Dominican Republic Livestock Protocol

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Acknowledgements

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The list of workgroup members below comprises all individuals and organizations who have assisted in developing and updating various versions of the protocol. Not all members were involved in every protocol revision process. For more information, see section 4.3 of the Reserve Offset Program Manual.

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Abbreviations and Acronyms

BCS	Biogas Control System
CDM	Clean Development Mechanism
CH_4	Methane
CNG	Condensed natural gas
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
DIGEGA	Directorate-General for Livestock Farming
EPA	Environmental Protection Agency
GHG	Greenhouse gas
GN	Natural gas
IDIAF	Dominican Institute of Agricultural and Forestry Research
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquefied natural gas
N_2O	Nitrous oxide
NAMA	Nationally Appropriate Mitigation Actions
NCCCDM	National Council for Climate Change and Clean Development Mechanism
QA/QC	Quality Assurance / Quality Control
Reserve	Climate Action Reserve
USDA	United States Department of Agriculture
NRCS	Natural Resources Conservation Service

1. Introduction

The Climate Action Reserve (Reserve) Dominican Republic Livestock Protocol provides guidance to account for and report greenhouse gas (GHG) emission reductions associated with the installation of a biogas control system (BCS) for manure management on dairy cattle and swine farms. The protocol focuses on quantifying the change in methane emissions, but also accounts for effects on carbon dioxide emissions.

The Climate Action Reserve is the most trusted, efficient, and experienced offset registry for global carbon markets. A pioneer in carbon accounting, the Reserve promotes and fosters the GHG emissions through credible market-based policies and standards and issues credits under those standards. As a high-quality offset registry for voluntary carbon markets, it establishes rigorous standards and issues carbon credits under those standards. The Reserve also supports compliance carbon markets and serves as an approved Offset Project Registry for the State of California's Cap-and-Trade Program. The Reserve is an environmental nonprofit organization headquartered in Los Angeles, California with satellite offices around the world. For more information, please visit www.climateactionreserve.org.

Project developers that install manure biogas capture and destruction technologies use this document to register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Verification Program Manual and Section 8 of this protocol.

This project protocol facilitates the creation of GHG emission reductions determined in a complete, consistent, transparent, accurate, and conservative manner, while incorporating relevant sources.[1]

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG accounting principles.

2. The GHG Reduction Project

Manure treated and stored under anaerobic conditions decomposes to produce methane, which, if uncontrolled, is emitted to the atmosphere. This predominantly occurs when livestock operations manage waste with anaerobic liquid-based systems (e.g., in lagoons, ponds, tanks, or pits). Within the livestock sector, the primary drivers of methane generation include the amount of manure produced and the fraction of volatile solids that decompose anaerobically. Temperature and the retention time of manure during treatment and storage also affect its production. A biogas control system captures and destroys methane gas created as a result of manure management.

2.1. Project Definition

For the purpose of this protocol, the GHG reduction project is defined as the installation of a biogas control system that captures and destroys methane gas from anaerobic manure treatment and/or storage facilities on livestock operations, specifically dairy cattle and swine operations.[2] The biogas control system must destroy methane gas that would otherwise have been emitted to the atmosphere in the absence of the project from uncontrolled anaerobic treatment and/or storage of manure.[3]

Captured biogas can be destroyed on-site, or transported for off-site use (e.g., through gas distribution or transmission pipeline), or used to power vehicles. Regardless of how project developers take advantage of the captured biogas, the ultimate fate of the methane must be destruction.

“Centralized digesters” that integrate waste from more than one livestock operation also meet this definition of the GHG reduction project.[4]

2.2. The Project Developer

The “project developer” is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers could be livestock facility owners and operators, GHG project financiers, or other entities. The project developer must have clear ownership of the project’s GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership by signing the Reserve’s Attestation of Title form.[5]

2.3. Additional Manure Management GHG Reduction Activities

The Reserve recognizes that project developers could implement a variety of GHG reduction activities at a livestock operation, which are complex interrelated systems that make use of

[2] Biogas control systems are commonly called digesters, which may be designed and operated in a variety of ways, from ambient temperature covered lagoons to heated lagoons to mesophilic plug flow or complete mix concrete tank digesters.

[3] The installation of a BCS at an existing livestock operation where the primary manure management system is aerobic (produces little to no methane) may result in an increase of the amount of methane emitted to the atmosphere. Thus, the BCS must digest manure that would primarily be treated in an anaerobic system in the absence of the project in order for the project to meet the definition of a GHG reduction project.

[4] The protocol also does not preclude project developers from co-digesting organic matter in the biogas control system. However, the additional organics could impact the nutrient properties of digester effluent, which project developers should consider when assessing the project’s associated water quality impacts.

[5] Attestation of Title form available at *https://www.climateactionreserve.org/how/program-resources/documents/.*

several types and combinations of manure management practices. Installing technology to capture and destroy methane from waste storage and/or treatment systems is but one of many projects that could occur at a livestock operation. Several options to modify solid and/or liquid manure management practices that do not involve a biogas control system – i.e., a digester – could also reduce methane, carbon dioxide, and nitrous oxide emissions (including land application). And a project developer could also change dietary regimes to reduce methane (either enteric fermentation or waste management-related) and nitrous oxide.

However, at this time, GHG reduction activities not associated with installing a biogas control system do not meet this protocol's definition of the GHG reduction project. Furthermore, producing power for the electricity grid (and thus displacing fossil-fueled power plant GHG emissions) is a complementary and separate GHG project activity to destroying methane gas from waste treatment/storage, and is not included within this protocol's accounting framework.[6]

3. Eligibility Rules

Project developers using this protocol satisfy the following eligibility rules to register reductions with the Reserve. The criteria only apply to projects that meet the definition of a GHG reduction project.

Eligibility Rule I:	Location	→	*Dominican Republic*
Eligibility Rule II:	Project Start Date	→	*Within 12 months prior to project submission*
Eligibility Rule III:	Anaerobic Baseline	→	*Demonstrate anaerobic baseline conditions*
Eligibility Rule IV:	Additionality	→	*Meet performance standard*
		→	*Avoid exceeding limits on credit stacking*
		→	*Exceed legal requirements*
Eligibility Rule V:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1. Location

Only projects located in the Dominican Republic are eligible to register reductions with the Reserve under this protocol. Livestock projects located in the United States or Mexico must use the respective Livestock Protocol if seeking to register GHG reductions with the Reserve.

3.2. Project Start Date

The start date for a livestock project is defined as the date at which the project's biogas control system becomes operational. For the purposes of this protocol, a BCS is considered *operational* on the date at which the system begins producing and destroying methane gas upon completion of an initial start-up period. This date can be selected by the project developer within a 12-month timeframe from the date at which methane is first produced in the digester.

Projects must be submitted to the Reserve no more than six months after the project start date.

[6] The Reserve anticipates the development of a supplement for this protocol for the reductions estimation and registration of activities that produces renewable electricity from biogas and that displaces the fossil-based electricity.

3.3. Project Crediting Period

Project developers are eligible to register GHG reductions with the Reserve according to this protocol for a period of 10-years following the project's operational start date. However, if a regulatory agency with authority over a livestock operation passes a rule obligating the installation of a biogas control system, the Reserve will only issue CRTs for GHG reductions achieved up until the date that the biogas control system is legally required to be operational. See Section 3.5.3 for more information.

At the end of a project's first crediting period, a project developer may apply for eligibility under a second crediting period. Thus, the Reserve may issue CRTs for GHG reductions quantified and verified according to the Dominican Republic Livestock Protocol for a maximum of two ten-year crediting periods after the project start date. Section 3.5.1 and 3.5.3 describe the requirements to qualify for a second crediting period.

3.4. Anaerobic Baseline

Consistent with CDM methodology ACM0010, project developers must demonstrate that the depth of their anaerobic ponds/lagoons pre-project were sufficient to prevent algal oxygen production and create an oxygen-free bottom layer; which usually means at least 1 meter depth. Ultimately, to generate methane emissions anaerobic systems should be designed and maintained with sufficient volume to properly treat volatile solids and prevent solids from accumulating, to the extent that they adversely impact the treatment zone. Additional information on the design and maintenance of anaerobic manure storage/treatment systems is available through USDA NRCS Standards and the Environmental technical regulation for the management of swine farms in Dominican Republic.[7]

Greenfield livestock projects (i.e., projects that are implemented at new livestock facilities that have no prior manure management system) are eligible only if the project developer can demonstrate that uncontrolled anaerobic storage and/or treatment of manure is common practice in the industry and geographic region where the project is located.

3.5. Additionality

The Reserve will only accept projects that yield surplus GHG reductions that are additional to what might have otherwise occurred. That is, the reductions are above and beyond business-as-usual operation.

Project developers satisfy the “additionality” eligibility rule by passing two tests:

1. The Performance Standard Test
2. The Legal Requirement Test

3.5.1. The Performance Standard Test

Project developers pass the Performance Standard Test by meeting a program-wide performance threshold – i.e., a standard of performance applicable to all manure management projects, established on an ex-ante basis. The performance threshold represents “better than business-as-usual.” If the project meets the threshold, then it exceeds what would happen under the business-as-usual scenario and generates surplus/additional GHG reductions.

For this protocol, the Reserve uses a technology-specific threshold; sometimes also referred to as a practice-based threshold, where it serves as “best-practice standard” for managing livestock manure. By installing a biogas control system a project developer passes the Performance Standard Test.

The Reserve defined this performance standard by evaluating manure management practices in Dominican Republic. A summary of the study to establish the threshold is provided in 0.

[7] See U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Storage Facility, No. 313; and U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Treatment Lagoon, No. 359. For swine operations, see also the "Environmental technical regulation for the management of pig farms" of the Ministry of Environment and Natural Resources of the Dominican Republic https://ambiente.gob.do/wp-content/uploads/2017/03/BORRADOR-REGLAMENTO-PORCINO-CCI-05-1-17.pdf

The Performance Standard Test is applied at the time of the project's start date. All projects that pass this test at the project's start date are eligible to register reductions with the Reserve for the duration of the first project crediting period, even if the Reserve revises the Performance Standard Test in subsequent versions of this protocol during that period. As stated in Section 3.3, the project crediting period is 10-years.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Performance Standard Test.

3.5.2. Limits on Credit Stacking

When multiple forms of incentive credits are sought for a single activity at a single facility or on a single piece of land, with some temporal overlap between the different credits or payments, it is referred to as "credit stacking". Under this protocol, credit stacking is defined as receiving both offset credits and other types of mitigation credits for the same activity on spatially overlapping areas (i.e., in the same digester). Mitigation credits are any instruments issued for the purpose of offsetting the environmental impacts of another entity, such as emissions of GHGs, or the displacement of fossil fuel emissions from transport applications, to name a few.

Project developers are strongly encouraged to reach out to the Reserve as early as possible when considering credit stacking. Furthermore, they must disclose any such payments to the Reserve at the time of listing and to the verification body and the Reserve at the time of verification. The Reserve maintains the right to determine if stacking has occurred, or is occurring, and whether it would impact project eligibility.

If a livestock project transitions to reporting under another standard but may wish to receive CRTs in future reporting periods, the project must maintain continuous reporting with the Reserve under the Dominican Republic Livestock Protocol. To maintain continuous reporting, the project developer must submit a Zero-Credit Reporting Period Acknowledgment and Election form and a monitoring report no later than six months following the end of each relevant reporting period under the other fuel standard.

3.5.3. The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. A project passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring the installation of a BCS at the livestock operation.

The Legal Requirement Test is applied at the time of the project's start date and each reporting period thereafter. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[8] prior to the commencement of verification activities each time the project is verified. If a regulatory agency with authority over a livestock operation passes a rule obligating the installation of a biogas control system, emission reductions can be registered in the Reserve from the project start date until the date that the biogas control system is legally required to be operational.

[8] Attestation forms are available at https://www.climateactionreserve.org/how/program-resources/documents/

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Legal Requirement Test.

The Reserve's analysis of manure management practices in the Dominican Republic found no federal, state, or municipal regulation that requires cattle owners to invest in a manure biogas control system. The Reserve did not find any laws requiring cattle operators to install a biogas control system.

3.6. Regulatory Compliance[9]

As a final eligibility requirement, project developers must attest that the project is in compliance with all laws applicable to the project activity (e.g., air, water quality, safety, etc.). To satisfy this requirement, project developers must submit a signed Attestation of Regulatory Compliance form[10] prior to commencement of verification activities for each verification period. Project developers are required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise - caused by the project or project activities.

A violation should be considered "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the project developer shall disclose the violations to the verifier.

If a verifier determines that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurring non-compliance or non-compliance that is the result of negligence or intent may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

With respect to projects that receive and manage manure from multiple discrete source facilities (separate from the BCS project in both physical location and management), it may be possible for a project developer to demonstrate that a regulatory violation occurring at one source facility does not affect the eligibility of the entire project under this section. Project developers should contact the Reserve to report a potential non-compliance issues.

[9] Refer to Appendix A.1 for an analysis of regulations in Dominican Republic applicable to livestock operations.
[10] Attestation forms are available at https://www.climateactionreserve.org/how/program-resources/documents/

3.7 Social and Environmental Safeguards

The Reserve requires project developers to demonstrate that their GHG projects will not give rise to environmental or social harm. Moreover, offset projects can create long-term social and environmental benefits and have the potential to improve quality of life for rural landowners, both in terms of increased revenues and in terms of sustaining and improving livestock practices and lands.

This protocol includes specific social and environmental safeguards that must be considered in the project design and implemented throughout the project life to help guarantee that the project will have positive environmental and social outcomes. In addition, all projects must comply with the Reserve's Offset Program Manual, including the section on regulatory compliance and programmatic environmental and social safeguards. The safeguards in the protocol are intended to respect internal governmental processes, customs, and rights of landowners while ensuring projects are beneficial, both socially and environmentally. The sections on monitoring, reporting, and verification (Sections 7 and 8) specify the criteria for verification of each of these safeguards and consequences for failure to achieve the minimum thresholds.

The social safeguard requirements include:

1. Free, Prior, and Informed Consent (FPIC):
    a. Project developers must address the following topics with the livestock operator prior to project approval:
        i. Concepts of climate change and carbon markets.
        ii. Requirements associated with livestock projects, including ongoing MRV.
        iii. Estimates of costs and benefits associated with the livestock project and the division of costs and distribution of benefits or benefit sharing. The source used for carbon pricing estimates must be disclosed.
    b. After the topics to comply with 1.a have been addressed, livestock operators must approve the livestock project under this protocol and the project developer.

2. Ongoing Notification, Participation, and Documentation:
    a. The project developer must review with the livestock operator on an annual basis the following topics:
        i. Ongoing project activities, including MRV.
        ii. Credits issued.
        iii. Purchase agreements, project finances, and ongoing benefit sharing arrangements.
    b. Project notification and documentation must be presented to the livestock operator in an appropriate format and language to ensure understanding.
3. Labor and Safety: The project developer must attest that the project is in material compliance with all applicable laws, including labor or safety laws. See Section 3.6 Regulatory Compliance for further information.
4. No conflicts: the livestock operator(s) and/or project developer must attest to having uncontested land title for the entire project boundary, including all livestock facilities directly associated with the carbon project.

The environmental safeguard requirements include:

1. The project developer must attest that the project is in material compliance with all applicable laws, including environmental regulations (e.g., air and water quality). See

Section 3.6 Regulatory Compliance and Appendix A Associated Environmental Impacts for further information.

2. Mitigation of pollutants: Projects must be designed and implemented to mitigate potential releases of pollutants that may cause degradation of the quality of soil, air, surface and groundwater such as those described in Appendix A, and project developers must acquire the appropriate local permits prior to installation to prevent violation of all applicable laws.

4. The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks and reservoirs (SSRs) that shall be assessed by project developers to determine the net change in emissions associated with installing a biogas control system. This protocol's assessment boundary captures sources from waste production to disposal, including off-site manure disposal. However, the calculation procedure only incorporates methane and carbon dioxide, so while nitrous oxide sources are technically within the boundary they are not assessed in the calculation procedure. See Box 4.1 for additional information.

This protocol does not account for carbon dioxide emission reductions associated with displacing grid-delivered electricity or fossil fuel use.

CO_2 emissions associated with the generation and destruction of biogas are considered biogenic emissions[11] (as opposed to anthropogenic) and are not included in the GHG Assessment Boundary. This is consistent with the Intergovernmental Panel on Climate Change's (IPCC) guidelines for captured landfill gas.[12]

Figure 4.1 provides a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the boundary. All SSRs within the dashed line are accounted for under this protocol.

Table 4.1 provides greater detail on each SSR and provides justification for the inclusion or exclusion of SSRs and gases from the GHG Assessment Boundary.

[11] The rationale is that carbon dioxide emitted during combustion represents the carbon dioxide that would have been emitted during natural decomposition of the manure. Emissions from the biogas control system do not yield a net increase in atmospheric carbon dioxide because they are theoretically equivalent to the carbon dioxide absorbed during plant/feed growth.

[12] *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*; p.5.10

Box 4.1. The Reserve's Treatment of Nitrous Oxide Emissions

This protocol's GHG Assessment Boundary conceptually encompasses sources of nitrous oxide emissions in the waste production, waste treatment and storage, and waste disposal source categories. However, project developers do not calculate nitrous oxide impacts. This determination is made for the sake of "conservativeness" since the high levels of uncertainty associated with the methods to assess nitrous oxide production could lead to overestimations of project reductions.

Procedures to calculate nitrous oxide emissions associated with a livestock operation's manure management system and from the application of manure to soils (both direct and indirect) rely on emission factors with at least an uncertainty range of a factor of two – either 100% above or 50% below the default value.[13] The reason for the large uncertainty is the complex emissions pathway from organic nitrogen in livestock waste to nitrous oxide – the nitrification-denitrification cycle.[14]

As the state of science advances and methods to calculate nitrous oxide emissions at the farm-level improve, the Registry will incorporate them into this protocol. In fact, as the assessment boundary includes sources from waste production to disposal it is set-up to integrate nitrous oxide calculations. The Registry will work with project developers and the research community to develop an appropriate "conservatism factor" that could sufficiently mitigate possible overestimations of project reductions that stem from uncertainty in nitrous oxide quantification.

The CDM "Consolidated baseline methodology for GHG emission reductions from manure management systems" (ACM0010 V.5) allows project developers to calculate decreases in nitrous oxide emissions from sources up to, but excluding, land application.

[13] See IPCC 2006 Guidelines volume 4, chapter 10, table 10.21 and volume 4, chapter 11, table 11.3.

[14] Uncertainty also exists with estimations of baseline methane emission. The Reserve takes steps to reduce this uncertainty by following a calculation approach that is based on the monthly biological performance of the operation's anaerobic manure handling systems that existed pre-project, as predicted by the van't Hoff-Arrhenius equation using site-specific data on temperature, Volatile Solids (VS) loading, and system VS retention time. The Reserve has been working to evaluate project-level uncertainty. This work is ongoing, but early results suggest that uncertainty levels associated with the quantification of nitrous oxide are more substantial than methane.

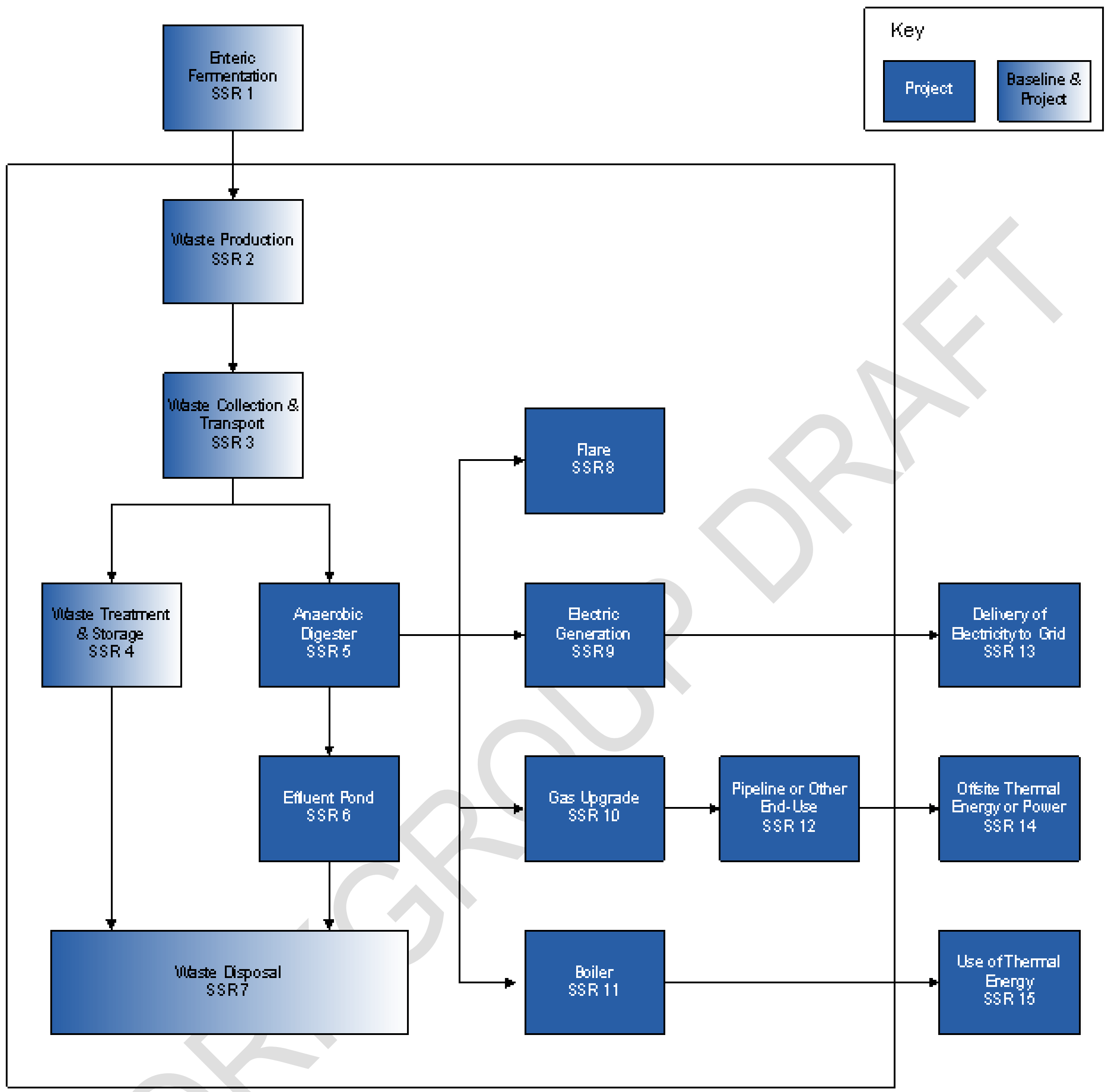


Figure 4.1. General Illustration of the GHG Assessment Boundary

Table 4.1 relates GHG source categories to sources and gases, and indicates inclusion in the calculation methodology. It is intended to be illustrative – GHG sources are indicative for the source category, GHGs in addition to the main GHG are also mentioned, where appropriate.

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	GHG Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
1	Emissions from enteric fermentation	CH_4	B, P	*Excluded*	It is very unlikely that a livestock operator would change its feeding strategy to maximize biogas production from a digester; thus impacting enteric fermentation emissions from ruminant animals.
2	Emissions from waste deposits in barn, milking parlor, or pasture/corral	N_2O	B, P	*Excluded*	See Box 4.1.
	Emissions from mobile and stationary support equipment	CO_2	B, P	*Included*	If any additional vehicles or equipment are required by the project beyond what is required in the baseline, emissions from such sources shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
3	Emissions from mechanical systems used to collect and transport waste (e.g. engines and pumps for flush systems; vacuums and tractors for scrape systems)	CO_2	B, P	*Included*	If any additional vehicles or equipment are required by the project beyond what is required in the baseline, emissions from such sources shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
	Vehicle emissions (e.g. for centralized digesters)	CO_2		*Included*	If any additional vehicles or fuel use is required by the project beyond what is required in the baseline, emissions from such equipment shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
4	Emissions from waste treatment and storage including: anaerobic lagoons, dry lot deposits, compost piles,	CO_2	B, P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions in the baseline.
		N_2O		*Excluded*	See Box 4.1.

	solid storage piles, manure settling basins, aerobic treatment, storage ponds, etc.				
	Emissions from support equipment	CO_2		*Included*	If any additional equipment is required by the project beyond what is required in the baseline, emissions from such equipment shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
5	Emissions from the anaerobic digester due to biogas collection inefficiencies and venting events	CH_4	P	*Included*	Project may result in leaked emissions from anaerobic digester.
6	Emissions from the effluent pond	CH_4	P	*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	See Box 4.1.
7	Emissions from land application	CH_4	B, P	*Excluded*	Project activity is unlikely to increase emissions relative to baseline activity.
		N_2O		*Excluded*	See Box 4.1.
	Vehicle emissions for land application and/or off-site transport	CO_2	B, P	*Included*	If any additional vehicle use is required by the project beyond what is required in the baseline, associated additional emissions shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
8	Emissions from combustion during flaring, including emissions from incomplete combustion of biogas	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
9	Emissions from combustion during electric generation, including incomplete combustion of biogas	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
10	Emissions from upgrading biogas for pipeline injection or use as CNG/LNG fuel	CO_2	P	*Included*	Emissions resulting from on-site fossil fuel use and/or grid electricity may be significant.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.

11	Emissions from combustion at boiler, including emissions from incomplete combustion of biogas	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
12	Emissions from combustion of biogas by end user of pipeline or CNG/LNG, including incomplete combustion	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
13	Delivery and use of project electricity to grid	CO_2	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas-generated electricity.
		CH_4			
		N_2O			
14	Off-site thermal energy or power	CO_2	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas delivered through pipeline or other end uses.
		CH_4			
		N_2O			
15	Use of project-generated thermal energy	CO_2	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas-generated thermal energy.
		CH_4			
		N_2O			
	Project construction and decommissioning emissions	CO_2	P	*Excluded*	Emission source is assumed to be very small.
		CH_4			
		N_2O			

5. Quantifying GHG Emission Reductions

GHG emission reductions from a livestock project are quantified by comparing actual project emissions to baseline emissions at the project site. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 0) that would have occurred in the absence of the livestock project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

GHG emission reductions are generally quantified and verified on an annual basis. Project developers may choose to quantify and verify GHG emission reductions on a more frequent or less frequent basis if they desire (see Section 7.3). The length of time over which GHG emission reductions are quantified and verified is called the "reporting period." The length of time over which GHG reductions are verified is called a "verification period." A verification period may cover multiple reporting periods (see Section 7.3.4). Project developers should take note that some equations to calculate baseline and project emissions are run on a month-by-month basis and activity data monitoring have varying levels of frequency. As applicable, monthly emissions data (for baseline and project) are summed together to calculate emission reductions.

The calculations provided in this protocol are derived from internationally accepted methodologies.[15] Project developers shall use the calculation methods provided in this protocol to determine baseline and project GHG emissions in order to quantify GHG emission reductions.

To support project developers and facilitate consistent and complete emissions reporting, the Reserve has developed an Excel based calculation tool. Instructions for obtaining the most recent version of this tool are available on the Dominican Republic Livestock Protocol Webpage. The Reserve *recommends* the use of the Dominican Republic Livestock Calculation Tool for all project calculations and emission reduction reports.[16] Only the most recent version of this tool should be used, unless otherwise recommended by Reserve staff. In any case where there is potential disagreement between guidance provided in the protocol and guidance provided in the calculation tool, the protocol shall take precedent.

The current methodology for quantifying the GHG impact associated with installing a biogas control system requires the use of both modeled reductions (following Equation 5.2 to Equation 5.4 and Equation 5.6 to Equation 5.9) as well as the utilization of *ex-post* metered data from the biogas control system to be used as a check on the modeled reductions.

The Reserve recognizes that there can be material differences between modeled methane emission reductions and the actual metered quantity of methane that is captured and destroyed by the biogas control system due to digester start-up periods, venting events, and other biogas control system operational issues. These operational issues have the potential to result in substantially less methane destruction than is modeled, leading to an overestimation of GHG reductions in the modeled case.

[15] The Reserve's GHG reduction calculation method is derived from the Kyoto Protocol's Clean Development Mechanism (ACM0010 V.5), the EPA's Climate Leaders Program (Manure Offset Protocol, August 2008), and the RGGI Model Rule (January 5, 2007).

[16] There are tools in other countries that are useful in supporting swine operations for estimating biogas production. However, actual GHG reductions should be calculated in accordance with the guidance of this Protocol.

To address this issue and maintain consistency with international best practice, the Reserve requires the modeled methane emission reduction results to be compared to the *ex-post* metered quantity of methane that is captured and destroyed by the biogas control system. The lesser of the two values will represent the total methane emission reductions for the reporting period. Equation 5.1 outlines the quantification approach for calculating the emission reductions from the installation of a biogas control system.[17]

5.1. Required Parameters for Modeling Baseline and Project Emissions

The following parameters must be determined for the modeling of baseline and project emissions:

Population – P_L

The procedure requires project developers to differentiate between livestock categories ('L') – e.g., lactating dairy cows, non-milking dairy cows, heifers, etc. This accounts for differences in methane generation across livestock categories. See Appendix B, Table B.2. The population of each livestock category is monitored on a monthly basis, and for Equation 5.4 averaged for an annual total population.

Volatile Solids – VS_L

This value represents the daily organic material in the manure for each livestock category and consists of both biodegradable and non-biodegradable fractions. The VS content of manure is a combination of excreted fecal material (the fraction of a livestock category's diet consumed and not digested) and urinary excretions, expressed in a dry matter weight basis (kg/animal).[18] This protocol requires that the VS value for all livestock categories be determined as outlined in Box 5.1.

$Mass_L$

This value is the annual average weight of the animals, per livestock category. Site specific livestock mass is preferred for all livestock categories. If site specific data is unavailable, Typical Average Mass (TAM) values can be used (Appendix B, Table B.2).

Maximum Methane Production – $B_{0,L}$

This value represents the maximum methane-producing capacity of the manure, differentiated by livestock category ('L') and diet. Project developers shall use the default B_0 factors from Appendix B, Table B.3. Alternatively, project developers may follow the sampling and testing procedure contained in Section **Error! Reference source not found.** in order to determine a s ite-specific B_0 value for a particular animal category.

MS

The MS value apportions manure from each livestock category to appropriate manure management system component ('S'). It reflects the reality that waste from the operation's livestock categories are not managed uniformly. The MS value accounts for the operation's multiple types of manure management systems. It is expressed as a percent (%), relative to the

[17] The calculation procedure only addresses direct emissions sources and does not incorporate changes in electricity consumption, which impacts indirect emissions associated with power plants owned and operated by entities other than the livestock operator.
[18] IPCC 2006 Guidelines volume 4, chapter 10, p. 10.42.

total amount of waste produced by the livestock category. As waste production is normalized for each livestock category, the percentage should be calculated as percent of population for each livestock category. For example, a dairy operation might send 85% of its milking cows waste to an anaerobic lagoon and 15% could be deposited in a corral. In this situation an MS value of 85% would be assigned to Equation 5.3 and 15% to Equation 5.4.

Importantly, the MS value indicates where the waste would have been managed in the baseline scenario.

Methane Conversion Factor – MCF

Each manure management system component has a volatile solids-to-methane conversion efficiency, which represents the degree to which maximum methane production (B_0) is achieved. Methane production is a function of the extent of anaerobic conditions present in the system, the temperature of the system, and the retention time of organic material in the system.[19]

According to this protocol, for anaerobic lagoons, storage ponds, liquid slurry tanks etc., project developers perform a site-specific calculation of the mass of volatile solids degraded by the anaerobic storage/treatment system. This is expressed as "degraded volatile solids" or "VS_{deg}" in Equation 5.3, which equals the system's monthly available volatile solids multiplied by the van't Hoff-Arrhenius (*f*) factor. The '*f*' factor effectively converts total available volatile solids in the anaerobic manure storage/treatment system to methane-convertible volatile solids, based on the monthly temperature of the system.

The multiplication of "VS_{deg}" by "B_0" gives a site-specific quantification of the uncontrolled methane emissions that would have occurred in the absence of a digester – from the anaerobic storage and/or treatment system, taking into account each livestock category's contribution of manure to that system.

This method to calculate methane emissions reflects the site-specific monthly biological performance of the operation's anaerobic manure handling systems that existed pre-project, as predicted by the van't Hoff-Arrhenius equation using farm-level data on temperature, VS loading, and system VS retention time.[20]

Default MCF values for non-anaerobic manure storage/treatment are available in Appendix B, Table B.4, which are used for Equation 5.4.

[19] IPCC 2006 Guidelines volume 4, chapter 10, p. 10.43.
[20] The method is derived from Mangino et al., "Development of a Methane Conversion Factor to Estimate Emissions from Animal Waste Lagoons"

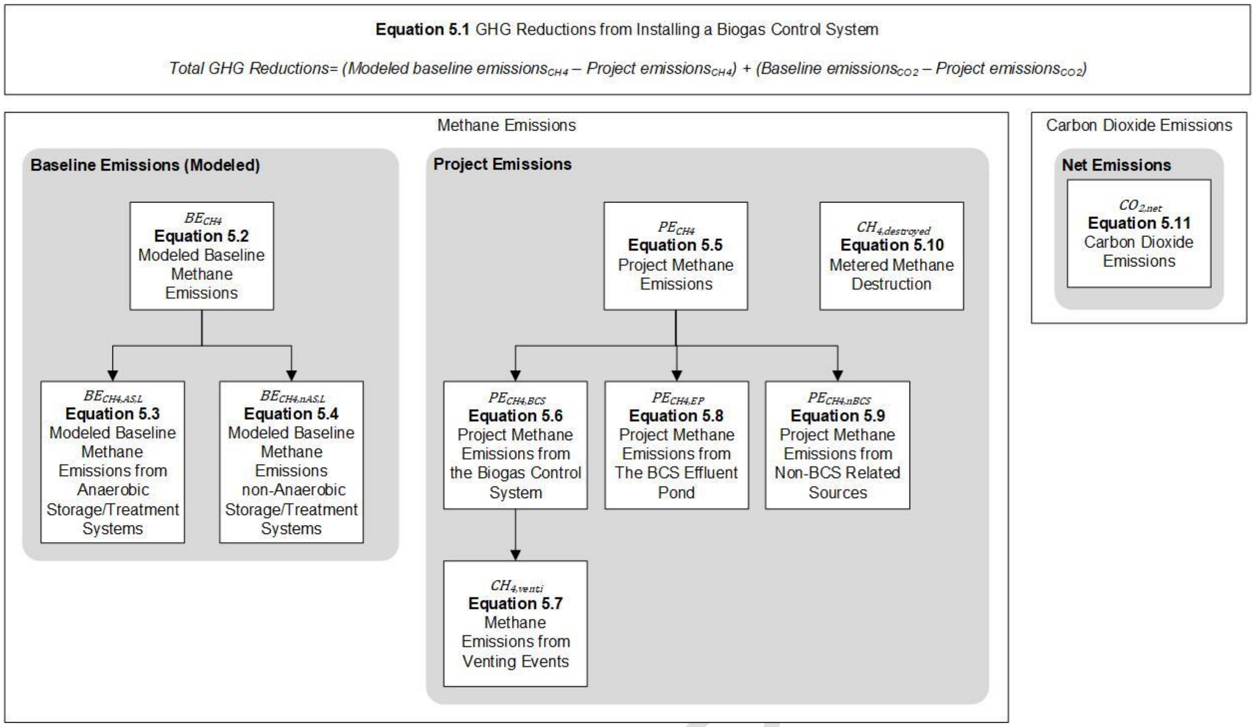


Figure 5.1. Organizational Chart for Equations in Section 5

Equation 5.1. GHG Reductions from Installing a Biogas Control System

Total GHG Reductions = *(Modeled baseline emissions* $_{CH4}$ *– Project emissions* $_{CH4}$*)* + *(Baseline emissions* $_{CO2}$ *– Project emissions* $_{CO2}$*)*

The (*Modeled baseline emissions* $_{CH4}$ – *Project emissions* $_{CH4}$) term shall be calculated according to Equation 5.2 to Equation 5.4 and Equation 5.6 to Equation 5.9. The resulting aggregated quantity of methane reductions must then be compared to the *ex-post* quantity of methane that is metered and destroyed in the biogas collection system, as expressed in Equation 5.10. In the case that the total *ex-post* quantity of metered and destroyed methane is less than the modeled methane reductions, the metered quantity of destroyed methane will replace the modeled methane reductions.

Therefore, the above equation then becomes:

Total GHG Reductions = *(Total quantity of metered and destroyed methane)* + *(Baseline emissions* $_{CO2}$ *– Project emissions* $_{CO2}$*)*

5.2. Modeling Baseline Methane Emissions

Baseline emissions represent the GHG emissions within the GHG Assessment Boundary that would have occurred if not for the installation of the biogas control system.[21] For the purposes of this protocol, project developers calculate their baseline emissions according to the manure management system in place prior to installing the biogas control system. This is referred to as a "continuation of current practices" baseline scenario. Additionally, project developers calculate baseline emissions each year of the project.[22] The procedure assumes there is no biogas control system in the baseline system. Regarding new livestock operations that install a biogas control system, project developers establish a modeled baseline scenario using the prevailing system type in use for the geographic area, animal type, and farm size that corresponds to their operation.

The procedure to determine the modeled baseline methane emissions follows Equation 5.2, which combines Equation 5.3 and Equation 5.4.

Equation 5.3 calculates methane emissions from anaerobic manure storage/treatment systems based on site-specific information on the mass of volatile solids degraded by the anaerobic storage/treatment system and available for methane conversion.[23] It incorporates the effects of temperature through the van't Hoff-Arrhenius (*f*) factor and accounts for the retention of volatile solids through the use of monthly assessments. Equation 5.4 is less intensive and applies to non-anaerobic storage/treatment systems. Both Equation 5.3 and Equation 5.4 reflect basic biological principles of methane production from available volatile solids, determine methane generation for each livestock category, and account for the extent to which the waste management system handles each category's manure.

Equation 5.2. Modeled Baseline Methane Emissions

$$BE_{CH_4} = (\sum_{S,L} BE_{CH_4,AS,L} + BE_{CH_4,non-AS,L} \quad)$$

[21] Emissions from anaerobic systems such as open lagoons or final disposal sites in the case of solid waste.
[22] Conversely, under a "static baseline," a project developer would assess baseline emissions once before project implementation and use that value throughout the project lifetime.
[23] Anaerobic storage/treatment systems generally refer to anaerobic lagoons, or storage ponds, etc.

Where,			Units
BE_{CH4}	=	Total annual baseline methane emissions, expressed in carbon dioxide equivalent	tCO_2e/yr
$BE_{CH4,AS,L}$	=	Total annual baseline methane emissions from anaerobic storage/treatment systems by livestock category 'L', expressed in carbon dioxide equivalent	tCO_2e/yr
$BE_{CH4,non\text{-}AS,L}$	=	Total annual baseline methane emissions from non-anaerobic storage/treatment systems, expressed in carbon dioxide equivalent	tCO_2e/yr

Equation 5.3. Modeled Baseline Methane Emissions from Anaerobic Storage/Treatment Systems

$$BE_{CH_4,AS,L} = \sum_{L,AS} VS_{deg,AS,L} \times B_{0,L} \times 0.717 \times 0.001 \times GWP$$

Where,			Units
$BE_{CH4,AS}$	=	Total annual baseline methane emissions from anaerobic manure storage/treatment systems, expressed in carbon dioxide equivalent	tCO_2e/yr
$VS_{deg,AS,L}$	=	Annual volatile solids degraded in anaerobic manure storage/treatment system 'AS' from livestock category 'L'	kg dry matter
$B_{0,L}$	=	Maximum methane producing capacity of manure for livestock category 'L' – Site specific values[24] or default values (Appendix B, Table B.3)	m^3 CH_4/kg of VS
0.717	=	Methane density conversion factor, m^3 to kg (at 0 °C and 1 atm pressure)[25]	
0.001	=	Conversion factor from kg to metric tons	
GWP	=	Global Warming Potential factor of methane to carbon dioxide equivalent[26]	

$$VS_{deg,AS,L} = \sum_{AS,L} VS_{avail,AS,L} \times f$$

Where,			Units
$VS_{deg,AS,L}$	=	Annual volatile solids degraded by anaerobic manure storage/ treatment system 'AS' by livestock category 'L'	kg dry matter
$VS_{avail,AS,L}$	=	Monthly volatile solids available for degradation from anaerobic manure storage/treatment system 'AS' by livestock category 'L'	kg dry matter
f	=	The van't Hoff-Arrhenius factor: "the proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system"[27]	

Equation 5.3. Continued

[24] B_0 for dairy cattle may be determined using site-specific data from the sampling and analysis methodology as defined in Section 6.1. However, default B_0 values are required for swine. See Appendix E for the development of the B_0 sampling and analysis methodology.
[25] These standard conditions refer to the International Union of Pure and Applied Technology (IUAPC). Methane density at the standard conditions of the National Institute of Standards and Technology (NIST), 20°C and 1 atm is 0.668 kg CH_4/m^3.
[26] Refer to section 2.6.1 in the Reserve Offset Program Manual and any policy memos for the most recent GWP value.
[27] Mangino et al.

$$VS_{avail,AS,L} = \left(VS_L \times P_L \times MS_{AS,L} \times dpm \times 0.8\right) + \left(VS_{avail-1,AS} - VS_{deg-1,AS}\right)$$

Where,

			Units
$VS_{avail,AS,L}$	=	Monthly volatile solids available for degradation in anaerobic storage/treatment system 'AS' by livestock category 'L'	kg dry matter
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis. *Important*: refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/day
P_L	=	Annual average population of livestock category 'L' (based on monthly population data)	
$MS_{AS,L}$	=	Percent of manure sent to (managed in) anaerobic manure storage/treatment system 'AS' from livestock category 'L'[28]	%
dpm	=	Days per month	days
0.8	=	System calibration factor[29]	
$VS_{avail-1,AS}$	=	Previous month's volatile solids available for degradation in anaerobic system 'AS'	kg
$VS_{deg-1,AS}$	=	Previous month's volatile solids degraded by anaerobic system 'AS'[30]	kg

$$f = exp\left[\frac{E(T_2 - T_1)}{RT_1T_2}\right]$$

Where,

			Units
f	=	The van't Hoff-Arrhenius factor	
E	=	Activation energy constant (15,175)	cal/mol
T_1	=	303.16	K
T_2	=	Monthly average ambient temperature (K = °C + 273). If T_2 < 5°C then *f* = 0.104 or if T_2 > 29.5°C then *f* = 0.95	K
R	=	Ideal gas constant (1.987)	cal/Kmol

[28] The MS value represents the percent of manure that would be sent to (managed by) the anaerobic manure storage/treatment systems in the baseline case – as if the biogas control system was never installed.

[29] Mangino, et al. This factor was derived to "account for management and design practices that result in the loss of volatile solids from the management system."

[30] The difference between VSavail-1 and VSdeg-1 represents VS retained in the system and not removed at month's end; thus VS could accumulate over time. However, project developers should not carry-over volatile solids from one month to the next after a system has been cleaned out, such as temporary storage ponds or tanks where the VS-retention time might be 30 days. For these systems project developers do not add "($VS_{avail-1}$ – VS_{deg-1})."

Equation 5.4. Modeled Baseline Methane for Non-Anaerobic Storage/Treatment Systems

$$BE_{CH_4,nAS} = \left(\sum_{L,S} P_L \times MS_{L,nAS} \times VS_L \times 365 \times MCF_{nAS} \times B_{0,L}\right) \times 0.717 \times 0.001 \times GWP$$

Where,

			Units
$BE_{CH4,nAS}$	=	Total annual baseline methane emissions from non-anaerobic storage/treatment systems, expressed in carbon dioxide equivalent	tCO_2e/yr
P_L	=	Annual average population of livestock category 'L' (based on monthly population data)	
$MS_{L,nAS}$	=	Percent of manure from livestock category 'L' managed in non-anaerobic storage/treatment systems	%
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis. *Important*: refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/ day
365	=	Days in a year	days
MCF_{nAS}	=	Methane conversion factor for non-anaerobic storage/treatment system 'S' – Appendix B, Table B.4	%
$B_{0,L}$	=	Maximum methane producing capacity for manure for livestock category 'L' – Site specific value or default factor (see Appendix B, Table B.3)	m^3 CH_4/kg of VS dry matter
0.717	=	Methane density conversion factor, m^3 to kg (at 0°C and 1 atm pressure)	
0.001	=	Conversion factor from kg to metric tons	
GWP	=	Global Warming Potential factor of methane to carbon dioxide equivalent	

Box 5.1. Daily Volatile Solids for All Livestock Categories

VS_L values for all livestock can be found in Appendix B, Table B.3.

Important: Units provided for all VS values in Appendix B are based on specific values for the Dominican Republic and default values from the IPCC guidelines. According to the CDM methodology ACM0010, it is recommended to adjust the VS values according to site-specific animal mass data, using the following equation:

$$VS_L = VS_{table} \cdot \left(\frac{Mass_L}{MTP_L}\right)$$

Where,

			Units
VS_L	=	Volatile solid excretion on a dry matter weight basis	kg/animal/day
VS_{Table}	=	Volatile solid excretion from lookup Table B.3	kg/animal/day
$Mass_L$	=	Average animal mass for livestock category 'L'. If site specific data is unavailable, use values from Appendix B, Table B.2	kg
MTP_L	=	Average animal mass from lookup Table B.2	kg

5.3. Calculating Project Methane Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary after the installation of the biogas control system. Project emissions are calculated on an annual, *ex-post* basis. But like baseline emissions, some parameters are monitored on a monthly basis. Methane emissions from manure storage and/or treatment systems other than the digester are modeled much the same as in the baseline scenario.

5.3.1 Modeled Methane Destruction

As shown in Equation 5.5, project methane emissions equal:

- The amount of methane from waste treatment and storage not captured and destroyed by the control system, plus
- Methane from the digester effluent storage pond (if necessary), plus
- Methane from sources in the waste treatment and storage category other than the biogas control system and associated effluent pond. This includes all other manure treatment systems such as compost piles, solids storage, daily spread, etc.

Consistent with ACM0010 and this protocol's baseline methane calculation approach, the formula to account for project methane emissions incorporates all potential sources within the waste treatment and storage category. Non-biogas control system-related sources follow the same calculation approach as provided in the baseline methane equations. Several activity data for the variables in Equation 5.9 will be the same as those in Equation 5.2 to Equation 5.4.

Although not common under normal digester operation, it is possible that a venting event may occur due to catastrophic failure of digester cover materials, the digester vessel, or the gas collection system. In the event that a catastrophic system failure results in the venting of biogas, the quantity of methane released to the atmosphere shall be estimated according to Equation 5.7 below.

Equation 5.5. Project Methane Emissions

$$PE_{CH_4} = \left[\left(PE_{CH_4,BCS} + PE_{CH_4,EP} + PE_{CH_4,non-BCS}\right) \times GWP\right]$$

Where,			Units
PE_{CH4}	=	Total annual project methane emissions, expressed in carbon dioxide equivalent	tCO_2e/yr
$PE_{CH4,\ BCS}$	=	Annual methane emissions from the BCS – Equation 5.6	tCH_4/yr
$PE_{CH4,\ EP}$	=	Annual methane emissions from the BCS effluent pond – Equation 5.8	tCH_4/yr
$PE_{CH4,\ non\text{-}BCS}$	=	Annual methane emissions from sources in the waste treatment and storage category other than the BCS and associated effluent pond – Equation 5.9	tCH_4/yr
GWP	=	Global Warming Potential factor of methane to carbon dioxide equivalent	

Equation 5.6. Project Methane Emissions from the Biogas Control System

$$PE_{CH_4,BCS} = \left[\left(\mathrm{CH}_{4,\mathrm{meter}}\right)\left(\left(\frac{1}{BCE}\right) - BDE_{i,weighted}\right)\right] + CH_{4,vent,i}$$

Where, Units

$PE_{CH4, BCS}$	=	Monthly methane emissions from the BCS, to be aggregated annually	tCH_4/yr
$CH_{4,meter}$	=	The monthly quantity of methane collected and metered	tCH_4/month
BCE	=	Monthly methane collection efficiency of the BCS. The default value is 85% [31]	% (as a decimal)
$BDE_{i,weighted}$	=	Monthly weighted average of all destruction devices used in month i	% (as a decimal)
$CH_{4,vent,i}$	=	The monthly quantity of methane that is vented to the atmosphere due to BCS venting events, as quantified in Equation 5.7 below	

$$CH_{4,meter} = F \times (273.15/T)^{*} \times (P/1)^{*} \times CH_{4,conc} \times 0.717 \times 0.001$$

Where, Units

$CH_{4,meter}$	=	The monthly quantity of methane collected and metered[32]	tCH_4/month
F	=	Measured volumetric flow of biogas per month	m^3/month
T	=	Temperature of the biogas flow (K = °C + 273.15)	K
P	=	Pressure of the biogas flow	atm
$CH_{4,conc}$	=	Measured methane concentration of biogas from the most recent methane concentration measurement	% (as a decimal)
0.717	=	Density of methane gas at STP (1 atm, 0°C)	$kgCH_4/m^3$
0.001	=	Conversion factor, kg to metric tons	

Equation 5.6. Continued

* The terms (273.15/T) and (P/1), above, should be omitted if the continuous flow meter automatically corrects for temperature and pressure.

$$BDE_{i,weighted} = \frac{\sum_{DD}\left(BDE_{DD} \times F_{i,DD}\right)}{F_i}$$

Where, Units

$BDE_{i,weighted}$	=	Monthly weighted average of all destruction devices used in month i	fraction
BDE_{DD}	=	Default methane destruction efficiency of a particular destruction device 'DD'. See Appendix B for default destruction efficiencies by destruction device[33]	
$F_{i,DD}$	=	Monthly flow of biogas to a particular destruction device 'DD'	m^3
F_i	=	Total monthly measured volumetric flow of biogas to all destruction devices	m^3

31 Project developers have the option to justify a higher BCS collection efficiency based on verifiable documentation.
32 This value reflects directly measured biogas mass flow and methane concentration in the biogas to the combustion device.
33 Project developers have the option of using either the default methane destruction efficiencies provided or the site-specific methane destruction efficiencies as provided by an accredited state or local agency providing testing services of origin, for each of the combustion devices used in the project. If neither the province, nor the municipality nor the district relevant to the project site offer an accreditation for proof of origin providers, an accredited service provider from another state or municipality may be chosen. Alternatively, projects may choose a non-accredited service provider, under the following conditions: 1) The service provider must provide verifiable evidence of prior testing that it has been accepted into compliance by a domestic regulatory agency, and 2) the prior testing procedures must be substantially similar to the procedures used to determine the methane destruction efficiency for the project destruction device(s).

Equation 5.7. Methane Emissions from Venting Events

$$CH_{4,vent,i} = \left(MS_{BCS} + (F_{pw} \times t)\right) \times CH_{4,conc} \times 0.04230 \times 0.000454$$

Where,			<u>Units</u>
MS_{BCS}	=	Maximum biogas storage of the BCS system[34]	m^3
F_{pw}	=	The average total flow of biogas from the digester for the entire week prior to the venting event[34]	m^3/day
t	=	The number of days of the month that biogas is venting uncontrolled from the BCS system (can be a fraction)	days

[34] If the BCS consists of multiple digester tanks or covered lagoons, the project only need quantify the maximum storage (MS_{BCS}) and biogas flow (F_{pw}) of the component(s) of the BCS that experienced the venting event.

Equation 5.8. Project Methane Emissions from the BCS Effluent Pond[35]

$$PE_{CH_4,EP} = VS_{ep} \times B_{o,ep} \times 365 \times 0.717 \times MCFep \times 0.001$$

Where,			Units
$PE_{CH4,EP}$	=	Methane emissions from the effluent pond	tCH_4/year
VS_{ep}	=	Volatile solid to effluent pond – 30% of the average daily VS entering the digester[36]	kg/day
$B_{o,ep}$	=	Maximum methane producing capacity (of VS dry matter)[37]	m^3CH_4/kg
365	=	Number of days in a year	days
0.717	=	Conversion factor for m^3 to kg	
MCF_{ep}	=	Methane conversion factor	%
0.001	=	Conversion factor from kg to metric tons	

$$VS_{ep} = \left(\sum_L (VS_L \times P_L \times MS_{L,BCS}) \right) \times 0.3$$

Where,			Units
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis. *Important:* refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/day
P_L	=	Annual average population of livestock category 'L' (based on monthly population data)	
$MS_{L,BCS}$	=	Percent of manure from livestock category 'L' that is managed in the biogas control system	%
0.3	=	Default value representing the amount of VS that exit the digester as a percentage of the VS entering the digester	

If the effluent from the project digester is directed to an open effluent pond, project developers should use the liquid slurry MCF value for uncovered effluent ponds from Appendix B, Table B.4. If the effluent from the project digester is directed to a covered liquid effluent storage system, and the biogas from this storage system is not collected and destroyed, then the following scenarios apply:

1. If the effluent from this system is applied directly to land, the value of $PECH_{4,EP}$ shall be equal to the quantity of methane released directly from this storage system, divided by the biogas collection efficiency (BCE). The monitoring of biogas flow and methane concentration shall follow the requirements of Section 6. For any periods where biogas data from this system are missing or not in conformance with Section 6, Equation 5.8 shall be used to determine the quantity of methane for those periods, applying a value of 1.0 for MCF_{ep}.
2. If the effluent from the covered liquid effluent storage system is directed to another treatment system (i.e., not land-applied), the additional methane released from this

[35] If there is no effluent pond and project developers send digester effluent (VS) to compost piles or apply it directly to land, then VS should also be tracked for these cases using Equation 5.9. Methane emissions from land application manure disposal are not included in the evolution of the greenhouse gas limit for livestock projects, nor in the baseline, or project scenario. However, if the effluent is transported off the project site for application elsewhere, the fossil fuels associated with this transport must be quantified as project emissions (Equation 5.11).
[38] According to the ACM0010 methodology.
[39] The B_o value for the project effluent pond is not differentiated by livestock category. Project developers shall use the B_o value that corresponds with a weighted average of the operation's livestock categories that contributes manure to the biogas control system. Supporting laboratory data and documentation per Section 6.1, need to be supplied to the verifier to justify the alternative value.

further treatment must be quantified. The following adapted version of Formula 1 shall be applied to determine the MCF value for a covered liquid effluent storage system in this case. Use of this formula requires that the biogas production of the covered liquid effluent storage system be metered. If the biogas from this system is not metered, the value of MCF_{ep} shall be 1.0. For any periods when biogas from this system is not metered, the value of MCF_{ep} shall be 1.0, and these periods shall be quantified separately from the formula 1 in Appendix B.

Equation 5.9. Project Methane Emissions from *Non*-Biogas Control System Related Sources[38]

$$PE_{CH_4,nBCS} = \left(\sum_{L}(EF_{CH_4,L}\ (nBCSs) \times P_L)\right) \times 0.001$$

Where,

			Units
$PE_{CH4,\ nBCS}$	=	Methane from sources in the waste treatment and storage category other than the biogas control system and associated effluent pond	tCH_4/yr
$EF_{CH4,L}$ (nBCSs)	=	Emission factor for the livestock population from non-BCS-related sources (calculated below)	$kgCH_4$/head/year
P_L	=	Population of livestock category 'L'	
0.001	=	Conversion factor from kg to metric tons	

$$EF_{CH_4,L}(nBCSs) = (VS_L \times B_{o,L} \times 365 \times 0.717) \times \left(\sum_{S}(MCF_S \times MS_{L,S})\right)$$

Where,

			Units
$EF_{CH4,L}$ (nBCSs)	=	Methane emission factor for the livestock population from non-biogas control system related sources	$kgCH_4$/head/year
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis. *Important*: refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/day
$B_{o,L}$	=	Maximum methane producing capacity for manure for livestock category 'L' – Appendix B, Table B.3	m^3 CH_4/kg of VS dry matter
365	=	Number of days in a year	days
0.717	=	Conversion factor for m^3 to kg	
MCF_S	=	Methane conversion factor for system component 'S' – Appendix B, Table B.4	%
$MS_{L,S}$	=	Percent of manure from livestock category L that is managed in non-BCS system component 'S'	%

5.3.2 Metered Methane Destruction Comparison

As described above, the Reserve requires all projects to compare the modeled methane emission reductions for the reporting period, as calculated in Equation 5.2 to Equation 5.4 and Equation 5.6 to Equation 5.9 above, with the actual metered amount of methane that is destroyed in the biogas control system over the same period. The lesser of the two values is to be used as the total methane emission reductions for the reporting period in question.

In order to calculate the metered methane reductions, the monthly quantity of biogas that is metered and destroyed by the biogas control system must be aggregated over the reporting period. In the event that a project developer is reporting reductions for a period of time that is less than a full year, the total modeled methane emission reductions would be aggregated over this time period and compared with the metered methane that is destroyed in the biogas control system over the same period of time. For example, if a project is reporting and verifying only 6 months of data, July to December for instance, then the modeled emission reductions over this 6 month period would be compared to the total metered biogas destroyed over the same six month period, and the lesser of the two values would be used as the total methane emission reduction quantity for this 6 month period.

[38] According to this protocol, non-BCS-related sources means manure management system components (system component 'S') other than the biogas control system and the BCS effluent pond (if used).

Equation 5.10. Metered Methane Destruction

$$CH_{4,destroyed} = \sum_{months} (CH_{4,meter} \times BDE) \times GWP$$

Where,			Units
$CH_{4,destroyed}$	=	The aggregated quantity of methane collected and destroyed during the reporting period	tCO_2e/yr
$CH_{4,meter}$	=	The monthly quantity of methane collected and metered. See Equation 5.6 for calculation guidance	$tCH_4/month$
$BDE_{i,weighted}$	=	Monthly weighted average of all destruction devices used in month i.[39] See Equation 5.6 for calculation guidance	% (as a decimal)
GWP	=	Global Warming Potential factor of methane to carbon dioxide equivalent	

5.3.3 Determining Methane Emission Reductions

If metered methane destruction ($CH_{4,destroyed}$) is less than modeled methane destruction (BE_{CH4} – PE_{CH4}) as calculated in Equation 5.2 to Equation 5.4 and Equation 5.6 to Equation 5.9 for the reporting period, then the methane emission reductions are equal to $CH_{4,destroyed}$. Otherwise, the methane emission reductions are equal to (BE_{CH4} – PE_{CH4}).

5.4 Calculating Baseline and Project Carbon Dioxide Emissions

Sources of carbon dioxide emissions associated with a project may include electricity use by pumps and equipment, fossil fuel generators used to power pumping systems or milking parlor equipment, tractors that operate in barns or freestalls, on-site manure hauling trucks, or vehicles that transport manure off-site. Per Table 4.1, the carbon dioxide emissions from any additional equipment, vehicles, or fuel use that is required by the project beyond what is required in the baseline shall be accounted for. In practice, project developers shall account for the emissions from any new electric- or fuel-powered equipment or vehicles purchased and installed/operated specifically for the purpose of implementing the project, as well as any additional fuel used by old or new vehicles to collect or transport waste.

Project developers may either use Equation 5.11 below to calculate the net change in carbon dioxide emissions, or, if they can demonstrate during verification that project carbon dioxide emissions are estimated to be equal to or less than 5% of the total baseline emissions, then the project developer may estimate baseline and project carbon dioxide emissions. If an estimation method is used, verifiers shall confirm based on professional judgment that project carbon dioxide emissions are equal to or less than 5% of the total baseline emissions based on documentation and the estimation methodology provided by the project developer. If emissions cannot be confirmed to be below 5%, then Equation 5.11 shall be used. Regardless of the method used, all estimates or calculations of anthropogenic carbon dioxide emissions within the GHG Assessment Boundary must be verified and included in emission reduction calculations.[40]

If calculations or estimates indicate that the project results in a net decrease in carbon dioxide emissions from grid-delivered electricity, mobile and stationary sources, then for quantification

[39] Project developers have the option to use either the default methane destruction efficiencies provided, or site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for each of the combustion devices used in the project.
[40] This is consistent with guidance in WRI's GHG Project Protocol regarding the treatment of significant secondary effects.

purposes the net change in these emissions must be specified as zero (i.e., $CO_{2,net}$ = 0 in Equation 5.11).

Equation 5.11 below calculates the net change in anthropogenic carbon dioxide emissions resulting from the project activity.

Equation 5.11. Carbon Dioxide Emission Calculations

$$CO_{2,net} = \left(BE_{CO_2MSC} - PE_{CO_2MSC}\right)$$

Where,

			Units
$CO_{2,net}$	=	Net change in anthropogenic carbon dioxide emissions from electricity consumption and mobile and stationary combustion sources resulting from project activity	tCO_2/yr
BE_{CO2MSC}	=	Total annual baseline carbon dioxide emissions from electricity consumption and mobile and stationary combustion sources (see equation below)	tCO_2/yr
PE_{CO2MSC}	=	Total annual project carbon dioxide emissions from electricity consumption and mobile and stationary combustion sources (see equation below)	tCO_2/yr

All electricity consumption and stationary and mobile combustion are calculated using the equation:

$$CO_{2,MSC} = \left(\sum_c QE_c \times EF_{CO_2,e}\right) + \left[\left(\sum_c QF_c \times EF_{CO_2,f}\right) \times 0.001\right]$$

Where,

			Units
$CO_{2\ MSC}$	=	Anthropogenic carbon dioxide emissions from electricity consumption and mobile and stationary combustion sources	tCO_2
QE_c*	=	Quantity of electricity consumed for each emission source ‘c’	MWh/yr
$EF_{CO2,e}$	=	CO_2 emission factor ‘e’ for electricity used[41]	tCO_2/MWh
$EF_{CO2,f}$	=	Fuel-specific emission factor ‘f’ – Appendix B, Table B.5	kg CO_2/GJ
QF_c	=	Quantity of fuel consumed for each mobile and stationary emission source ‘c’[42]	GJ/yr
0.001	=	Conversion factor from kg to metric tons	

* If total electricity being generated by project activities is ≥ the additional electricity consumption, then QE_c shall not be accounted for in the project emissions and shall be omitted from the equation above.

[41] The most recent annual emissions factor associated with power generation calculated by National Climate Change Council is available at https://cambioclimatico.gob.do/ and is equivalent to 0.6367 tons of CO_2 for each MWh/year.

[42] If the quantity of fuel consumed is given in mass (kg or tones) or volume (L or m^3) units, convert it into energy units by multiplying the fuel quantity by its net calorific value. Use the calorific value provided by the fuel supplier or a laboratory analysis, if it is not available use the net calorific values provided in Appendix B, Table B.6.

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 (below) will be collected and recorded.

At a minimum the Monitoring Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); the frequency of instrument field check and calibration activities; and the role of individuals performing each specific monitoring activity. The Monitoring Plan should include QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision.

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.5.3).

Project developers are responsible for monitoring the performance of the project and operating each component of the biogas collection and destruction system in a manner consistent with the manufacturer's recommendations.

6.1 Site-Specific Determination of Maximum Methane Potential (B_0)[43]

The determination of a site-specific value for maximum methane potential (B_0) is optional for manure from dairy facilities. Swine facilities must use the default values. For projects that choose this option for the quantification of emission reductions related to one or more manure streams being digested in the project's BCS, or the BCS effluent, the following criteria must be met in order to ensure accuracy and consistency of the site-specific B_0 values:

1. Manure samples for each eligible livestock category must be sampled prior to mixing with manure from other animal categories or any other waste streams. These samples shall be taken from the manure collection system, rather than from an individual animal.
    a. Scrape systems: Samples shall be collected from the freshly scraped manure.
    b. Flush systems: Samples shall be collected at the point that the flushed manure leaves the barn. Additional samples must be collected of the flush water prior to mixing with manure.
    c. BCS effluent: Samples shall be collected after the effluent has exited the digester and prior to any further treatment.

2. Sampling events shall occur during the time period between **[Month range with average or below average milk production in the jurisdiction]**, inclusive.
    a. Manure samples: For each eligible animal category, there shall be one single-day sampling event. A total of at least six samples of at least one-half liter each must be taken during the event. Samples shall be taken one to three hours apart, and all samples of the same type shall be combined (i.e., dairy cow manure samples

[43] Background information on the development of this section can be found in Appendix E

in one container). The composite sample shall be delivered to the testing laboratory as soon as possible following the collection of the final sample.[30]

b. Flush water samples: If the farm utilizes a flush system for manure collection, the flush water must be sampled prior to mixing with manure. Two samples of at least one liter shall be collected, one to three hours apart, during the manure sampling event. These samples shall be combined into one container and delivered to the testing laboratory as soon as possible.
c. Effluent samples: Two samples of at least one liter shall be collected, one to three hours apart, during the manure sampling event. These samples shall be combined into one container and delivered to the testing laboratory as soon as possible.[31]

3. All samples must be analyzed using a Biochemical Methane Potential (BMP) Assay procedure at an independent, third-party laboratory that is familiar and experienced with this test and ISO 11734.[32] The laboratory must be able to document at least three years of experience with the BMP assay, and must have procedures in place to maintain a consistent inoculum. The laboratory must maintain and follow a standard operating procedure that outlines the process used in undertaking BMP analysis at that laboratory, and which can be made available to the verifier upon request.

4. At least six test runs shall be conducted using material from the mixed manure sample (i.e., split the sample into two and test each in triplicate). Tests shall report the weight of VS for the sample (as kg of dry matter) as well as the volume of methane produced, in order to determine the maximum methane potential as m^3 CH_4/kg VS. If applicable, the flush water sample and effluent sample shall each be used for one test run in triplicate. The laboratory shall conduct an assay on the seed inoculum itself in order to control for its contribution to the methane potential of the manure samples. The laboratory shall also conduct a control assay with a substrate of known methane potential (such as glucose or cellulose) to verify correct procedures were followed and that the inoculum was viable. If the control assay differs from its established expected value by greater than 15%, all results from that batch of assays shall be discarded. Measurement of gas flow shall be corrected to standard temperature and pressure (0°C and 1 atm). Devices used to measure gas flow and methane content shall be properly installed and calibrated, such that they can provide results within +/- 5% accuracy.

5. After the manure sample has been analyzed, there should be at least six estimates for the methane potential. The site-specific value for B_0 shall equal the 90% lower confidence limit of all assay results. For flush systems, the mean methane potential of the flush water results must be subtracted from the calculated methane potential of the flushed manure sample. For BCS effluent, the mean methane potential of the test results shall be used for the quantification. Additional sampling and assays may be carried out, and will reduce uncertainty and result in a final value that is closer to the mean.

Site-specific B_0 values determined using this procedure shall be valid for the reporting period during which the sampling occurred. Projects may elect to determine a site-specific B_0 value for only a subset of the eligible manure streams and utilize default values for the remainder. The verifier must confirm that sampling procedures conform to this section and that the personnel responsible for the sampling are trained and competent.

6.2 Monitoring Requirements

The methane capture and control system must be monitored with measurement equipment that directly meters:

- The total flow of biogas, measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure, prior to delivery to the destruction device(s)
- The flow of biogas delivered to each destruction device,[44] measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure
- The fraction of methane in the biogas, measured with a continuous analyzer or, alternatively, with quarterly measurements
- Operational status of each destruction device (except as described below), measured and recorded at least hourly.

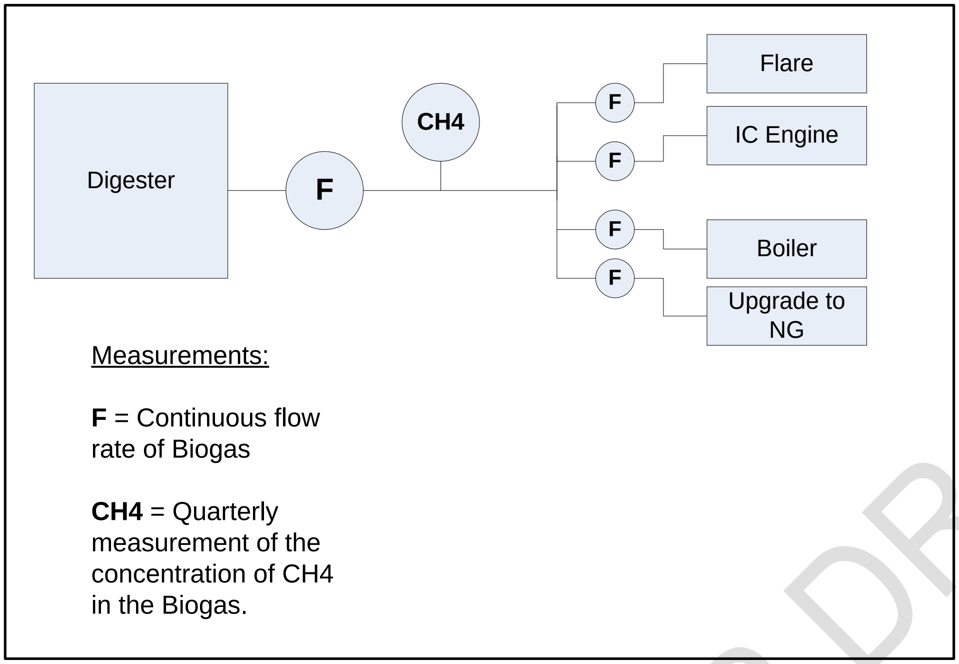
Flow data must be corrected for temperature and pressure at 0ºC and 1 atm, either internally or by following the guidance in Equation 5.6.

A single flow meter may be used to monitor the flow of gas to multiple destruction devices under certain conditions. If all destruction devices are of identical methane destruction efficiency (as described in Table B.7) and verified to be operational (i.e., there is recorded evidence of destruction), no additional steps are necessary for project registration. One example of this scenario would be a single meter used for a bank of multiple, identical engines that are in constant operation. If the destruction devices are not of identical efficiency, then the destruction efficiency of the least efficient device shall be applied to the flow data for this meter.
If there are any periods where the operational data show that one or more devices were not destroying methane, these periods are eligible for crediting, provided that the verifier can confirm all of the following conditions are met:

a. The destruction efficiency of the least efficient destruction device in operation shall be used as the destruction efficiency for all destruction devices monitored by this meter;
b. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and
c. For any period where one or more destruction device(s) within this arrangement is not operational, it must be documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period. For devices other than flares, it must be shown that the output corresponds to the flow of gas.

Note: The number of flow meters must be sufficient to track the total flow as well as the flow to each combustion device. The above scenario includes one more flow meter than would be necessary to achieve this objective.
Figure 6.1 represents the suggested arrangement of the biogas flow meters and methane concentration metering equipment.

[44] A single meter may be used for multiple, identical destruction devices. In this instance, methane destruction in these units will be eligible only if both units are monitored to be operational.



Note: The number of flow meters must be sufficient to track the total flow as well as the flow to each combustion device. The above scenario includes one more flow meter than would be necessary to achieve this objective.

Figure 6.1. Suggested Arrangement of Biogas Metering Equipment

Operational activity of the biogas collection system and the destruction devices shall be monitored and documented at least hourly to ensure actual methane destruction. GHG reductions will not be accounted for or credited during periods which the destruction device is not operational. This period is defined as the time between the flow reading preceding and following the outage. Alternatively, any destruction device equipped with a safety shut off device that prevents biogas flow to the destruction device when the destruction device is not operational does not require hourly monitoring, provided that the presence, operability, and use of the safety device are verified.

If for any reason the destruction device or the operational monitoring equipment (for example, the thermal coupler on the flare) is inoperable, then all metered biogas going to the particular device shall be assumed to be released to atmosphere during the period of inoperability. During the period of inoperability, the destruction efficiency of the device must be assumed to be zero. In Equation 5.6 the monthly destruction efficiency (BDE) value shall be adjusted accordingly. As an example, consider the primary destruction device to be an open flare with a BDE of 96% and it is found to be inoperable for a period of 5 days of a 30-day month. In this case the monthly BDE would be (0.96 x 25)/30 = 80%.

6.3 Biogas Measurement Instrument QA/QC

All gas flow meters[45] and continuous methane analyzers must be:

- Cleaned and inspected on a quarterly basis, with the activities performed and as found/as left condition of the equipment documented.

[45] Field checks and calibrations of flow meters shall assess the volumetric output of the flow meter.

- Field checked by an appropriately trained individual for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube)[46] or manufacturer specified guidance, at the end of but no more than two months prior to the end date of the reporting period.[47]
- Calibrated by the manufacturer or a certified calibration service per manufacturer's guidance or every 5 years, whichever is more frequent.

If a stationary meter that was in use for 60 days or more is removed and not reinstalled during a reporting period, that meter shall either be field-checked for calibration accuracy prior to removal or calibrated (with percent drift documented) by the manufacturer or a certified calibration service prior to quantification of emission reductions for that reporting period.

The as-found condition (percent drift) of a field check must be recorded. If a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that equipment.

For the interval between the last successful field check and any calibration event that confirms accuracy below the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check to the time the meter was correctly calibrated, unless the last event occurred during the prior reporting period, in which case adjustment is made back to the beginning of the current reporting period. If at the time of the failed field check, the meter is cleaned and checked again, with the as-left condition found to be within the accuracy threshold, a full calibration is not required for that piece of equipment. This shall be considered a failed field check followed by a successful field check. The data adjustment shall be based on the percent drift recorded at the time of the failed field check. However, if the as-left condition remains outside of the +/- 5% threshold (whether or not additional cleaning and accuracy testing occurs), calibration by the manufacturer or a certified service provider is required for that piece of equipment.

For calibrations that include meter confirmation of accuracy outside of a +/- 5% threshold, the project developer must estimate total emission reductions using i) uncorrected measured values, and ii) measured values adjusted for the largest recorded movement of the calibration at this time. The more conservative value of the two emissions estimates is reported as the reduced emissions estimate.

For example, if a project conducts field checks quarterly during a year-long reporting period, then only three months of data will be subject at any one time to the penalties above. However, if the project developer feels confident that the meter does not require field checks or calibration on a greater than annual basis, then failed events will accordingly require the penalty to be applied to the entire year's data. Further, frequent calibration may minimize the total accrued drift (by zeroing out any error identified), and result in smaller overall deductions.

[46] It is recommended that a professional third party calibration service be hired to perform flow meter field checks if using pitot tubes or other portable instruments, as these types of devices require professional training in order to achieve accurate readings.
[47] Instead of performing field checks, the project developer may instead have equipment calibrated by the manufacturer or a certified calibration service per manufacturer's guidance, at the end of but no more than two months prior to the end date of the reporting period to meet this requirement.

In order to provide flexibility in verification, data monitored up to two months after a field check may be verified. As such, the end date of the reporting period must be no more than two months after the latest successful field check.

If a portable instrument is used, such as a handheld methane analyzer, the portable instrument shall be calibrated at least annually by the manufacturer or at an ISO 17025 accredited laboratory.

6.3.1 Missing Data

In situations where the flow rate or methane concentration monitoring equipment is missing data, the project developer shall apply the data substitution methodology provided in Appendix D. This methodology may also be used for periods where the project developer can show that the data are available but known to be corrupted (and where this corruption can be verified with reasonable assurance). If for any reason the monitoring equipment on any given destruction device is inoperable (for example, the thermocouple on the flare) or the presence and operability of the safety shut off valve cannot be verified, then the destruction efficiency of that device must be assumed to be zero. For periods when it is not possible to use data substitution to fill data gaps, no emission reductions may be claimed. The methane flow volume for these days shall be zero, and the number of reporting days for that month shall be reduced to exclude the days of missing data.

During any period where the project is not claiming emission reduction credits and is not classifying the period as a venting event, the project developer must be able to demonstrate that project emissions were not greater than baseline emissions.

6.4 Monitoring Parameters

Provisions for monitoring other variables to calculate baseline and project emissions are provided in
Table **6.1**. The parameters are organized by general project factors then by the calculation methods.

Table 6.1. Project Monitoring Parameters

Parameter	Description	Data unit	calculated (c) measured (m) reference(r) operating records (o)	Measurement frequency	Comment
General Project Parameters					
Regulations	Project developer attestation to compliance with regulatory requirements relating to the manure digester project	All applicable regulations	n/a	Annually	Information used for: 1) Demonstrate the ability to comply with the Regulatory Test – when the regulation requires the installation of a biogas system. 2) Demonstrate compliance with associated environmental regulations, for example, effluent discharge limits and criteria pollutants. Verifier: Determine the regulatory agencies in charge of regulating the cattle operation; review regulations and permits corresponding to the cattle operation.
L	Type of livestock categories on the farm	Livestock categories	o	Monthly	Select from list provided in Appendix B, Table B.2. *Verifier:* Review herd management software; Conduct site visit; Interview operator.
MS_L	Fraction of manure from each livestock category managed in the baseline waste handling system ‘S’	Percent (%)	o	Every reporting period	Reflects the percent of waste handled by the system components ‘S’ pre-project. Applicable to the entire operation. Within each livestock category, the sum of MS values (for all treatment/storage systems) equals 100%. Select from list provided in Appendix B, Table B.1. *Verifier:* Conduct site visit; Interview operator; Review baseline scenario documentation.
P_L	Average number of animals for each livestock category	Population (# head)	o	Monthly	*Verifier:* Review the cattle management software or record; Review submissions of water or air quality reports, if reported to local, state, or federal authorities.

Parameter	Description	Data unit	calculated (c) measured (m) reference(r) operating records (o)	Measurement frequency	Comment
$Mass_L$	Average animal mass by livestock category	kg	o,r	Monthly	From operating records, or if onsite data is unavailable, from lookup table (Appendix B, Table B.2). *Verifier*: Conduct site visit; Interview livestock operator; Review average daily gain records, operating records.
T	Average monthly temperature at location of the operation	°C	m/o	Monthly	Used for van't Hoff Calculation and for choosing appropriate MCF value. *Verifier*: Review temperature records obtained from weather service.
Baseline Methane Calculation Variables					
$B_{0,L}$	Maximum methane producing capacity for manure by livestock category	(m^3 CH_4/kgVS)	r	Annually	From Appendix B, Table B.3. *Verifier*: Verify correct value from table used.
MCF_S	Methane conversion factor for manure management system component 'S'	Percent (%)	r	Annually	From Appendix B, Table B.4. Differentiate by livestock category *Verifier*: Verify correct value from table used.
VS_L	Daily volatile solid production	(kg/animal/day)	r,c	Every reporting period	Appendix B, Table B.3; see Box 5.1 for guidance on adjusting default values. *Verifier*: Ensure appropriate year's table is used; Review data units.
VS_{avail}	Monthly volatile solids available for degradation in each anaerobic storage system, for each livestock category	kg	c,o	Monthly	Calculated value from operating records. Recommend Reserve's Livestock Calculation Tool for all calculations. *Verifier*: Ensure proper use of Reserve's Livestock Calculation Tool; Review operating records.
VS_{deg}	Monthly volatile solids degraded in each anaerobic storage system, for each livestock category	kg	c,o	Monthly	Calculated value from operating records. Recommend Reserve's Livestock Calculation Tool for all calculations. *Verifier*: Ensure proper use of Reserve's Livestock Calculation Tool; Review operating records.

Parameter	Description	Data unit	calculated (c) measured (m) reference(r) operating records (o)	Measurement frequency	Comment
f	van't Hoff-Arrhenius factor	n/a	c	Monthly	The proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system. Recommend Reserve's Livestock Calculation Tool for all calculations. *Verifier*: Ensure proper use of Reserve's Livestock Calculation Tool; Review calculation; Review temperature data.
Project Methane Calculation Variables – BCS + Effluent Pond					
$CH_{4,\ destroyed}$	Aggregated amount of methane collected and destroyed in the biogas control system	Metric tons of CH_4	c,m	Every reporting period	Calculated as the collected methane times the destruction efficiency (see the '$CH_{4,meter}$' and 'BDE' parameters below). *Verifier:* Review meter reading data; Confirm proper operation of the destruction device(s); Ensure data is accurately aggregated over the correct amount of time.
$CH_{4,meter}$	Amount of methane collected and metered in biogas control system	Metric tons of CH_4 (tCH_4)	c,m	Monthly	Calculated from biogas flow and methane fraction meter readings (see 'F' and '$CH_{4,conc}$' parameters below). *Verifier*: Review meter reading data; Confirm proper operation, in accordance with the manufacturer's specifications; Confirm meter calibration data.
F	Monthly volume of biogas from digester to destruction devices	m^3/month	m	Continuously, aggregated monthly	Measured and recorded continuously from flow meter (every 15 minutes) or in an accumulated manner at least daily. Data to be aggregated monthly. *Verifier*: Review meter reading data; Confirm proper aggregation of data; Confirm proper operation in accordance with the manufacturer's specifications; Confirm meter calibration data.
T	Temperature of the biogas	°C	m	Continuously, averaged Monthly	Measured to normalize volume flow of biogas to STP (0ºC, 1 atm). No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing biogas volumes in normalized cubic meters.

Parameter	Description	Data unit	calculated (c) measured (m) reference(r) operating records (o)	Measurement frequency	Comment
P	Pressure of the biogas	atm	m	Continuously, averaged Monthly	Measured to normalize volume flow of biogas to STP (1 atm, 0ºC). No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing biogas volumes in normalized cubic meters.
$CH_{4,conc}$	Methane concentration of biogas	Percent (%)	m	Quarterly	Use a direct sampling approach that yields a value with at least 95% confidence. Samples to be taken at least quarterly. Calibrate monitoring instrument in accordance with the manufacturer's specifications. *Verifier*: Review meter reading data; Confirm proper operation, in accordance with the manufacturer's specifications.
BDE	Methane destruction efficiency of destruction device(s)	Percent (%)	r, c	Monthly	Reflects the actual efficiency of the system to destroy captured methane gas, accounts for different destruction devices (see guidance and default factors in Equation 5.6). *Verifier*: Confirm proper and continuous operation in accordance with the manufacturer's specifications.
BCE	Biogas capture efficiency of the anaerobic digester, accounts for gas leaks	Percent (%)	r	Every reporting period	Default value is 85%. Project developers may justify a higher BCE using verifiable evidence. *Verifier:* Review operation and maintenance records to ensure proper functionality of BCS; Assess claims that BCE is higher than default.
VS_{ep}	Average daily volatile solid of digester effluent to effluent pond	kg/day	c	Annually	If project uses effluent pond, equals 30% of the average daily VS entering the digester (from ACM0010 -V2 Annex I). *Verifier*: Review VS_{ep} calculations.
$MS_{L,BCS}$	Fraction of manure from each livestock category managed in the biogas control system	Percent (%)	o	Annually	Used to determine the total VS entering the digester. The percentage should be tracked in operational records. *Verifer*: Check operational records and conduct site visit.

Parameter	Description	Data unit	calculated (c) measured (m) reference(r) operating records (o)	Measurement frequency	Comment
$B_{0,ep}$	Maximum methane producing capacity for manure to effluent pond	(m^3 CH_4/ kgVS)	c	Annually	An average of the $B_{0,ep}$ value of the operation's livestock categories that contribute manure to the biogas control system. *Verifier:* Check calculation.
MCF_{ep}	Methane conversion factor for biogas control system effluent pond	Percent (%)	r	Annually	Appendix B, Table B.4, (from IPCC v.4, chapter 10, Table 10.17). Project developers should use the *liquid slurry* MCF value. *Verifier*: Verify value from table.
MS_{BCS}	The maximum biogas storage of the BCS system	m^3	r	Every reporting period	Obtained from digester system design plans. Necessary to quantify the release of methane to the atmosphere due to an uncontrolled venting event.
F_{pw}	The average flow of biogas from the digester for the entire week prior to the uncontrolled venting event	m^3/day	m	Weekly	The average flow of biogas can be determined from the daily records from the previous week.
t	The number of days of the month that biogas is venting uncontrolled from the project's BCS	Days	m, o	Monthly	The number of days of the month that biogas is venting uncontrolled from the project's BCS.
Project Methane Calculation Variables – Non-BCS Related Sources					
$MS_{L,S}$	Fraction of manure from each livestock category managed in non-anaerobic manure management system component 'S'	Percent (%)	o	Monthly	Based on configuration of manure management system, differentiated by livestock category. *Verifier*: Conduct site visit; Interview operator.
$EF_{CH4,L}$ (nBCSs)	Methane emission factor for the livestock population from non-BCS related sources	(kgCH_4/ head/year)	c	Annually	Emission factor for all non-BCS storage systems, differentiated by livestock category (see Equation 5.8). *Verifier*: Review calculation, operations records.
Baseline and Project CO_2 Calculation Variables					
$EF_{CO2,f}$	Fuel-specific emission factor for mobile and stationary combustion sources	kg CO_2/TJ	r	Annually	Refer to Appendix B, Table B.5 for emission factors. If biogas produced from digester is used as an energy source, the EF is zero. *Verifier*: Review emission factors.

Parameter	Description	Data unit	calculated (c) measured (m) reference(r) operating records (o)	Measurement frequency	Comment
QF_c	Quantity of fuel used for mobile/stationary combustion sources	TJ/year or lt/year or m^3/year	o,c	Annually	Fuel used by project for manure collection, transport, treatment/storage, and disposal, and stationary combustion sources including supplemental fossil fuels used in combustion device. *Verifer:* Review operating records and quantity calculation; Review calorific values.
$EF_{CO2,e}$	Emission factor for electricity used by project	tCO_2/MWh	r	Every reporting period	If biogas produced from digester is used to generate electricity consumed, the emission factor is zero. *Verifier*: Review emission factors.
QE_c	Quantity of electricity consumed	MWh/year	o, c	Every reporting period	Electricity used by project for manure collection, transport, treatment/storage, and disposal. *Verifier:* Review operating records and quantity calculation.

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit either a project monitoring report or a verified emission reduction reports to the Reserve annually at a minimum, depending on the verification option selected by the project developer.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to list a livestock project:

- Project Submittal form
- Pre-project diagram (not public)
- Project diagram (not public)

Project developers must provide the following documentation each verification period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Completed Calculation Tool (not public)
- Project diagram – only if there has been a change since the previous reporting period
- Project monitoring plan
- Verification Report
- Verification Statement
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of No Conflicts

The above project documentation will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project forms can be found at https://www.climateactionreserve.org/how/program-resources/documents/

7.2 Record Keeping

For purposes of independent verification and historical documentation, project developers shall be required to keep all information outlined in this protocol for a period of 10 years after the information is generated. This information will not be publicly available, but may be requested by the verifier or the Reserve.

Social and Environmental Safeguards:

- Documentation of the Free, Informed, and Prior Consent that was presented to the livestock operator and/or relevant participants at the project livestock operation site.
- Historical records and ongoing monitoring and reporting of safeguards through data logging of physical measurements, online sources, and government data.
- All other methods and procedures in place for the project to adhere to social and environmental safeguards requirements.

System Information:

- All data inputs for the calculation of the baseline emissions and project emission reductions
- CO_2e annual tonnage calculations
- Relevant sections of the biogas control system operating permits
- Executed Attestation of Title forms, Attestation of Regulatory Compliance forms, and Attestation of Voluntary Implementation forms
- Biogas control system information (installation dates, equipment list, etc.)
- Biogas flow meter information (model number, serial number, manufacturer's calibration procedures)
- Methane monitor information (model number, serial number, calibration procedures)
- Cleaning and inspection records for all biogas meters
- Field check results for all biogas meters
- Biogas flow data (for each flow meter)
- Biogas flow meter calibration data (for each flow meter)
- Biogas temperature and pressure readings (only if flow meter does not correct for temperature and pressure automatically)
- Methane concentration monitoring data
- Methane concentration monitor calibration data
- Destruction device monitoring data (for each destruction device)
- Destruction device, methane monitor and biogas flow monitor information (model numbers, serial numbers, calibration procedures)
- Initial and annual verification records and results
- All maintenance records relevant to the biogas control system, monitoring equipment, and destruction devices

If using a calibrated portable gas analyzer for CH_4 content measurement:

- Date, time, and location of methane measurement
- Methane content of biogas (% by volume) for each measurement
- Methane measurement instrument type and serial number
- Date, time, and results of instrument calibration
- Corrective measures taken if instrument does not meet performance specifications

7.3 Reporting Period and Verification Cycle

To provide flexibility and help manage verification costs associated with livestock projects, there are three verification options to choose from after a project's initial verification and registration.

Regardless of the option selected, project developers must report GHG reductions resulting from project activities during each reporting period. A "reporting period" is a period of time over which a project developer quantifies and reports GHG reductions to the Reserve. Under this protocol, the reporting period cannot exceed 12 months. A "verification period" is the period of time over which GHG reductions are verified. Under this protocol, a verification period may cover multiple reporting periods (see Section **Error! Reference source not found.**). The end d ate of any verification period must correspond to the end date of a reporting period.

A project developer may choose to utilize one option for the duration of a project's crediting period, or may choose different options at different points during a single crediting period. Regardless of the option selected, reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced.

7.3.1 Initial Reporting Period and Verification

The reporting period for projects undergoing initial verification and registration cannot exceed 12 months, and no more than 12 months of emission reductions can be verified during the initial verification. Once a project is registered and has had at least 3 months of emission reductions verified, the project developer may choose one of the verification options below.

7.3.2 Option 1: Twelve-Month Maximum Verification Period

Under this option, the verification period may not exceed 12 months. Verification with a site visit is required for CRT issuance. The project developer may choose to have a sub-annual verification period (e.g., quarterly or semi-annually).

7.3.3 Option 2: Twelve-Month Verification Period with Desktop Verification

Under this option, the verification period cannot exceed 12 months. However, CRTs may be issued upon successful completion of a desktop verification as long as: (1) a site-visit occurred in conjunction with the previous reporting period; (2) the current verification is being conducted by the same verification body that conducted the site visit for the previous verification; and (3) the verifier has confirmed that there have been no significant changes in data management systems, equipment, or personnel since the previous site visit. Desktop verifications must cover all other required verification activities.

Prior to a desktop verification commencing, the project developer must attest to the verifier that there have been no significant changes to the project's data management systems, project set up/equipment, or site personnel involved with the project since the last site-visit verification. For each verification period, the project developer must provide the following documentation for review by the verifier prior to the desktop verification commencing:

1. A schematic of system equipment and configuration, detailing any changes since the previous site visit, and any other supporting documentation for system or operation changes;
2. A list of personnel performing key functions related to project activities (personnel who manage and perform monitoring, measurement, and instrument QA/QC activities for the project), and documentation of any personnel or roles or changes since the pervious site visit; this shall include documented handover of personnel changes, including personnel change dates; and
3. The sections from the Monitoring Plan that summarize the data management systems and processes in place and a summary of any changes to the systems or processes since the previous site visit.

Desktop verifications are allowed only for a single 12-month verification period in between 12-month verification periods that are verified by a site visit. Sub-annual verification periods are not allowed under this option.

Taking into consideration the Reserve's policy that a verification body may provide verification services to a project for a maximum of six consecutive years (see the Verification Program Manual, Section 2.6 for more information), **Error! Reference source not found.** below details w hat the verification cycle might look under Option 2.

Table 7.1. Sample Verification Cycle under Option 2

Reporting Period	Verification Activity	Verification Body (VB)
Year 1 *(initial verification)*	Site-visit verification	VB A

Year 2	Desktop verification	VB A
Year 3	Site-visit verification	VB A
Year 4	Desktop verification	VB A
Year 5	Site-visit verification	VB A
Year 6	Desktop verification	VB A
Year 7	Site-visit verification	VB B *(new verification body)*
Year 8	Desktop verification	VB B

7.3.4 Option 3: Twenty-Four Month Maximum Verification Period

Under this option, the verification period cannot exceed 24 months and the project's monitoring plan and a project monitoring report must be submitted to the Reserve for the interim 12-month reporting period. The project monitoring plan and monitoring report must be submitted for projects that choose Option 3 to meet the annual documentation requirement of the Reserve program. They are meant to provide the Reserve with information and documentation on a project's operations and performance. They also demonstrate how the project's monitoring plan was met over the course of the first half of the verification period. They are submitted via the Reserve's online registry, but are not publicly available documents. A monitoring report template for livestock projects is available at https://www.climateactionreserve.org/how/program-resources/documents/. The monitoring plan and monitoring report shall be submitted within 30 days of the end of the reporting period.

Under this option, CRTs may be issued upon successful completion of a site-visit verification for GHG reductions achieved over a maximum of 24 months. CRTs will not be issued based on the Reserve's review of project monitoring plans/reports. Project developers may choose to have a verification period shorter than 24 months.

Taking into consideration the Reserve's policy that a verification body may provide verification services to a project for a maximum of six consecutive years (see the Verification Program Manual, Section 2.6 for more information), **Error! Reference source not found.** below details w hat the verification cycle might look under Option 3.

Table 7.2. Sample Verification Cycle under Option 3

Reporting Period	Verification Activity	Verification Body (VB)
Year 1 *(initial verification)*	Site-visit verification	VB A
Year 2	Project monitoring plan and report submitted to Reserve	n/a
Year 3	Site-visit verification for years 2 & 3	VB A
Year 4	Project monitoring plan and report submitted to Reserve	n/a
Year 5	Site-visit verification for years 4 & 5	VB A
Year 6	Project monitoring plan and report submitted to Reserve	n/a
Year 7	Site-visit verification for years 6 & 7	VB B *(new verification body)*
Year 8	Project monitoring plan and report submitted to Reserve	n/a

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with installing a biogas control system for manure management on dairy cattle and swine farms. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to livestock manure management projects.

Verification bodies trained to verify livestock projects must be familiar with the following documents:

- Reserve Program Manual
- Reserve Verification Program Manual
- Reserve Dominican Republic Livestock Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify livestock projects. Verification bodies approved under other Reserve or California Air Resources Board waste handling and methane destruction protocol types are also permitted to verify livestock projects in the Dominican Republic. Verification bodies and project developers should consider if the verification team has the necessary language capabilities to perform and complete verification activities. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org.

8.1 Standard of Verification

The Reserve's standard of verification for livestock projects is the Dominican Republic Livestock Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify a livestock project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.2 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Section 6 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm a livestock project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for livestock projects. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.1.

Table 8.1. Summary of Eligibility Criteria for a Livestock Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Projects must be submitted for listing within 6 months of the project start date	Once during first verification
Location	Dominican Republic	Once during first verification
Performance Standard	Installation of a biogas control system that captures and destroys methane gas from anaerobic manure treatment and/or storage facilities on livestock operations	Once during first verification
Anaerobic Baseline	Projects must demonstrate that the depth of the anaerobic lagoons or ponds prior to the project's implementation were sufficient to prevent algal oxygen production and create an oxygen-free bottom layer; which means at least 1 meter in depth	Once during first verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and additional documentation demonstrating that the project passes the Legal Requirement Test	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier, and monitoring; project must be in material compliance with all applicable laws	Every verification

8.4 Core Verification Activities

The Dominican Republic Livestock Project Protocol provides explicit requirements and guidance for quantifying the GHG reductions associated with installing a BCS to capture and destroy methane gas from livestock operations. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a livestock project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the SSRs identified for a project, such as energy use waste collection and transport, treatment and storage, and uncombusted methane from the biogas control system.

Reviewing GHG management systems and estimation methodologies

The verification body reviews and assesses the appropriateness of the methodologies and management systems that the livestock project operator uses to gather data and calculate baseline and project emissions.

Verifying emission reduction estimates

The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.5 Verification Period

Per Section 7.3, this protocol provides project developers three verification options for a project after its initial verification and registration in order to provide flexibility and help manage verification costs associated with livestock projects. The different options require verification bodies to confirm additional requirements specific to this protocol, and in some instances, to utilize professional judgment on the appropriateness of the option selected.

8.5.1 Option 1: Twelve-Month Maximum Verification Period

Option 1 does not require verification bodies to confirm any additional requirements beyond what is specified in the protocol.

8.5.2 Option 2: Twelve-Month Verification Period with Desktop Verification

Option 2 requires verification bodies to review the documentation specified in Section 0 in order to determine if a desktop verification is appropriate. The verifier shall use his/her professional judgment to assess any changes that have occurred related to a project's data management systems, equipment, or personnel and determine whether a site visit should be required as part of verification activities in order to provide a reasonable level of assurance on the project's verification. The documentation shall be reviewed prior to the COI/NOVA renewal being submitted to the Reserve, and the verification body shall provide a summary of its assessment and decision on the appropriateness of a desktop verification when submitting the COI/NOVA renewal. The Reserve reserves the right to review the documentation provided by the project developer and the decision made by the verification body on whether a desktop verification is appropriate.

8.5.3 Option 3: Twenty-Four Month Maximum Verification Period

Under Option 3 (see Section 7.3.4), verification bodies shall look to the project monitoring report submitted by the project developer to the Reserve for the interim 12 month reporting period as a resource to inform its planned verification activities. Verification bodies will need to provide a reasonable level of assurance about the accuracy of the monitoring report as part of the verification, the verification body shall list a summary of discrepancies between the monitoring report and what was ultimately verified in the List of Findings.

8.6 Livestock Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a livestock project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to livestock projects that must be addressed during verification.

8.6.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for livestock projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the verification period. If any requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.1	Verify that the project meets the definition of a livestock project	No
2.2	Verify ownership of the reductions by reviewing Attestation of Title and other relevant contracts, documentation	No
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that project is within its 10 year crediting period	No
3.4	Verify that all pre-project manure treatment lagoons/ponds/tanks were of sufficient depth to ensure an oxygen free bottom layer (> 1m)	Yes
3.4	If the project is a Greenfield project at a new livestock facility, verify that uncontrolled anaerobic treatment is common practice for the industry in the geographic region where the project is located	Yes
3.5.1	Verify that the project meets the Performance Standard Test	No
3.5.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.6	Verify that the project activities comply with applicable laws by reviewing instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
3.7	Verify that the project developer complied with the social and environmental safeguard. Confirm with the farm owner and/or landowner that the project developer conducted Informed, free, and prior consent requirements. Review that the Attestation of No Conflict was signed and submitted to the Reserve.	Yes
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that variance has been approved for monitoring variations	No
6	Verify that all gas flow meters and continuous methane analyzers adhered to the inspection, cleaning, and calibration schedule specified in the protocol. If they do not, verify that a variance has been approved for monitoring variations or that adjustments have been made to data per the protocol requirements	No
6	Verify that adjustments for failed calibrations were properly applied	No
6, Appendix D	If used, verify that data substitution methodology was properly applied	No

8.6.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for	No
5	Verify that the modeled baseline is compared with the total amount of methane metered and destroyed by the project, and the lesser of the two values is used as the baseline for the GHG reduction calculation	No
5.1	Verify that the livestock categories (L) are correctly differentiated	Yes
5.1	Verify that the project developer applied the correct VS and B_0 values for each livestock category	No
5.1	Verify that the fraction of manure (MS) handled by the different manure management system components (i.e., GHG source) is satisfactorily represented	Yes
5.1	Verify that the project developer used methane conversion factors (MCF) differentiated by temperature	No
5.1	Verify that the methane baseline emissions calculations for each livestock category were calculated according to the protocol with the appropriate data	No
5.1	Verify that the project developer correctly aggregated methane emissions from sources within each livestock category	Yes
5.4	Verify that the project developer correctly monitored, quantified and aggregated electricity use	Yes
5.2, 5.4	Verify that the project developer correctly monitored, quantified and aggregated fossil fuel use	Yes
5.2, 5.4	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
5.2	Verify that the project developer applied the correct methane destruction efficiencies	No
5.2	Verify that the project developer correctly quantified the amount of uncombusted methane	No
5.2	Verify that methane emissions resulting from any venting event are estimated correctly	Yes
5.2	Verify that the correct MCF factor was used for the effluent storage pond	No
5.2, 5.4	Verify that the project emissions calculations were calculated according to the protocol with the appropriate data	No
5.2, 5.1	Verify that the project developer assessed baseline and project emissions on a month-to-month basis	No
5.2	Verify that the project developer correctly monitored and quantified the amount of methane destroyed by the project	No
5.3	Verify that the modeled methane emission reductions are compared with the *ex-post* methane metered and destroyed by the project, and the lesser of the two values is used to quantify project emission reductions	No

8.6.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that the BCS was operated and maintained according to manufacturer specifications	No
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
7.2	Verify that all required records have been retained by the project developer	No

8.7 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Opinion, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Reserve to provide verification services for project developers.
Additionality	Manure management practices that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the carbon cycle (i.e., fossil fuel combustion, deforestation etc.).
Biogas	The mixture of gas (largely methane) produced as a result of the anaerobic decomposition of livestock manure.
Biogas control system (BCS)	A system designed to capture and destroy the biogas that is produced by the anaerobic treatment and/or storage of livestock manure and/or other organic material. Commonly referred to as a "digester."
Biogenic CO_2 emissions	CO_2 emissions resulting from the combustion and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the carbon cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
Clean Development Mechanism (CDM)	One of the three flexible mechanisms established by the Kyoto Protocol. CDM is the market instrument in which certified emission reductions can be achieved from a project developed in a "non-Annex I" country (developing country) with the assistance of an "Annex I" country (industrialized country). These reductions are accrued to the reduction commitment of the "Annex I" party (Art. 12 of the Kyoto Protocol) in the Kyoto Protocol's first commitment period (2008-2012).
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Emission factor	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).

Flare	A destruction device that uses an open flame to burn combustible gases with combustion air provided by uncontrolled ambient air around the flame.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Means carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Emissions that are a consequence of the actions of a reporting entity, but are produced by sources owned or controlled by another entity.
Livestock project	Installation of a biogas control system that, in operation, causes a decrease in GHG emissions from the baseline scenario through destruction of the methane component of biogas.
Metric ton (MT or tonne)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 28 (AR5), consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g., cars, trucks, tractors, dozers, etc.).
Nitrous oxide (N_2O)	A potent GHG with a GWP of 265 (AR5), consisting of two nitrogen atoms and a single oxygen atom.
Project baseline	A business-as-usual GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.

Project developer	An entity that undertakes a project activity, as identified in the Dominican Republic Livestock Project Protocol. A project developer may be an independent third party or the dairy/swine operating entity.
Reporting period	The period of time over which a project developer quantifies and reports GHG reductions to the Reserve. Under this protocol, the reporting period cannot exceed 12 months.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
van't Hoff-Arrhenius factor	The proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system.[48]
Verification	The process used to ensure that a given participant's greenhouse gas emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve accredited firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Verification period	The period of time over which GHG reductions are verified. Under this protocol, a verification period may cover multiple reporting periods (see Section **Error! Reference source not found.**). The end date of any verification period must correspond to the end date of a reporting period.

[48] Mangino, et al.

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Appendix A Associated Environmental Impacts

Manure management projects have many documented environmental benefits, including air emission reductions, water quality protection, and electricity generation. These benefits are the result of practices and technologies that are well managed, well implemented, and well designed. However, in cases where practices or technologies are poorly or improperly designed, implemented, and/or managed, local air and water quality could be compromised.

With regard to air quality, there are a number of factors that must be considered and addressed to realize the environmental benefits of a biogas project and reduce or avoid potential negative impacts. Uncontrolled emissions from combustion of biogas may contain between 200 to 300 ppm NOx. The anaerobic treatment process creates intermediates such as ammonia, hydrogen sulfide, orthophosphates, and various salts, all of which must be properly controlled or captured.

In addition, atmospheric releases at locations off-site where biogas is shipped may negate or decrease the benefit of emissions controls on-site. Thus, while devices such as Selective Catalyst Reduction (SCR) units can reduce NOx emissions and proper treatment system operation can control intermediates, improper design or operation may lead to violations of federal, state, and local air quality regulations as well as release of toxic air contaminants.

With regard to water quality, it is critical that project developers and managers ensure digester integrity and fully consider and address post-digestion management of the effluent in order to avoid contamination of local waterways and groundwater resources. Catastrophic digester failures; leakage from pipework and tanks; and lack of containment in waste storage areas are all examples of potential problems. Further, application of improperly treated digestate and/or improper application timing or rates of digestate to agricultural land may lead to increased nitrogen oxide emissions, soil contamination, and/or nutrient leaching, thus negating or reducing benefits of the project overall.

Project developers must not only follow the protocol to register GHG reductions with the Reserve, they must also comply with all local, state, and national air and water quality regulations. Projects must be designed and implemented to mitigate potential releases of pollutants such as those described, and project managers must acquire the appropriate local permits prior to installation to prevent violation of the law.

The Reserve agrees that GHG emission reduction projects should not undermine air and water quality efforts and will work with stakeholders to establish initiatives to meet both climate-related and localized environmental objectives.

A.1 Environmental Regulations in the Dominican Republic

Environmental legislation associated with livestock operations is framed by the "General Law on the Environment and Natural Resources 64-00" published in 2000. This law establishes that the companies or institutions that control wastewater management services in a locality, will be responsible for compliance with current standards and parameters regarding domestic wastewater discharges, or other types discharged through the municipal sewage system (Article 87), and wastewater can only be used after having been subjected to treatment processes that guarantee compliance with current regulations based on the use for which it is going to be destined according with Ministry of State for Public Health and Social Assistance (Article 89).

The following paragraphs summarize the current legislation regarding environmental protection in the Dominican Republic which may apply to biogas capture and use projects. Applicable legislations include the management of wastewater and its final disposal and noise generation regulations. Project developers are encouraged to periodically review each of the laws listed below in order to learn more about the regulations that apply to these projects.

The Environmental Regulation on Water Quality and Discharge Control is intended to protect and improve the quality of national water bodies, in compliance with the provisions of the General Law on Environment and Natural Resources (Law 64-00). The requirements are mandatory throughout the national territory for all natural or legal persons responsible for discharges of wastewater or liquid waste generated by industrial, commercial, agricultural, service, domestic, municipal, recreational and any other type of activities. This standard does not have a specific section for farms and establishment of the maximum permissible values for discharge parameters. However, as a reference, the maximum permissible values can be used for the animal slaughter and meat packaging sectors and the processing of meat and fish products:

Table A.1 Maximum permissible discharge values

	Daily average (mg/L), except pH	
Parameter	**Animal slaughter and meat packaging**	**Processing of meat and fish products**
pH	6-9	6-9
BOD_5	50	50
COD	150	250
TSS	50	50
Grease and oils	30	10

Source: The Environmental Regulation on Water Quality and Discharge Control

The Environmental Regulation on Groundwater Quality and Subsoil Discharges is intended to protect and improve the quality of national water bodies, in compliance with the provisions of the General Law on Environment and Natural Resources (Law 64-00). The requirements are mandatory throughout the national territory for all natural or legal persons responsible for discharges of wastewater or liquid waste generated by industrial, commercial, agricultural, service, domestic, municipal, recreational and any other type of activities.

To facilitate the implementation of this regulation, the Ministry for the Environment and Natural Resources classified the types of polluting sources and the different works for the subsurface disposal of wastewater into the following types (Art. 40):

- Type I Source: discharges related to substances with a high risk of toxicity, persistence, and bioaccumulation. It includes, for example, the organic compounds of tin, mercury, and cadmium, among others.
- Type II Source: discharges from activities and industries that do not contain substances considered of high risk of toxicity, persistence, and bioaccumulation.
- Type III Source: domestic wastewater discharges, which are subdivided into: 1) Those with wastewater production is less than or equal to 10 m^3/day; and 2) Those with residual productions greater than 10 m^3/day.
- Type IV Source: stormwater drainage.

In relation to the different options of works for the sub-surface disposal of wastewater, the following classification is made (Art. 41):

- Deep injection wells: wells used to inject hazardous waste (Type I) ensuring that groundwater and surface water are not put at risk.
- Systems with prior treatment: include treatment processes that guarantee compliance with the standards of the policy, followed by soil absorption works, such as: beds, trenches and/or filter wells, which are selected according to the specific characteristics of the place.
  Are required for discharges from Type II and Type III sources with flows greater than 10 m^3/day.
- Systems for individual households: domestic wastewater disposal systems with discharge flows equal to or less than 10 m^3/day made up of chambers or septic tanks that discharge into a filter well or other infiltration systems.
- Drainage wells: used to dispose of rainwater.

Sampling and methods will be governed by the latest edition of the Standard Methods for the Examination of Water and Wastewater, published by the American Public Health Association (APHA) (Art. 49). Each facility or project that generates discharges is responsible for their follow-up and control and must do so through operational reports to the Ministry that will be sent together with periodic follow-up reports to the Environmental Management and Adaptation Plan of installation, agreed (Art. 52).

The discharge into the subsoil of solid or viscous waste is prohibited, without the corresponding treatment and/or disposal facility, duly authorized, in compliance with current regulations for each case (Art. 69). These materials include, but are not limited to, the following: fats, animal tissues, manure, bones, hair, fur, blood, feathers, sand, sugars and their derivatives, bits of metal, glass, straw, grains, ashes, wastepaper, wood, plastic, asphalt waste, fuel or lubricating oil processing waste and, in general, solids larger than 1.5cm, in any of its dimensions. The dilution of effluents with external water to the process is prohibited as a treatment procedure (Art. 71).

The Environmental Standards for Air Quality and Emissions Control establish permissible limits for nine pollutants, however, do not include methane. This Standard establishes the maximum permissible concentration values for pollutants, with the purpose of protecting the population health. It is applied throughout the national territory taking into account the meteorological and topographic conditions of each region.

The air quality standards include permissible limits for nine pollutants: total suspended particles, particulate fraction (PM-10 and PM-2.5), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), hydrocarbons (non-methane) and lead (Pb).

Transgressions or violations of the provisions of this Policy may be penalized through the administrative and/or judicial mechanisms set forth in the General Law on the Environment and Natural Resources (Law 64-00), and its regulations.

The analysis of regulations provided above should not be seen as a complete list of regulations. The project's monitoring plan shall include procedures that the project developer will follow to ascertain and demonstrate that the project is in compliance with regulations at all times.

Appendix B Emission Factor Tables

Table B.1. Manure Management System Components

System	Definition
Pasture/Range/ Paddock	The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.
Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.
Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.
Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year.
Uncovered anaerobic lagoon	A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.
Pit storage below animal confinements	Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year.
Anaerobic digester	Animal excreta with or without straw are collected and anaerobically digested in a large containment vessel or covered lagoon. Digesters are designed and operated for waste stabilization by the microbial reduction of complex organic compounds to CO_2 and CH_4, which is captured and flared or used as a fuel.
Burned for fuel	The dung and urine are excreted on fields. The sun dried dung cakes are burned for fuel.
Cattle and Swine deep bedding	As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system also is known as a bedded pack manure management system and may be combined with a dry lot or pasture.
Composting – In-vessel*	Composting, typically in an enclosed channel, with forced aeration and continuous mixing.
Composting – Static pile*	Composting in piles with forced aeration but no mixing.
Composting – Intensive windrow*	Composting in windrows with regular (at least daily) turning for mixing and aeration.
Composting – Passive windrow*	Composting in windrows with infrequent turning for mixing and aeration.
Aerobic treatment	The biological oxidation of manure collected as a liquid with either forced or natural aeration. Natural aeration is limited to aerobic and facultative ponds and wetland systems and is due primarily to photosynthesis. Hence, these systems typically become anoxic during periods without sunlight.

*Composting is the biological oxidation of a solid waste including manure usually with bedding or another organic carbon source typically at thermophilic temperatures produced by microbial heat production.

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10: Emissions from Livestock and Manure Management, Table 10.18: Definitions of Manure Management Systems, p. 10.49.

Table B.2. Livestock Categories and Typical Average Mass

Livestock category (L)	Livestock Typical Average Mass (kg)
Dairy cattle	
Dairy and non-milking dairy cows (on feed in intensive systems)	550[a]
Heifers/Steers (with feeding in intensive systems)	332[b]
Bulls (grazing in large areas)	450[b]
Calves (grazed in semi-stalled systems with pasture or dual purpose)	152[c]
Heifers and steers (grazed in semi-stalled systems with pasture or dual purpose)	300[c]
Cows (semi-stalled with pasture or extensive dual-purpose grazing)	400[c]
Swine	
Nursery swine	28[d]
Growing swine	68[d]
Finished swine	100[d]
Male swine	200[d]
Female swine	190[e]

[a] Average weight of females as a reference for Latin America. Sources: National Institute of Innovation and Transfer of Agricultural Technology, 2017, Management Manual: sustainable intensive systems of fattening livestock, Costa Rica; FIRCO-SAGARPA, Biogas Potential in Mexico, SAGARPA, Generation and Use of Biogas in Pig Farms and Dairy Barns.

[b] Asocebú, 2021, Genetic Evaluation, Colombia. Table 1. Average Progeny Weights of Evaluated Bulls in the Caribbean area, pg. 6.

[c] Default values for Latin America. Source: IPCC, 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 10, Annex 10-A2. (Table 10A-2).

[d] TetraTech, 2012, Feasibility study for the development of CDM Program of Activities for the capture and use of methane in the swine sector in the Dominican Republic, Arlington.

[e] National Statistics Office, 2022, National Consolidated Livestock Production, per month, 2016-2022, Dominican Republic

Table B.3. Volatile Solids and Maximum Methane Potential by Livestock Category

Livestock category (L)	VS_L (kg/head/day)	$B_{o,L}$ (m^3 CH_4/kg VS)
Dairy cattle		
Cows average	3.55[a]	0.188[b]
Heifers/Steers (in intensive systems – feedlot)	2.02[c]	0.17[b]
Bulls (grazing)	2.87[c]	0.10[c]
Calves (grazed in semi-stalled systems with pasture or dual purpose)	2.14[c]	0.10[c]
Calves and heifers (pasture or grazing in semi-intensive systems or dual-purpose)	2.14[c]	0.10[c]
Swine		
Nursery swine	0.166[d]	0.29[e]
Growing swine	0.405[d]	0.29[e]
Finished swine	0.596[d]	0.29[e]
Male swine	1.192[d]	0.29[e]
Female swine	1.139[d]	0.29[e]

[a] Estimates based on a study of laboratory measurements and chemical analysis of cattle manure. Volatile solids values were estimated by multiplying the rate of fresh excreta by the percentage of volatile solids. Sources: FAO, 2019. Manure management on cattle farms. Ganaclima Dominican Republic. Delgado, E., 2018. Valuation of bovine and pig manure in the production of biogas in a staged production biodigester. Degree work. Salesian Polytechnic University, Ecuador.
[b] Value as a reference for Latin America. Source: González-Ávalos, E., 1999. Experimental Determination of Methane Emission Factors from Cattle Excreta in Mexico, PhD Thesis in Physical Sciences of the Atmosphere, National Autonomous University of Mexico, Mexico (page 76).
[c] Default values for Latin America (mature males and young animals). Source: IPCC, 1996. IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 4, Annex B (Table B-1)
[d] Estimates based on reference data for volatile solids in excreta in kg SVT/100 kg. of live weight multiplying by the average typical mass for each type of swine herd (from Table B.2) per animal. SVT value source: Mexican Pig Farming Council, 1997, Manual for the management and control of wastewater and swine excreta in Mexico, project developed by E.P. Taiganides, R. Pérez-Espejo, and E. Girón-Sánchez, México, D.F., México (Table 3.9).
[e] Default values for Latin America. Source: IPCC, 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 10, Annex 10-A2. (Tables 10A-7 and 10A-8).

Table B.4. IPCC 2006 Methane Conversion Factors by Manure Management System Component/Methane Source 'S' [49]

MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS																					
System[a]		**MCFs by average annual temperature (°C)**																			**Source and comments**
		Cool					**Temperate**											**Warm**			
		≤ 10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**≥ 28**	
Pasture/Range/Paddock		1.0%					1.5%											2.0%			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Daily spread		0.1%					0.5%											1.0%			Hashimoto and Steed (1993).
Solid storage		2.0%					4.0%											5.0%			Judgment of IPCC Expert Group in combination with Amon et al. (2001), which shows emissions of approximately 2% in winter and 4% in summer. Warm climate is based on judgment of IPCC Expert Group and Amon et al. (1998).
Dry lot		1.0%					1.5%											2.0%			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Liquid/Slurry	With natural crust cover	10%	11%	13%	14%	15%	17%	18%	20%	22%	24%	26%	29%	31%	34%	37%	41%	44%	48%	50%	Judgment of IPCC Expert Group in combination with Mangino et al. (2001) and Sommer (2000). The estimated reduction due to the crust cover (40%) is an annual average value based on a limited data set and can be highly variable dependent on temperature, rainfall, and composition.
	Without natural crust cover	17%	19%	20%	22%	25%	27%	29%	32%	35%	39%	42%	46%	50%	55%	60%	65%	71%	78%	80%	Judgment of IPCC Expert Group in combination with Mangino et al. (2001).

[49] From 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10: Emissions from Livestock and Manure Management, Table 10.17

Table B.4. Continued

MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS																					
System[a]		**MCFs by average annual temperature (°C)**																			**Source and comments**
		Cool					**Temperate**											**Warm**			
		≤ 10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**≥ 28**	
Uncovered anaerobic lagoon		66%	68%	70%	71%	73%	74%	75%	76%	77%	77%	78%	78%	78%	79%	79%	79%	79%	80%	80%	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Uncovered lagoon MCFs vary based on several factors, including temperature, retention time, and loss of volatile solids from the system (through removal of lagoon effluent and/or solids).
Pit storage below animal confinements	< 1 month	3%					3%											3%			Judgment of IPCC Expert Group in combination with Moller et al. (2004) and Zeeman (1994). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions.
	> 1 month	17%	19%	20%	22%	25%	27%	29%	32%	35%	39%	42%	46%	50%	55%	60%	65%	71%	78%	80%	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions.

Table B.4. Continued

MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS																					
System[a]		MCFs by average annual temperature (°C)																			Source and comments
		Cool					Temperate											Warm			
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28	
Anaerobic digester		0-100%					0-100%											0-100%			Should be subdivided in different categories, considering amount of recovery of the biogas, flaring of the biogas and storage after digestion.
Burned for fuel		10%					10%											10%			Judgment of IPCC Expert Group in combination with Safley et al. (1992).
Cattle and Swine deep bedding	< 1 month	3%					3%											30%			Judgment of IPCC Expert Group in combination with Moller et al. (2004). Expect emissions to be similar, and possibly greater, than pit storage, depending on organic content and moisture content.
Cattle and Swine deep bedding (cont.)	> 1 month	17%	19%	20%	22%	25%	27%	29%	32%	35%	39%	42%	46%	50%	55%	60%	65%	71%	78%	90%	Judgment of IPCC Expert Group in combination with Mangino et al. (2001).
Composting - In-vessel[b]		0.5%					0.5%											0.5%			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are less than half of solid storage. Not temperature dependant.
Composting - Static pile[b]		0.5%					0.5%											0.5%			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are less than half of solid storage. Not temperature dependant.
Composting - Intensive windrow[b]		0.5%					1.0%											1.5%			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are slightly less than solid storage. Less temperature dependant.
Composting – Passive windrow[b]		0.5%					1.0%											1.5%			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are slightly less than solid storage. Less temperature dependant.
Aerobic treatment		0%					0%											0%			MCFs are near zero. Aerobic treatment can result in the accumulation of sludge which may be treated in other systems. Sludge requires removal and has large VS values. It is important to identify the next management process for the sludge and estimate the emissions from that management process, if significant.

a Definitions for manure management systems are provided in Table B.1.
b Composting is the biological oxidation of a solid waste including manure usually with bedding or another organic carbon source typically at thermophilic temperatures produced by microbial heat production.

Table B.5. Emission Factor for Stationary and Mobile Combustion

Fuel	Emission Factors [kg CO_2/GJ]
Stationary Combustion [a]	
Crude oil	73.30
Natural gas liquids	64.20
Gasoline	69.30
Kerosene	71.90
Diesel	74.10
Residual fuel oil	77.40
Liquefied Petroleum Gas (LPG)	63.10
Naphtha	73.30
Lubricants	73.30
Petroleum coke	97.50
Coking coal	94.60
Bituminous coal	94.60
Sub-bituminous coal	96.10
Natural gas	56.10
Waste oils	73.30
Mobile combustion [b *]	
gasoline vehicles	69.3
Gas/Diesel Vehicles	74.1
Liquefied petroleum gas (LPG) vehicles	63.1
Compressed natural gas (CNG) vehicles	56.10
Liquefied natural gas (LNG) vehicles	56.10
Aircraft (kerosene)	71.90

[a] IPCC, 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 2, Chapter 2, Stationary Combustion, Table 2.5, pages 2.22-2.23.
[b] IPCC, 2006. IPCC *Guidelines for National Greenhouse Gas Inventories*, Volume 2, Chapter 3, Mobile Combustion, Table 3.2.1, page 3.16.
[*] To consult specific values by car model in the Dominican Republic see: https://dgii.gov.do/vehiculosMotor/consultas/Paginas/valoresCO2.aspx

Table B.6. Fossil Fuel Net Calorific Values

Fuel	Net calorific value
Petroleum liquid gas	0.003734 MJ/m^3
Gasoline	0.005126 MJ/m^3
Diesel	0.005729 MJ/m^3
Gasoil	0.006650 MJ/m^3
Natural gas	0.032326 GJ/m^3

Source: CNE, 2006. *Diagnosis and definition of the strategic lines on the rational use of energy in the Dominican Republic*. Technical Assistance Project for the Energy Sector.

Table B.7. Biogas Destruction Efficiency Default Values by Destruction Device

If available, the official source tested methane destruction efficiency shall be used in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for each of the combustion devices used in the project case performed on an annual basis.

Biogas Destruction Device	Biogas Destruction Efficiency (BDE)*
Open Flare	0.96[1]
Enclosed Flare	0.995[1,3]
Lean-burn Internal Combustion Engine	0.936[1,2]
Rich-burn Internal Combustion Engine	0.995[1,2]
Boiler	0.98[1]
Microturbine or large gas turbine	0.995[1]
Upgrade and use of gas as CNG/LNG fuel	0.95
Upgrade and injection into natural gas pipeline	0.98[4]

Source:

[1] IPCC 2006 Guidelines volume 4, chapter 10, p. 10.43.

[2] Seebold, J.G., et al., Reaction Efficiency of Industrial Flares, 2003

[3] The default destruction efficiencies for this source are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. Default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data is made available to the Reserve.

[4] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000 $kgCH_4$/PJ based on gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000 $kgCH_4$/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000 kg/CH_4/PJ, which is 0.8%. These leakage estimates are compounded and multiplied. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations.

Formula 1: MCF value for a covered liquid effluent storage system with additional effluent treatment

$$MCF_{ep} = \frac{\frac{CH_{4,meter,ep}}{BCE}\left(MCF_{add} \times B_{0,ep} \times 0.3 \times VS_{ep} \times 0.717 \times d\right)}{B_{0,ep} \times VS_{ep} 0.717 \times d}$$

Where,			Units
MCF_{ep}	=	Methane conversion factor for a covered liquid effluent storage system	fraction
$CH_{4,meter,ep}$	=	Total quantity of methane released (uncombusted) from the effluent storage system. Biogas flow and methane concentration must be metered according to the requirements of Section 6	kg CH_4
BCE	=	Biogas collection efficiency (BCE) (see guidance in Equation 5.8)	fraction
MCF_{add}	=	Methane conversion factor for the additional treatment of effluent after the covered liquid effluent storage system. Project developers shall use the MCF value that corresponds to the treatment system.	fraction
$B_{0,ep}$	=	Maximum methane producing capacity (of VS dry matter) (see guidance in Equation 5.9)	$m^3 CH_4$/kg VS
0.3	=	Default value representing the amount of VS that exits the covered liquid effluent storage system as a percentage of the VS entering the covered liquid effluent storage system	fraction
VS_{ep}	=	Volatile solid to covered liquid effluent storage system (see guidance in Equation 5.9)	kg/day
0.717	=	Density of methane (1 atm, 0°C)	kg/m^3
d	=	Number of days in reporting period	days

Appendix C Summary of the Performance Standard Analysis

The purpose of a performance standard is to establish a threshold that is significantly better than average GHG production for a specified service, which, if met or exceeded by a project developer, satisfies the criterion of "additionality". The Reserve's project protocol focuses on the following direct emission reduction activity: capturing and combusting methane from livestock manure management. Therefore, in this case the methane emissions correspond to GHG production, and manure treatment/storage correspond to the specified service.

The analysis to establish the performance standard evaluated Dominican Republic-specific data on dairy and swine manure management systems. Ultimately, it recommended a practice-based/technology-specific GHG emissions performance standard – i.e., installation of a manure digester (or biogas control system, more generally defined). The paper included the following sections:

- Livestock industry in the Dominican Republic
- GHG emissions from livestock manure management
- Data on livestock manure management practices in the Dominican Republic
- Dominican Republic environmental regulations impacting manure management practices
- Recommendation for a performance threshold for livestock operations

C.1 Livestock Operations in Dominican Republic

According to the 2015 land use and cover map, the surface land area dedicated to livestock in the Dominican Republic amounted to 1,400,000 ha, representing approximately 29% of the country's territory.

According to the Food and Agriculture Organization of the United Nations (FAO), by 2020, a national cattle population of 3.05 million heads was estimated[46]. The Dominican Republic does not have accurate and updated statistics on the dairy sector, however, estimates by DIGEA and CONALECHE indicate that the national livestock activity involves some 58,000 producers dedicated to raising and reproducing cattle. Of this total, around 17,000 producers are dedicated exclusively to milk production and approximately 530,500 heads, the rest to the production related to meat and milk or dual purpose[47].

Based on census conducted by the Dominican Federation of Pig Farmers (FEDOPOR), in 2020, the pig population in the Dominican Republic was approximately 1,800,000 pigs[48].

Swine production in the Dominican Republic can be divided into two main groups: production in "organized" or technical farms and traditional or "backyard" (informal) production. According to DIGEGA, there are approximately 450,000 backyard pigs, that is, 25% of the swine livestock population, and 75% in technical farms.

The country can be divided into eight agricultural regions: Northwest, North, Northeast, Northcentral, Southwest, South, Central, and East, as shown in Figure C.1. Cibao groups the four northern regions and concentrates most of the country's agricultural production.

[46] FAO, 2020. Crops and livestock products database. Dominican Republic, Cattle, stock. Available at: https://www.fao.org/faostat/en/#data/QCL

[47] ECLAC, 2017. Strengthening the dairy value chain in the Dominican Republic. United Nations, p. 22

[48] OIRSA, 2021. OIRSA supports containment and control of the outbreak of African Swine Fever in the Dominican Republic. Available at: https://www.oirsa.org/noticia-detalle.aspx?id=8114

Figure C.1 Agricultural regions of the Dominican Republic. Source: Tetra Tech, 2011

C.2 Analysis of Common Practices of the Manure Management Systems in Dominican Republic

Methane generation conditions occur in manure treatment and storage, specifically in anaerobic lagoons and/or storage ponds. The distribution of livestock across multiple sizes may be an important criterion on the development of the Performance Standard for livestock manure management. There is a general relationship between manure management practices and the operation size, operations with large herds (in terms of head count) tend to use manure management systems that treat and store waste properly (i.e., pressurized water or scrape/liquid manure systems), particularly in dairy and swine operations.

In general, swine farms have several buildings for each type of animal: boars, replacement sows, gestating sows, lactating, or farrowing sows with farrowing, weaning and fattening pigs. Sheds can be of two main types: grids or grates with dry or water-filled pits on the bottom, or concrete floors with channels or ponds on the side that are dry or filled with water.

On most farms, the feeder, replacement, and boar houses have concrete floors and are washed daily with a high-pressure water hose.

Farrowing houses (lactating sows and farrowing swine) usually have grates with pits below and are only washed every three to four weeks when the houses are emptied (when farrowing pigs go to weaning). In general, weaning houses also have grates with pits on the bottom and are washed when the weanlings leave.

Although anaerobic biodigesters are known within the livestock sector, these are not a common practice. Until 2012 there were at least thirty experiences of small equipment, however, these experiences were mostly unsuccessful due to little or no capacity to manage a maintenance protocol, misuse of the digester exceeding its capacity or filling it with external elements and finally the lack of a standard technology for electricity generation with biogas[49]. In 2022, the total number of recent biodigesters rises to 27 including swine, cattle (sweeps) and chicken farms.

On the other hand, GANACLIMA project of the Dominican Republic has published a bulletin proposing the realization of a cattle manure management plan through different practices. Its use is recommended as a soil fertilizer due to its high amount of nutrients and benefits to agriculture soil.

C.3 Use of biodigesters in the Dominican Republic

Since the entry into force of the Kyoto Protocol and the operability of the CDM in 2005, the capture and destruction of methane on large-scale agricultural operations has gained worldwide importance. Nevertheless, of the 15 projects in the country listed under this standard, none refers to the capture and destruction of methane from livestock waste.

There is no official database on biodigesters installed and operating in the Dominican Republic. However, according to a study carried out by MÉXICO$_2$ and financed by the French Development Agency (AFD), by 2022, 27 biodigesters are identified in operation in the Dominican Republic or in the process of construction. As shown in Table C.1, most of these are found in swine farms. Some of the installed biodigesters have the potential to develop a carbon capture project aligned with CDM protocols, however, to date they are not registered as carbon capture projects.

Table C.1. Quantity of biodigesters installed in the Dominican Republic by livestock subsector

Subsector	Number of biodigesters
Swine farm	20
Laying hen farm	3
Slaughterhouse	1
Swine slaughterhouse	1
Chicken slaughterhouse	2

Source: MÉXICO$_2$, AFD, 2022

[49] Tetratech, 2011. Study of the swine sector in the Dominican Republic.

C.4 Performance Standard Recommendation

The agricultural and livestock sector is a traditional pillar of the Dominican economy that contributes to food security, employment, foreign currency generation and the creation of raw materials for other industries. This sector is considered an engine for poverty reduction in rural areas of the country. According to the Dominican Central Bank and the World Bank, the agricultural sector (which includes livestock, forestry, fishing, and agriculture itself) represents 7.6% of GDP, of which 3.9% corresponds to livestock activities, 3.6% to agriculture and only 0.03% to forestry.

The recommended performance standard is a specific technology threshold that dairy or swine operators must meet. The threshold should be the installation of a biogas control system (anaerobic digester). This type of technology is not frequently used in the livestock industry. It is mainly used in large-sized swine farms with a medium-high technological level. In recent years, these technologies are being introduced in cattle, but with low frequency.

Up to 2012, the analysis of the swine sector in the Dominican Republic carried out by Tetra Tech confirmed a total methane emission reduction potential of 241,800 $MtCO_2e$, estimating a growth of up to 349,500 $MtCO_2e$ by the end of 2018, of which approximately 20% could be feasible to materialize in emission credits projects.

Some barriers to the implementation of biodigesters technology in the country include:

Institutional barriers

- Lack of environmental regulations for livestock operations and low compliance with existing regulations for waste management associated with the livestock sector
- Low financial incentives and government support for the development of these technologies

Technological barriers

- Deficit of specialists and technical assistance during operation support and in the emission reduction analysis
- Dependence on technology transfer from countries with higher development and experience in the implementation of biogas control systems

Economic Barriers

- Absence of a green financing mechanism, associated with the high initial investment costs required to install a biogas control system in livestock operations. Nowadays, it is economically difficult to adopt this type of technologies that promote sustainability.

Cultural Barriers

- Resistance to change by the population of the Dominican Republic to adopt new practices and change traditional manure management practices in the livestock sector
- Lack of knowledge among the livestock sector of the climatic benefits and potential additional economic benefits of installing a biogas control system in livestock operations

Although organizations such as GANACLIMA recommend the use of specific manure treatment and storage systems, the installation and use of digesters is not mandatory in the municipalities of the Dominican Republic.

There is a National Appropriate Mitigation Actions (NAMAs) project for the installation of biogas capture systems in the Dominican Republic, however, this project is not yet operational, so additional financial incentives for the installation of such systems are still needed. Table C.4.1 provides more information about the NAMA.

Table C.4.1 Description of the NAMA Reduction of GHG emissions in swine farms in the Dominican Republic (NS-149)

Description	GHG emissions reduction through the implementation of anaerobic digestion in swine farms in the Dominican Republic
Sectors	AFOLU
Gases	CH_4
Coverage	Geographic coverage: national
	Temporary coverage: 15 years of implementation
Condition	Seeking implementation support
Actors involved	National Council for Climate Change and Clean Development Mechanism
Objectives and quantitative goal	Installation of 1750 biodigesters nationwide for an estimated reduction of 0.36 $MtCO_2e$/year
Indicators	Not specified
Methodologies and assumptions	Emissions are calculated based on the IPCC methodology, vol. 4, ch. 10: Emissions from Livestock and Manure Management. Emissions reduction calculation does not include reductions in avoided electricity consumption from the grid and other non-renewable resources.
Measures taken or forecast to achieve that action	Execution of the UNDP Carbon 2012 regional project for the feasibility study of a methane capture and use program on pig farms in the Dominican Republic and the preparation of a NAMA Concept
Implementation progress	NAMA is currently seeking implementation support
Results obtained	NAMA is currently seeking implementation support
Other information	Estimated costs for its formulation and/or implementation: USD 216 million for implementation; 80 million initial investment, USD 120 million for O&M over a period of 15 years and 16 million for unforeseen expenses. Cooperation needs: USD 38,800,000

Source: Public registry of NAMAs by UNFCCC countries

In accordance with a case study in the Dominican Republic[50] and, in comparison with a study carried out for subnational entities in Mexico, the installation of a biodigester for the treatment of livestock waste ranges between 6.9 to 14.9 million Dominican pesos (USD 125,600 to 271,200) for a range between 2,000 to 6,000 animals respectively. While an electric generator would have an approximate investment of 7.1 million Dominican pesos[51] (USD 129,200).

At the national level, Ministry of the Environment, Agriculture and Climate Change promotes sustainable practices and environmentally friendly production models. On the other hand, the National Energy Commission provides support through the tax equipment imports, established in Law 57-07, of Incentives for the Development of Renewable Energies.

[50] TetraTech, 2012, *Feasibility study for the development of a CDM Program of Activities for the capture and use of methane in the swine sector in the Dominican Republic*, Arlington. The correction was made with an inflation for the Dominican Republic of 60% according to World Bank data: https://datos.bancomundial.org/indicador/FP.CPI.TOTL.ZG?end=2021&locations=DO&start=2009&view=chart

[51] Casas, M., B.A. Rivas, M. Soto, A. Segovia, H.A. Morales, M.I. Cuevas, C.M. Keissling, 2009. Feasibility Study for the implementation of anaerobic digesters in dairy farms in the Delicias Basin, Chihuahua in *Revista Mexicana de Agronegocios*, volume 24, Universidad Autónoma de la Laguna, Mexico, p. 745-756. The correction was made with an inflation for Mexico of 70% in the period 2009-2022 according to INEGI data: https://www.inegi.org.mx/app/indicesdeprecios/calculadorainflacion.aspx

Appendix D Data Substitution

This appendix provides guidance on calculating emission reductions when data integrity has been compromised either due to missing data points or a failed calibration. No data substitution is permissible for equipment such as thermocouples which monitor the proper functioning of destruction devices. Rather, the methodologies presented below are to be used only for the methane concentration and flow metering parameters.

Missing Data

The Reserve expects that projects will have continuous, uninterrupted data for the entire verification period. However, the Reserve recognizes that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for flow and methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Data substitution can only be applied to methane concentration *or* flow readings, but not both simultaneously. If data is missing for both parameters, no reductions can be credited.

Further, substitution may only occur when two other monitored parameters corroborate proper functioning of the destruction device and system operation within normal ranges. These two parameters must be demonstrated as follows:

1. Proper functioning can be evidenced by thermocouple readings for flares, energy output for engines, etc.
2. For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.
3. For flow substitution, methane concentration rates during the data gap must be consistent with normal operations.

If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology maybe applied:

Duration of Missing Data	Substitution Methodology
Less than six hours	Use the average of the four hours immediately before and following the outage.
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness.
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness.
Greater than one week	No data may be substituted and no credits may be generated.

For livestock projects, both the lower and upper limit must be utilized. For calculating fugitive emissions from the gas management system ($PE_{CH4,BCS}$), the upper limit should be used. However, for calculating combusted gas ($CH_{4,destroyed}$), the lower limit must be applied.[52]

[52] When using the livestock calculation tool, only one value for methane flow can be entered, and is automatically populated into $PE_{CH4,BCS}$ and $CH_{4,destroyed}$. The *higher* values should be input initially, as this is conservative of the project emissions calculations. However, if the comparison of modeled to measured emissions indicates that reductions will be based off of monitored emissions, then the *lower* value must be substituted and used, as this will result in conservativeness.

Appendix E Development of the B_0 Sampling and Analysis Methodology

With the release of Livestock Protocol Version 4.0 in January 2013, the Reserve adopted a novel methodology for the sampling and analysis of livestock manure to determine maximum methane potential. In all previous versions of the livestock protocol, in both Mexico and the U.S., the value of this term was defined by the default options provided in Table B.3, which were themselves sourced from the EPA Climate Leaders Draft Manure Offset Protocol. Other than a change in the value of the default for Dairy Cows with Version 2.1 from a “low roughage” value to a “high roughage” value, these default values have not changed since the first version of the protocol was adopted. Reserve staff have received feedback from stakeholders that in many cases, the default value for a particular animal category, especially Dairy Cows, is excessively conservative. Based on this feedback, the Reserve initiated a process to explore the options for updating the default values for maximum methane potential (B_0). After review of existing methodologies and literature related to manure methane potential, the Reserve determined that there is currently not a clear basis for establishing different default values. However, direct sampling and analysis were identified as an option that could be immediately provided as an alternative to the existing default values.

In 2009 the Reserve adopted the Organic Waste Digestion project protocol (updated to Version 2.0 in 2011). This protocol introduced a procedure for the determination of site-specific B_0 value for organic wastewater streams (OWD V2.0, Section 6.1.3.2). These requirements formed the basis for the development of a sampling and analysis procedure for livestock projects.

In early September 2012, the Reserve solicited stakeholder interest for participation in the development process for this new methodology. A diverse group of 36 stakeholders representing carbon project developers, academia, government, livestock industry, GHG verification bodies, and others, responded to this request. These stakeholders then received a memorandum detailing the proposed methodology and were invited to a webinar on September 19, 2012 to provide feedback and engage in discussion. A total of 22 individuals participated in the webinar discussion, providing a great deal of feedback and suggestions for improvement.

In addition to the public stakeholder consultation, Reserve staff worked directly with experts in industry and academia to further refine the methodology. The goal was to identify a sampling and testing regime that could consistently provide accurate estimates of the B_0 value of different manure streams, and that would be reasonably practical for implementation. The major considerations and decisions are addressed below.

A subsequent review was performed when developing the Dominican Republic Livestock Protocol to adapt the sampling and analysis methodology for the jurisdiction.

Sampling Schedule

The sampling procedure requires that six samples be taken at regular intervals throughout the day. These individual samples are then combined into one composite sample to represent that event. The sampling procedure in the OWD protocol calls for 10 samples spaced out over at least one week. In consultation with expert stakeholders, it was determined that livestock manure will be less variable over such short timescales, and that the collection of multiple samples in a single day would be sufficient to control for sample variability and error. A more onerous sampling requirement would introduce additional resourcing requirements and costs disproportionate to any reduction in uncertainty/error.

The procedure also requires that the sampling event take place between the months of August through November (inclusive). The Reserve has limited the applicability of this procedure to dairy facilities, and expects that it will mainly be used for the determination of a site-specific B_0 for dairy cows. Thus, the timing of the sampling procedure is designed to avoid overestimating the B_0 value for this particular livestock category. Academic experts advised the Reserve that the methane generating potential of dairy cow manure tends to be positively correlated with milk production.[50] To ensure that the average B_0 value for the year is not overestimated, it is appropriate to avoid sampling the manure during periods of above-average milk production. Reserve staff used data from the National Agricultural Statistics Service[51] to examine monthly milk production trends. For the years 1998-2011, the milk production for each month (in lbs/head) was compared to the average monthly milk production for that year. This process highlighted the months with above or below-average milk production, while controlling for the overall trend of increasing milk production year-over-year. **Figure E.1** shows the results of this analysis and the consistent pattern of milk production during this 14-year period.

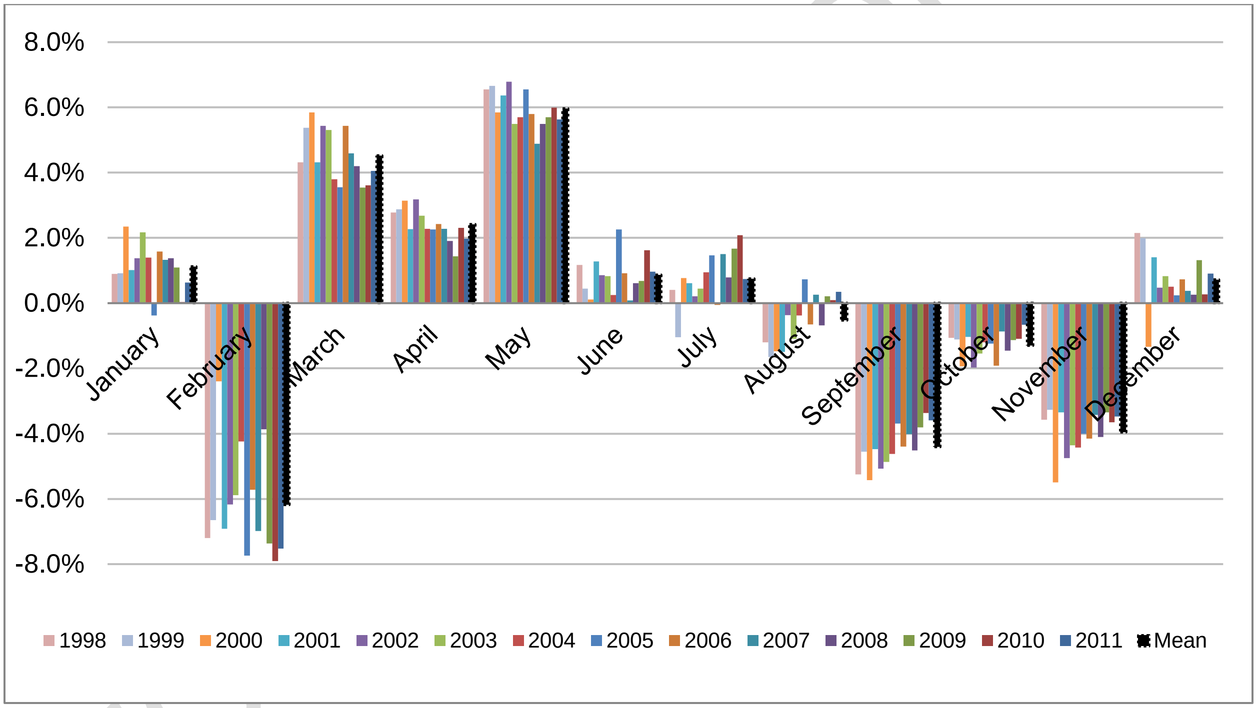

Figure E.1. Monthly Milk Production Trends as a Percent Change Over Annual Average Monthly Milk Production (1998-2011)

Based on this analysis the Reserve has limited the sampling period to August through November. These months consistently exhibit average- to below-average milk production, which should result in a conservative estimate of the annual average B_0 value.

Sample Source

The procedure instructs the user to obtain a manure sample that represents only a single animal category, prior to mixing with other residues (except for flush water in the case of flush

[50] In the future, it may be possible to develop a default methane potential that is based directly on monthly milk production, though additional research is needed.
[51] Accessed from the USDA website at http://quickstats.nass.usda.gov/.

systems). While certain stakeholders indicated through public comment that they would prefer to sample the entire waste stream as it enters the digester, there are two main reasons why this requirement was not amended:

1. The waste stream entering the digester may contain ineligible materials which, while permitted to be processed by the project BCS, should not be represented in the quantification of baseline emissions.
2. The baseline quantification model is run on a monthly basis, using the actual animal population figures for that month. The relative populations of different animal categories may change during the year, resulting in an overall B_0 value for the manure from that facility that is variable through time. To use a composite Bo value, representative of multiple animal categories, would create quantification inaccuracies if relative populations change from one month to the next (see Table E.1).

Table E.1. Effects of Relative Population Size on Composite B_0 Value

Animal Category	B_0 Value	Population in Month 1	Population in Month 2	Population in Month 3
Dairy Cows	0.24	2,000	800	3,000
Heifers	0.17	500	2,000	200
Calves	0.17	500	1,200	0
	Composite B_0 Value	***0.22***	***0.18***	***0.24***

There is an additional step for dairies that utilize a flush system for manure management, as the flush water is typically composed of some type of wastewater, which could have a significant methane potential. For these systems it is necessary to also sample the flush water inlet point prior to mixing with the manure, so that the methane potential of the flush water can then be subtracted from the methane potential of the sample.

Laboratory Analysis

The Reserve undertook research to determine whether standard procedures/processes existed for the professional analysis of B_0 potential. This research revealed that while there is currently no standard laboratory certification scheme within the US pertaining to this type of analysis, there are commonly-accepted methods for undertaking the relevant biochemical methane potential (BMP) analysis itself. The requirements to document a laboratory's experience and standard operating procedures were introduced to ensure rigor and consistency among testing bodies.

The Reserve consulted with commercial and university testing laboratories regarding the requirements for the biochemical methane potential (BMP) assay. The resulting requirements closely resemble the standard procedures of existing laboratories. It is necessary for the protocol to prescribe at least basic parameters for the BMP assay in order to ensure consistency among projects that hire different laboratories. The inclusion of a control assay was suggested by multiple laboratories as an important quality check on the viability of the seed inoculum that is used for the BMP assay.

Stakeholder Participation

The Reserve would like to thank the following stakeholders, in addition to others not listed here, for their participation in the research and development of this methodology during development of the U.S. Livestock Protocol V4.0.

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Cortney Itle	Eastern Research Group, Inc.
Dr. Xiaomei Li	XY Green Carbon
Dr. John H. Martin, Jr.	Hall Associates
Carl Morris	Joseph Gallo Farms
Dr. Scott Subler	Environmental Credit Corp.
Peter Weisberg	The Climate Trust