QUANTIFICATION PROTOCOL FOR THE ANAEROBIC DECOMPOSITION OF AGRICULTURAL MATERIALS

ABRIDGED

Submitted to:

Alberta Environment

and

Alberta Agriculture, Food and Rural Development

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Disclaimer

The following document presents an abridged version of the Anaerobic Decomposition of Agricultural Materials protocol prepared for Alberta Environment and Alberta Agriculture, Food and Rural Development which has completed an initial round of technical review. This document has been prepared as a means of supporting a broader stakeholder consultation process. As such, this document should not be used as a quantification protocol.

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1.0 Project and Methodology Scope and Description

This quantification protocol is applicable to the quantification of direct and indirect reductions of greenhouse gas (GHG) emissions resulting from the implementation of anaerobic digestion of organic feedstocks, primarily agricultural materials such as manure, silage, dead animal stocks, etc. The anaerobic digestion of the feedstock generates methane gas which can be combusted to produce electrical and thermal energy, or processed, if required, for inclusion in the gas transmission systems. The digestate and effluent water may be stored and then land applied or else further processed by recycling water and/or recovering nutrients as fertilizers which are then land applied.

The greenhouse gas emission reductions are primarily derived from the capture and combustion of the methane. This can include controlled flaring, generating electricity to offset power from the grid, thermal energy to offset offsite use of non-renewable energy sources and/or biogas production to offset natural gas or other fuel use off site. The agricultural material may represent part or all of the feedstock to the renewable energy facility.

Typically anaerobic digestion of agricultural material involves the establishment of an integrated material management system for a single or multiple agricultural facilities. Anaerobic digesters, generators, thermal energy recovery systems, biogas processing, fertilizer production, and/or water treatment systems are built on a site to handle any number of agricultural materials. The most prevalent feedstocks are animal manures, silage and dead animal stocks. These materials are collected, transported to the facility, processed, and anaerobically digested, with the resulting materials being processed, combusted and disposed. **FIGURE 1.1** offers a project element life cycle chart for a typical project.

To demonstrate that a project is covered by the scope of the protocol, the project proponent must demonstrate that the agricultural material would have been collected, processed, and either land spread, sent to landfill or incinerated as per the current agricultural practices. As evidence, the project proponent must demonstrate that this baseline condition was either the previous practise or most likely practise. Further, they must show that the agricultural material has been treated in an anaerobic digestion facility. **FIGURE 1.2** offers an element life cycle chart for a typical baseline configuration.

Facilities that cannot show that the agricultural material would have been either land spread, sent to landfill or incinerated, or that the agricultural material was anaerobically digested, cannot apply this quantification protocol.

The baseline condition is considered as projection based. Under this scenario, the emissions from the disposal of an equivalent quantity of agricultural material being either land applied, sent to landfill or incinerated would be calculated using existing models covering the activities under the baseline condition.

FIGURE 1.1: Project Element Life Cycle Chart

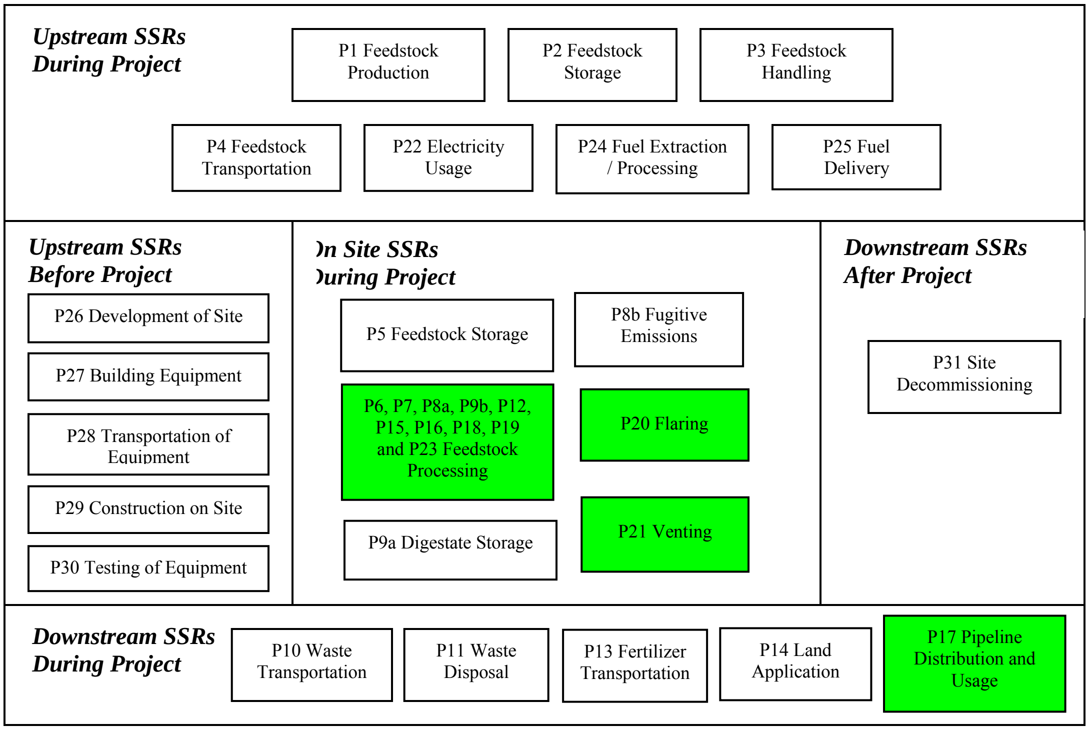
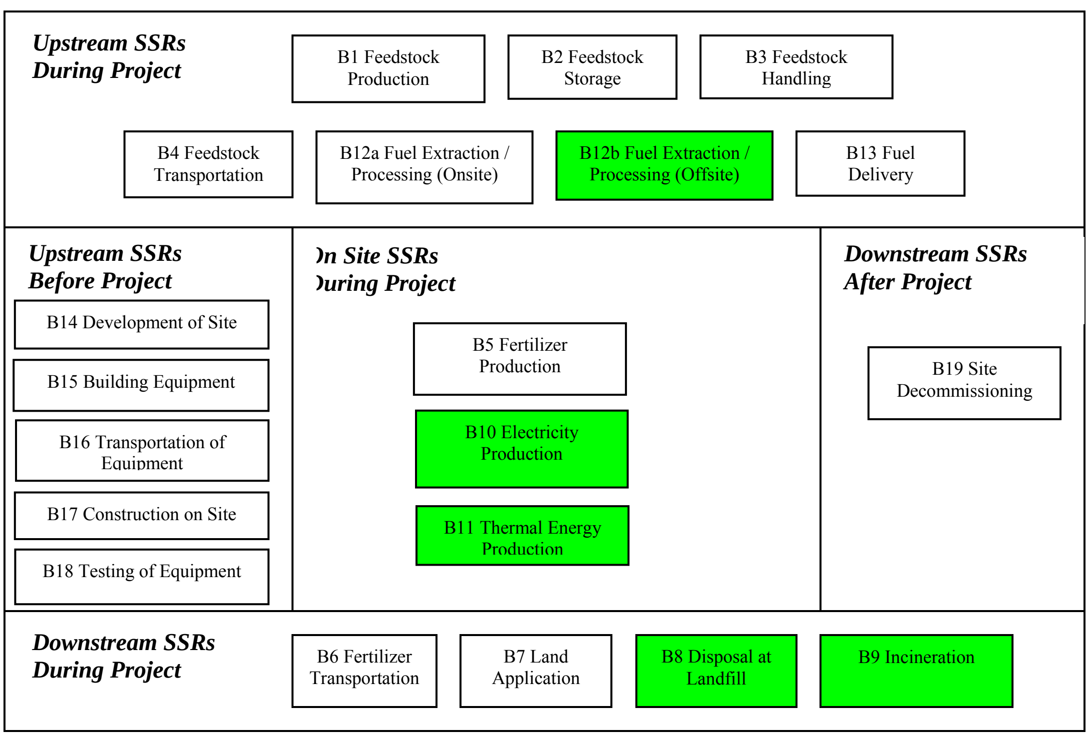


FIGURE 1.2: Baseline Element Life Cycle Chart



* Sources, sinks and reservoirs selected for measurement and monitoring under this protocol are highlighted.

This dynamic approach accounts for the market forces, weather and energy demand and operational parameters without adding multiple streams of material management. There are suitable models that can provide reasonable certainty.

To demonstrate that a project meets the requirements under this protocol, the project proponent must supply sufficient evidence to demonstrate that:

1. The agricultural material diverted to the anaerobic digestion facility would have been either land spread, sent to landfill or incinerated as confirmed by an attestation from the biomass supplier;
2. The agricultural material diverted to the anaerobic digestion facility would have been either land spread, sent to landfill or incinerated as confirmed by an attestation from the biomass supplier;
3. For projects where methane production processes are enhanced (e.g. mesophilic, thermophilic, etc.) the anaerobic digestion facility manages the risk of fugitive emissions in keeping with the guidance provided in **APPENDIX A** as evidenced by an attestation from the project proponent and applicable records;
4. The digestate does not undergo active windrow composting as indicated by an attestation from the project proponent; and
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.

Flexibility in applying the quantification protocol is provided to project developers in three ways:

1. Where the conditions for functional equivalence for certain components of the baseline and project condition or other justification for excluding SSRs cannot be assured, the respective SSRs may be added back to the protocol as indicated. Calculation methodologies, data requirements, etc., have been specified for each of these SSRs;
2. Grouping of SSRs is possible where one meter covers the fuel supply to multiple SSRs. In this case the highest level of quality assurance / quality control must be employed, and all of the fuel or electricity must be attributed to the SSR such that the most reasonable emissions values are attained;
3. 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 be sufficiently robust as to ensure reasonable accuracy; and
4. Measurement and data management procedures may be modified by the project proponent to account for the available equipment as long as the specified minimum standards for data quantity, frequency and quality are met. Where these standards cannot be met, the project proponent must justify why this represents a reasonable change to the methodology provided.

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

2.0 Quantification of Identified Sources, Sinks and Reservoirs

Quantification of the reductions, removals and reversals for the sources, sinks and reservoirs selected for measurement and monitoring under this protocol will be completed using the methodologies outlined in **TABLE 2.1**, below. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

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

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Feedstock Disposal}} + \text{Emissions}_{\text{Incineration}} + \text{Emissions}_{\text{Electricity}} + \text{Emissions}_{\text{Thermal Heat}} + \text{Emissions}_{\text{Fuel Extraction / Processing}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Multiple Sources}} + \text{Emissions}_{\text{Pipeline Distribution and Usage}} + \text{Emissions}_{\text{Flaring}} + \text{Emissions}_{\text{Venting}}$$

TABLE 2.1: Quantification Procedures

1.0 Project/ Baseline SSR	2. Parameter / Variable	3. Unit
	Project SSRs	
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and 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. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)	
	Emissions $_{Multiple\ Sources}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Biogas Combusted / Vol. Biogas $_{Combusted}$	m^3
	Methane Composition in Biogas / % CH_4	-
	CH_4 Emissions Factor for Biogas / EF Biogas $_{CH4}$	kg CH_4 per m^3
	N_20 Emissions Factor for Biogas / EF Biogas $_{N2O}$	kg N_2O per L / m^3 / other
	Volume of Each Type of Fuel / Vol Fuel $_i$	L / m^3 / other
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other
P17 Pipeline Distribution and Usage	Emissions $_{Pipeline\ Distribution\ and\ Usage}$ = (Vol Fuel $_{Pipeline}$ * % CH_4 * EF Biogas $_{CH4}$) ; (Vol Fuel $_{Pipeline}$ * % CH_4 * EF Biogas $_{N2O}$)	
	Emissions $_{Pipeline\ Distribution\ and\ Usage}$	kg of CH_4 ; N_2O
	Volume of Biogas Piped from the Site / Vol Fuel $_{Pipeline}$	m^3
	Methane Composition in Biogas / % CH_4	-
	CH_4 Emissions Factor for Biogas / EF Biogas $_{CH4}$	kg CH_4 per m^3
	N_20 Emissions Factor for Biogas / EF Biogas $_{N2O}$	kg N_2O per L / m^3 / other
P20 Flaring	Emissions $_{Flaring}$ = (Vol. Biogas Flared * % CH_4 * EF Biogas $_{CH4}$) ; (Vol. Biogas Flared * % CH_4 * EF Biogas $_{N2O}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)	
	Emissions $_{Flaring}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Biogas Flared / Vol. Biogas Flared	m^3
	Volume of Each Type of Fuel used to Supplement Flare / Vol Fuel $_i$	L / m^3 / other
P21Venting	Emissions $_{Venting}$ = (Max. Storage Vol. $_{Vessel}$ + Flow Biogas $_{Vessel}$ * Time $_{Venting}$) * % CH_4	
	Emissions $_{Venting}$	kg of CH_4
	Maximum volume of biogas stored in Vessel at Steady State / Max. Storage Vol. $_{Vessel}$	m^3
	Flow Rate of Biogas at Steady State / Flow Biogas $_{Vessel}$	m^3 / hr
	Time that vessel is venting / t	days
	Baseline SSRs	
B8 Disposal at Landfill	Emissions $_{Feedstock\ Disposal}$ = (Mass $_{Feedstock\ Landfill}$ * MCF * DOC * DOC_F * F * 16/12 - R) * (1 - OX)	
	Emissions $_{Feedstock\ Disposal}$	kg of CH_4
	Mass of Feedstock to Landfill / Mass $_{Feedstock\ Landfill}$	kg
	Methane Correction Factor / MCF	-
	Degradable Organic Carbon / DOC	-

	Fraction of Degradable Organic Carbon Dissimilated / DOC_F	-
	Fraction of CH_4 in Offgas from Disposal Site / F	-
	Recovered CH_4 at Disposal Site / R	kg of CH4
	Oxidation Factor / OX	-
B9 Incineration	$Emissions_{Incineration} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$	
	$Emissions_{Incineration}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel used for incineration / Vol $Fuel_i$	L / m^3 / other
B10 Electricity Production	$Emissions_{Electricity} = Electricity * EF_{Elec}$	
	$Emissions_{Electricity}$	kg of CO2e
	Electricity Sent to Grid / Electricity	kWh
	Emissions Factor for Electricity / EF_{Elec}	kg of CO2e per kWh
B11 Thermal Energy Produced	$Emissions_{Thermal\ Heat} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$	
	$Emissions_{Thermal\ Heat}$	kg of CO_2 ; CH_4 ; N_2O
B12b Fuel Extraction / Processing (Offsite)	$Emissions_{Fuel\ Extraction\ /\ Processing} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$	
	$Emissions_{Fuel\ Extraction\ /\ Processing}$	kg of CO2e
	Volume of Biogas Input to Pipeline / Vol Fuel	L / m^3 / other

APPENDIX A: Glossary of New Terms

Active Windrow Composting:	Windrow composting is the production of compost by the aerobic decomposition of organic matter, such as animal manure and crop residues, piled in long rows (windrows) which may be periodically watered and/or turned.
Agricultural Material:	Agricultural material is defined to include organic residues from the full life cycle of agricultural production. This material may include crop residues, livestock manures, dead stock (special handling likely applies), food processing by-products, etc. These materials may be produced at primary production agricultural operations or agri-food processing facilities.
Anaerobic Digestion:	An active and naturally occurring biological process where organic matter is degraded by methanogenic bacteria to yield methane gas and mineralized organic nutrients.
Land Application:	The beneficial use of agricultural material and/or digestate, applied to cropland based upon crop needs and the composition of the agricultural material, as a source of soil amendment and/or nutrition.
Fugitive Emissions:	Intentional and unintentional releases of GHGs from joints, seals, packing, gaskets, etc. within anaerobic digestion systems, including all processing, piping and treatment equipment.