or usage.

APPENDIX D:

Equations for Inclusion of Transportation

TABLE D1: Quantification Procedures

1. Project / Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
Transportation	Emissions $_{Transportation}$ = ∑ (Distance $_{Load\ i}$ * Fuel Eff $_{Load\ i}$ * EF Fuel $_{CO2}$) ; ∑ (Distance $_{Load\ i}$ * Fuel Eff $_{Load\ i}$ * EF Fuel CH_4) ; ∑ (Distance $_{Load\ i}$ * Fuel Eff $_{Load\ i}$ * EF Fuel N_2O)					
	Emissions $_{Transportation}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated.
	Distance Driven for each truck Load / Distance $_{Load\ i}$	km	Measured	Distance each load travels.	Annual	The distance of most probable route is measured once for each source of recyclables for each project.
	Fuel Efficiency of the truck used for each load / Fuel Eff $_{Load\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Annual	This method is conservative as it incorporates all travel time and idling.
	CO_2 Emissions Factor for Each Type of Fossil Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L, m^3 or other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fossil Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L, m^3 or other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fossil Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L, m^3 or other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

Guidance on the calculation of the transportation emissions, for methods other than by road transportation, may be found in the appendices of the Anaerobic Biodigester and Energy from Biomass protocols published by Alberta Environment.

TABLE D2: Contingent Data Collection Procedures

1. Project / Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Contingency Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SSs						
Transportation	Fuel Efficiency of the truck used for each load / $Fuel\ Eff_{Load\ i}$	L per 100 km	Estimated	Average fuel efficiency for vehicles used	Annual	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.