Mexico Livestock Protocol Version 2.0
ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its Mexico Livestock Protocol Version 2.0 (MXLSP V2.0) in September 2010. While the Reserve intends for the MXLSP V2.0 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the MXLSP V2.0.[1]

Per the Reserve Offset Program Manual, both errata and clarifications are considered effective on the date they are first posted on the Reserve website. The effective date of each erratum or clarification is clearly designated below. All listed and registered MXLSP projects must incorporate and adhere to these errata and clarifications when they undergo verification. The Reserve will incorporate both errata and clarifications into future versions of the MXLSP.

All project developers and verification bodies must refer to this document to ensure that the most current guidance is adhered to in project design and verification. Verification bodies shall refer to this document immediately prior to uploading any Verification Statement to assure all issues are properly addressed and incorporated into verification activities.

If you have any questions about the updates or clarifications in this document, please contact the Reserve at policy@climateactionreserve.org or (213) 891-1444 x3.

[1] See Section 4.3.4 of the Reserve Offset Program Manual for an explanation of the Reserve's policies on protocol errata and clarifications. "Errata" are issued to correct typographical errors. "Clarifications" are issued to ensure consistent interpretation and application of the protocol. For document management and program implementation purposes, both errata and clarifications are contained in this single document.

Errata and Clarifications (arranged by protocol section)

Section 3

1. Regulatory Compliance for Centralized Digesters (CLARIFICATION – April 29, 2022)

Section: 3.6 (Regulatory Compliance)

Context: This section states that projects that do not comply with air and water quality regulations are not eligible to register greenhouse gas (GHG) reductions with the Reserve. The guidance in this section does not specify how to address regulatory compliance for projects where manure is received from multiple farms and managed in a centralized biogas control system (BCS).

It is unclear whether a violation with respect to one manure source facility would jeopardize the ability of the project to receive credit from emission reductions related to manure from other source facilities. It may be possible for an offset project at a centralized digester to have CRTs issued to it for manure from compliant manure source facilities during a period of time when one or more manure source facilities are materially noncompliant with a regulation.

Clarification: The following text shall be inserted on page 7, at the end of Section 3.6:

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

Section 5

2. Calculating the van't Hoff-Arrhenius Factor (ERRATUM – March 28, 2012)

Section: 5.1 (Modeling Baseline Methane Emissions)

Context: The first step involved in Equation 5.3 (pages 16-17) is the calculation of the van't Hoff-Arrhenius factor (*f*). This factor estimates the percentage of volatile solids (VS) that will be biologically available for degradation in the baseline lagoon, depending on the ambient temperature. The equation is set up with a base temperature of 30°C, based on the assumption that this is the point at which biological availability will reach its maximum. One resultant outcome is that if a temperature of greater than 30°C is input for T_2, the calculated value of *f* will be greater than 100%, which is physically impossible.

Additionally, the reference source for this equation states that, under actual field conditions, the value of *f* is not likely to exceed 95% (Mangino et al., 2001). Thus, the user-calculated value for *f* should never exceed 0.95 (95%), which occurs when T_2 > 29.5°C. The current calculation is taken from this specific reference, but the limit of 95% was erroneously omitted.

Correction: The following text shall be added to the definition of T_2 in Equation 5.3 on page 17:

> "If T_2 > 29.5°C then f = 0.95."

3. Service Providers for Site-Specific Destruction Efficiency Testing (CLARIFICATION – April 29, 2022)

Section: 5.2 (Calculating Project Methane Emissions)

Context: Footnote 30 on page 22 states that service providers used to determine site-specific values for methane destruction efficiency must be "state or local agency accredited." It is not clear what specific options are available and permissible to projects located in a state or locality which does not have an accreditation program for source test service providers.

Clarification: The intent of this requirement is to ensure that any source testing conducted for the determination of a site-specific value for methane destruction efficiency is of a quality that would be acceptable for compliance by a regulatory body. The following text shall be added to the end of footnote 30 on page 22:

> "If neither the state nor locality relevant to the project site offer accreditation for source testing service providers, projects may use an accredited service provider from another state or domestic locality. Alternatively, projects may choose a non-accredited service provider, under the following conditions: 1) the service provider must provide verifiable evidence of prior testing which was accepted for compliance by a domestic regulatory agency, and 2) the prior testing procedures must be substantially similar to the procedures used for determining methane destruction efficiency for the project destruction device(s)."

4. MCF Value for a Covered Liquid Effluent Storage System (CLARIFICATION – April 29, 2022)

Section: 5.2 (Calculating Project Methane Emissions)

Context: Equation 5.8 on page 23 is used to calculate the methane emissions released from the treatment of the effluent upon leaving the anaerobic digester. To complete this calculation, the project developer must select the appropriate value for the methane conversion factor (MCF) based on the type of treatment system (usually an open effluent pond). Table B.4 in Appendix B is the source for the MCF values to be used in this equation.

In the case of a project which installs an impermeable cover on the effluent pond, effectively creating a second anaerobic digester, it is not clear how to determine the correct MCF value. Table B.4 lists the MCF value for an anaerobic digester as a range, from 0 percent to 100 percent, and directs the reader to use Formula 1 to determine the correct MCF. This formula, which was included as a footnote to the table in the original IPCC source, was omitted from the Mexico Livestock Protocol. In addition, it is not clear how to apply this formula for use in determining the MCF of a covered effluent pond. In the original source document, Formula 1 is not intended for determining the MCF of a covered effluent storage pond, but rather for determining the MCF of an entire digester system. Thus, the terms are not defined appropriately for this purpose.

Clarification: If the project elects to install an impermeable cover over its liquid effluent storage system, and to collect the methane gas from this covered storage and connect it to the biogas control system (BCS), it may be considered to be part of the project digester system, rather than a separate effluent treatment system. The fate of the effluent from this covered storage would then need to be quantified using Equation 5.8.

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 $PE_{CH4,EP}$ 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 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 below.

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

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

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

5. Calculating VS for Projects with No Effluent Ponds (ERRATUM – April 29, 2022)

Section: 5.2 (Calculating Project Methane Emissions)

Context: Footnote 32 on page 23 states, "if no effluent pond exists and project developers send digester effluent (VS) to compost piles or apply directly to land, for example, then the VS for these cases should also be tracked using equation 3b." This footnote references the equation in the US Livestock v2.1 Protocol.

Correction: The footnote should instead read: "if no effluent pond exists and project developers send digester effluent (VS) to compost piles or apply directly to land, for example, then the VS for these cases should also be tracked using equation 5.9."

6. Emissions from Land Application (ERRATUM – April 29, 2022)

Section: 5.2 (Calculating Project Methane Emissions)

Context: Equation 5.8 on page 23 is used to quantify the methane emissions associated with the effluent pond that receives and stores the effluent from the anaerobic digester. Though the title of the equation implies that it is only to be used for quantifying the methane from an effluent pond, footnote 32 clarifies that this same equation is to be used to quantify the methane emissions from an alternative form of effluent storage or treatment. However, this footnote erroneously includes land application as a form of treatment that shall be quantified as a source of project emissions.

Methane emissions from the disposal of manure by land application are excluded from the greenhouse gas assessment boundary for livestock projects.

Correction: Methane emissions from the disposal of manure by land application are not included within the greenhouse gas assessment boundary for livestock projects, either in the baseline or the project scenario. However, if the effluent is transported off-site for land application elsewhere, the fossil fuel emissions associated with this transportation must be quantified as project emissions (Equation 5.11).

Section 6

7. Adjustments to Metered Biogas Flow Data (ERRATUM – March 28, 2012)

Section: 6.2 (Biogas Measurement Instrument QA/QC)

Context: On page 30 of MXLSP V2.0, the protocol provides two requirements that govern how metered flow data is scaled in the event that a meter has been confirmed during a calibration event to be outside the allowable +/- 5% accuracy threshold. These two requirements for scaling the data are not intended for livestock project GHG accounting, and are not conservative.

Correction: The requirements on page 30 of the MXLSP V2.0 shall be replaced with the following requirement:

1. For calibrations that indicate the flow meter was outside the +/- 5% accuracy threshold, the project developer shall estimate total emission reductions using i) the metered values without correction, and ii) the metered values adjusted based on the greatest calibration drift recorded at the time of calibration. The lower of the two emission reduction estimates shall be reported as the scaled emission reduction estimate.

8. Instrument QA/QC for a Stationary Flow Meter In Use for 60 Days or More That is Removed and Not Reinstalled During the Same Reporting Period (CLARIFICATION – July 19, 2023)

Section: 6.2 (Biogas Measurement Instrument QA/QC)

Context: The protocol is silent on QA/QC requirements in instances when a stationary flow meter is in use for 60 days or more but is then removed and not reinstalled during the same reporting period.

Clarification: The following text shall be included on page 30 above the first paragraph:

"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 within 2 months of removal; or
- calibrated (with percent drift documented) by the manufacturer or a certified calibration service (with as-found results recorded) no more than 12 months prior to use of the meter to quantify emission reductions and no later than the commencement of verification activities for the relevant reporting period."

Section 7

9. Initial Reporting and Verification Period (ERRATUM – March 28, 2012)

Section: 7.3.1 (Initial Reporting Period and Verification)

Context: On page 38 of MXLSP V2.0, the protocol states that "[o]nce a project is registered and has had at least 6 months of emission reductions verified, the project developer may choose one of the verification options below." The 6-month requirement is inconsistent with the original intent of the protocol, which was to maximize the flexibility of reporting periods and verification schedules. To remain consistent with the original intent of the verification options, the 6-month reporting period requirement shall be changed to a "one quarter" or 3-month reporting period requirement.

Correction: The protocol shall be corrected to read "[o]nce 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."

10. Reporting and Verification Cycle – Option 2 (CLARIFICATION – March 28, 2012)

Section: 7.3.3 (Option 2: Twelve-Month Verification Period with Desktop Verification)

Context: On page 39 of MXLSP V2.0, the protocol states that under Option 2, "[d]esktop 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." This verification option is intended to provide greater flexibility and ease verification costs for livestock projects. However, the disallowance of sub-annual (i.e., less than 12-month) verification periods, in particular for the initial verification, is inconsistent with the intent of the requirements in Section 7.3.1 (p.38) of the protocol.

Clarification: The protocol shall be clarified to read "[f]or projects using this option, the initial verification in this cycle shall be a full verification, including a site visit, and shall cover a minimum of 3 months and maximum 12 months of project data. All subsequent reporting periods under this option shall be 12-month reporting periods."

11. Reporting and Verification Cycle – Option 3: Monitoring Report (CLARIFICATION – March 28, 2012)

Section: 7.3.4 (Option 3: Twenty-Four Month Maximum Verification Period)

Context: On page 40 of MXLSP V2.0, the protocol states that "[u]nder 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." In this context, it is unclear what information is to be provided in the monitoring plan, and what is to be provided in the monitoring report, and where any overlap may exist. For clarity and ease of use, the Reserve will require only one document, hereafter referred to as "monitoring report" to meet the interim documentation requirement under this option. The template available online provides guidance on what is expected from a monitoring report.

Clarification: The protocol shall be clarified to read "[u]nder this option, the verification period cannot exceed 24 months and the project's monitoring report must be submitted to the Reserve for the interim 12-month reporting period. The project 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, and adherence to the project's monitoring plan."

12. Reporting and Verification Cycle – Option 3: Interim Reporting Period (CLARIFICATION – March 28, 2012)

Section: 7.3.4 (Option 3: Twenty-Four Month Maximum Verification Period)

Context: On page 40 of MXLSP V2.0, the protocol states that "[t]he monitoring report shall be submitted within 30 days of the end of the reporting period." While the terms "reporting period" and "verification period" are defined in the protocol glossary, with verification period referring to a period that may cover multiple reporting periods under Section 7.3.4, the language regarding when the monitoring report is to be submitted is potentially unclear.

Clarification: The protocol shall be clarified to read "[t]he monitoring report shall be submitted within 30 days of the end of the *interim* reporting period."

Appendix B

13. Default Destruction Efficiency for Upgrade and Injection into Natural Gas Pipeline (CLARIFICATION – March 28, 2012)

Section: Table B.7 (Biogas Destruction Efficiency Default Values by Destruction Device)

Context: On page 62 of MXLSP V2.0, the protocol provides a table with default values for approved destruction devices that may be used by project developers. The last destruction device listed, described as: "Upgrade and injection into natural gas pipeline," has a listed default destruction efficiency of 98% (0.98). This default destruction efficiency is derived as an average value appropriate for scenarios where the methane component of the biogas is injected into a transmission/distribution system and ultimately distributed to unknown end-users in the residential or commercial sector, or to unknown industrial plants or power stations. This default factor is not intended to be used for scenarios where biogas is destroyed by a third party under a direct-use agreement. Under such a scenario, the destruction efficiency should correspond to the type of destruction device that is used by the third party.

Clarification: The entry in the last row of the first column of Table B.7 on page 62 shall be clarified to read "Upgrade and injection into natural gas *transmission and distribution* pipeline."

14. Default Destruction Efficiency Footnote References (ERRATUM – March 28, 2012)

Section: Table B.7 (Biogas Destruction Efficiency Default Values by Destruction Device)

Context: On page 62 of MXLSP V2.0, the protocol provides a table with default values for approved destruction devices that may be used by project developers. The footnote citations provided in Table B.7 are not correct for many of the destruction device efficiencies.

Correction: The following table containing the correct footnote references for each destruction device should replace Table B.7 on page 62.

Biogas Destruction Device	Biogas Destruction Efficiency (BDE)
Open Flare	0.96[1]
Enclosed Flare	0.995[2]
Lean-Burn Internal Combustion Engine	0.936[2]
Rich-Burn Internal Combustion Engine	0.995[2]
Boiler	0.98[2]
Microturbine or Large Gas Turbine	0.995[2]
Upgrade and Use of Gas as CNG/LNG Fuel	0.95[2]
Upgrade and Injection into Natural Gas Pipeline	0.98[3]

Source:
[1] Seebold, J.G., et al., Reaction Efficiency of Industrial Flares, 2003
[2] 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. The 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.
[3] The 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 118,000kgCH_4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH_4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/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.[2]

[2] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007).

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Mexico Livestock

Project Protocol

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1 Introduction

The Climate Action Reserve (Reserve) Mexico Livestock Project 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 a national offsets program working to ensure integrity, transparency and financial value in the U.S. carbon market. It does this by establishing regulatory-quality standards for the development, quantification and verification of GHG emissions reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRTs) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. Adherence to the Reserve's high standards ensures that emission reductions associated with projects are real, permanent and additional, thereby instilling confidence in the environmental benefit, credibility and efficiency of the U.S. carbon market.

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.[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 http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

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]

[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 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	→	*Mexico*
Eligibility Rule II:	Project Start Date	→	*Within 6 months prior to project submission*
Eligibility Rule III:	Anaerobic Baseline	→	*Demonstrate anaerobic baseline conditions*
Eligibility Rule IV:	Additionality	→	*Meet performance standard*
		→	*Exceed regulatory requirements*
Eligibility Rule V:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Only projects located in Mexico are eligible to register reductions with the Reserve under this protocol. Livestock projects located in the United States must use the U.S. Livestock Project 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 6 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.

3.3 Project Crediting Period

Project developers are eligible to register GHG reductions with the Reserve according to this protocol for a period of ten 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 3.5.2 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 Mexico Livestock Project Protocol for a maximum of two ten year crediting periods after the project start date. Section 3.5.1 and 3.5.2 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 Handbook for management and control of wastewater and swine manure in Mexico.[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 Mexico. A summary of the study to establish the threshold is provided in Appendix C.

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

[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 “Handbook for management and control of wastewater and swine manure in Mexico” of the Mexican Swine Confederation at http://www.porcimex.org/apoyos/aguasresiduales.htm.

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 ten 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 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 a project's start date. 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.

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.

Environmental legislation associated with livestock operations is framed by the "General Law for Ecological Equilibrium and Environmental Protection" (LGEEPA by its Spanish acronym), enacted in 1988. This law establishes that wastewater discharges from the agriculture and livestock sector are subject to federal and local regulation (Article 120, paragraph III), and that wastewater discharges to sewage systems in populated areas, to water bodies, and those that are spilled in the soil or are infiltrated in the sub-soil should comply with the necessary conditions to prevent water and soil contamination. To that end, the National Water Commission (CONAGUA by its Spanish acronym), in coordination with state and municipal governments, are responsible for setting the conditions on wastewater discharges, for issuing permits and licenses for water use and discharge, and for drafting and enforcing the corresponding Mexican Official Standards. With regard to wastewater discharges applicable to livestock operations, SEMARNAT has published two environmental standards:

- "NOM- 001-ECOL-1996," which sets the maximum contamination limits for wastewater discharge in water sources and other national resources, and
- "NOM-002-ECOL-1996," which establishes the maximum contaminant limits for wastewater discharges into urban and municipal sewage systems.

NOM-001 regulates the receptor water body and not the activity that discharges the water, establishing the maximum contamination limits according to 2 elements: the receptor water body (rivers, natural or artificial reservoirs, coastal waters, soil and natural wetlands) and the

[8] Attestation forms are available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

subsequent use of the wastewater (agricultural irrigation or urban public supply). For this reason, the wastewater quality monitoring is conducted prior to the discharge to the water bodies. In addition, compliance with NOM-001 is graduated according to the contamination load measured on the basis of the bio-chemical oxygen demand (BOD) or of the total suspended solids (TSS). Large polluters (discharging more than 3 tonnes per day of BOD or TSS) had to comply by January 1, 2000; the medium-sized polluters (from 1.2 to 3 tonnes per day), by January 1, 2005 and the remaining should comply with this standard by January 1, 2010.

The “General Law for the Prevention and Integral Waste Management”, published in 2003, identifies the residues of cattle raising activity as special management waste (Article 19, paragraph III). However, the definition of the waste that is subject to waste management plans corresponds to state or municipal authorities (Article 20).

With regard to state level regulation, the environmental laws regulate mainly the wastewater discharges from agricultural and livestock uses, and in most cases the authorization of permits and the compliance enforcement is transferred to the municipal governments. It is important to mention that the Livestock Law of the state of Michoacán, published in 2007, establishes in their Article 106 that the Rural Development Office of the state, in coordination with local cattle raisers organizations, will establish mandatory programs of manure management in relevant locations according to their animal concentration and it will supervise their compliance.

As to the municipal level, several environmental rules require the treatment of cattle manure, and the treatment systems should be authorized by the municipal agencies. This is the case of the municipalities of Mexicali, Rosarito and Tecate in the State of Baja California; of Irapuato in the State of Guanajuato; of Acapulco in the State of Guerrero; and of Ahome, Angostura, Cozalá and Culiacán in the State of Sinaloa. In most cases, the installation of an anaerobic digester is one of the several options of the authorized systems for manure treatment. However, the high costs of capital seem to prohibit the use of digesters as a practical mechanism for complying with these regulations.

The Reserve’s analysis of manure management practices in Mexico identified no regulations that obligate livestock owners to invest in a manure biogas control system. Although the Reserve found no regulations driving livestock operators to install a biogas control system, project developers pass the Legal Requirement Test by demonstrating that there are no state or federal regulations or local agency ordinances/rulings requiring the installation of a biogas control system.

3.6 Regulatory Compliance

As a final eligibility requirement, project developers must attest that the project is in material compliance with all applicable laws relevant to the project activity (e.g. air, water quality, safety, etc.) by signing the Reserve’s Attestation of Regulatory Compliance form[9] prior to verification activities commencing for each verification period. Furthermore, project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law. If a verifier finds that a project is in a state of recurrent non-compliance or non-compliance that is the result of negligence or intent, then CRTs will not be issued for GHG reductions that occurred during the period of non-compliance. Non-compliance solely due to administrative or reporting issues, or due to “acts of nature,” will not affect CRT crediting.

[9] Attestation forms are available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

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[10] (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.[11]

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.

[10] 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.

[11] *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*; p.5.10, ftnt 4.

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.[12] The reason for the large uncertainty is the complex emissions pathway from organic nitrogen in livestock waste to nitrous oxide – the nitrification-denitrification cycle.[13]

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.

This approach is consistent with the Regional Greenhouse Gas Initiative's (RGGI) treatment of nitrous oxide. Under the RGGI Model Rule (January 5, 2007) project developers do not receive credit for reductions in nitrous oxide. The CDM "Consolidated baseline methodology for GHG emission reductions from manure management systems" (ACM0010 V.5) and the U.S. EPA Climate Leaders Offset Project Methodology for Managing Manure with Biogas Recovery Systems (August 2008 Version 1.3) on the other hand allow project developers to calculate decreases in nitrous oxide emissions from sources up to, but excluding, land application.

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

[13] 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. Furthermore, all existing estimates of uncertainty (of which the Reserve is aware) involve the quantification of nitrous oxide at a national level, not a project-level. 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.

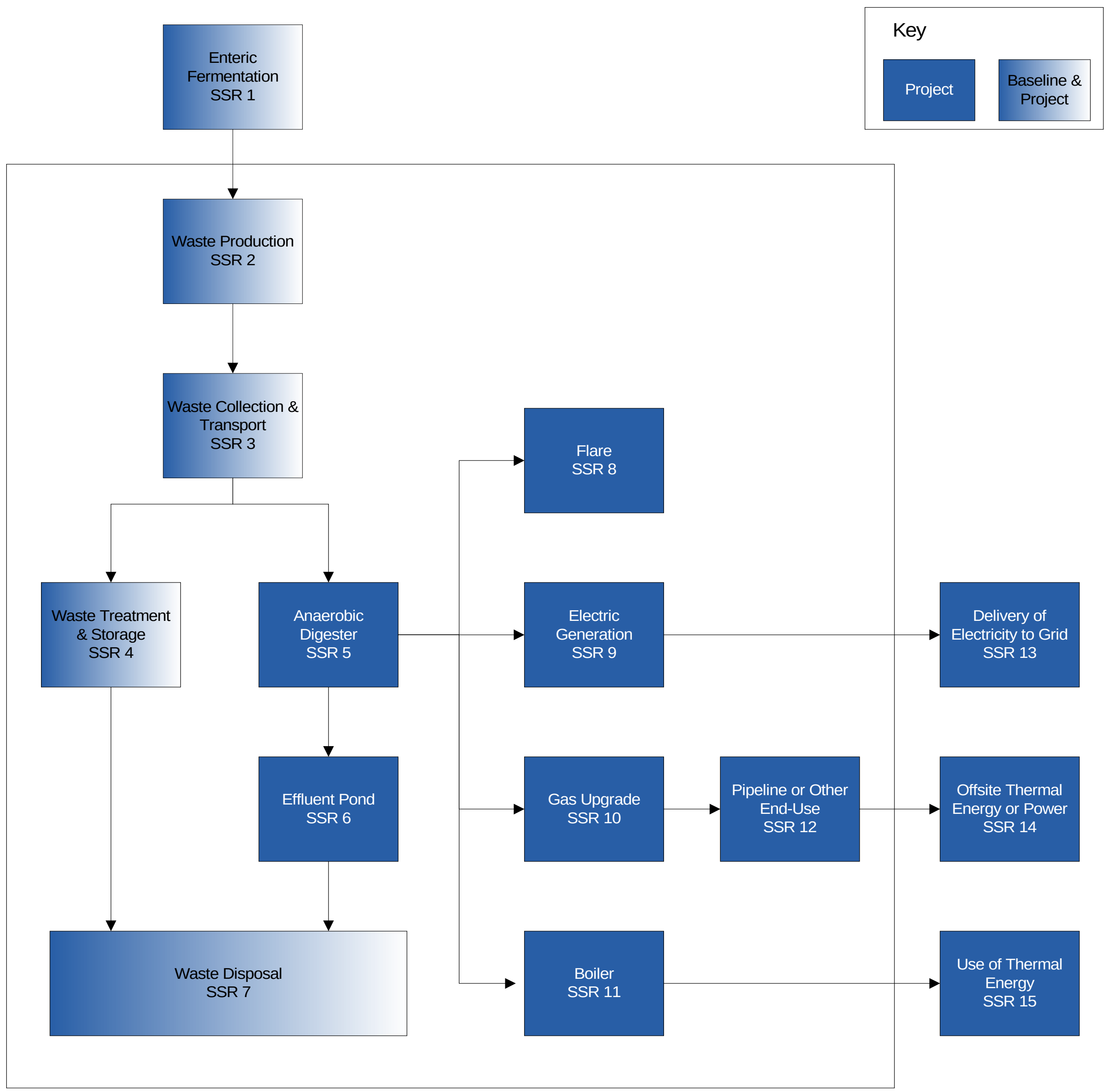


Figure 4.1. General Illustration of the GHG Assessment Boundary

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	CO_2	B, P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions in the baseline.

SSR	GHG Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
	deposits, compost piles, solid storage piles, manure settling basins, aerobic treatment, storage ponds, etc.	N_2O		*Excluded*	See Box 4.1.
	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.

SSR	GHG Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
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 CH_4 N_2O	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas-generated electricity.
14	Off-site thermal energy or power	CO_2 CH_4 N_2O	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas delivered through pipeline or other end uses.
15	Use of project-generated thermal energy	CO_2 CH_4 N_2O	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas-generated thermal energy.
	Project construction and decommissioning emissions	CO_2 CH_4 N_2O	P	*Excluded*	Emission source is assumed to be very small.

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 4) 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.[14] 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 available at: http://www.climateactionreserve.org/how-it-works/protocols/adopted-protocols/livestock/current-livestock-project-protocol/. The Reserve *recommends* the use of the Livestock Calculation Tool for all project calculations and emission reduction reports.[15]

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.

[14] 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).

[15] The software "PigMex" of the Mexican Swine Confederation is a useful support tool for swine operations. In its update, it will include biogas production estimations. However, actual GHG reductions must be calculated according to 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 below outlines the quantification approach for calculating the emission reductions from the installation of a biogas control system.[16]

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* $_{CO2}$*)*

5.1 Modeled 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.[17] 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.[18] 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.[19] It incorporates the effects of

[16] 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.
[17] The Reserve has developed the U.S. Organic Waste Digestion Project Protocol, which includes co-digesting eligible waste streams with livestock manure. The protocol is available at http://www.climateactionreserve.org/how/protocols/adopted/organic-waste-digestion/current/.
[18] Conversely, under a “static baseline,” a project developer would assess baseline emissions once before project implementation and use that value throughout the project lifetime.
[19] Anaerobic storage/treatment systems generally refer to anaerobic lagoons, or storage ponds, etc.

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

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

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

$$BE_{CH_4,AS} = \sum_{L,AS} VS_{\deg,AS,L} \times B_{0,L} \times 0.717 \times 0.001 \times 21$$

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' – 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)[20]	
0.001	=	Conversion factor from kg to metric tons	
21	=	Global Warming Potential factor of methane to carbon dioxide equivalent	

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

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"[21]	

[20] 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^oC and 1 atm is 0.668 kg CH_4/m^3.

Equation 5.3. Continued

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

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'[22]	%
dpm	=	Days per month	days
0.8	=	System calibration factor[23]	
$VS_{avail-1,AS}$	=	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'[24]	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	K
R	=	Ideal gas constant (1.987)	cal/Kmol

[21] Mangino et al.
[22] 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.
[23] 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."
[24] 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 "(VSavail-1 – VSdeg-1)."

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

$$BE_{CH_4,nAS} = \left(\sum_{L,S} P_L \times MS_{L,nAS} \times VS_L \times 365 \times MCF_{nAS} \times B_{0,L} \right) \times 0.717 \times 0.001 \times 21$$

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' – 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	
21	=	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 Mexico 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:

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

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

5.1.1 Modeled Baseline Methane Calculation Variables

The calculation procedure uses a combination of site-specific values and default factors.

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).[25] 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 use the default B_0 factors from Appendix B, Table B.3.

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 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

[25] IPCC 2006 Guidelines volume 4, chapter 10, p. 10.42.

system, the temperature of the system, and the retention time of organic material in the system.[26]

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.[27]

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

5.2 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.

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.

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

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

$$PE_{CH_4} = \left[\left(PE_{CH_4,BCS} + PE_{CH_4,EP} + PE_{CH_4,non-BCS}\right) \times 21\right]$$

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
$PE_{CH4, non-BCS}$	=	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
21	=	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% [28]	% (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[29]	$tCH_4/month$
F	=	Measured volumetric flow of biogas per month	$m^3/month$
T	=	Temperature of the biogas flow (K = ^oC + 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^oC)	$kgCH_4/m^3$
0.001	=	Conversion factor, kg to metric tons	

[28] Project developers have the option to justify a higher BCS collection efficiency based on verifiable documentation.
[29] This value reflects directly measured biogas mass flow and methane concentration in the biogas to the combustion device.

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[30]	
$F_{i,DD}$	=	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

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, Units

MS_{BCS}	=	Maximum biogas storage of the BCS system[31]	m^3
F_{pw}	=	The average total flow of biogas from the digester for the entire week prior to the venting event	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

[30] 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.

[31] 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[32]

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

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[33]	kg/day
$B_{o,ep}$	=	Maximum methane producing capacity[34]	m^3CH_4/kg of VS dry matter
365	=	Number of days in a year	days
0.717	=	Conversion factor for m^3 to kg	
MCF_{ep}	=	Methane conversion factor – Appendix B, Table B.4. Project developers should use the liquid slurry MCF value for effluent ponds	%
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	

[32] If no effluent pond exists and project developers send digester effluent (VS) to compost piles or apply directly to land, for example, then the VS for these cases should also be tracked using equation 3b.
[33] Per ACM0010 (V2 Annex I).
[34] The B_o value for the project effluent pond is not differentiated by livestock category. Project developers could use the B_o value that corresponds with an average of the operation's livestock categories that contributes manure to the biogas control system. Supporting laboratory data and documentation need to be supplied to the verifier to justify the alternative value.

Equation 5.9. Project Methane Emissions from *Non*-Biogas Control System Related Sources[35]

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

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 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

[35] 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).

month period, and the lesser of the two values would be used as the total methane emission reduction quantity for this 6 month period.

Equation 5.10 below details the metered methane destruction calculation.

Equation 5.10. Metered Methane Destruction

$$CH_{4,destroyed} = \sum_{months}(CH_{4,meter} \times BDE) \times 21$$

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.[36] See Equation 5.6 for calculation guidance	% (as a decimal)
21	=	Global Warming Potential factor of methane to carbon dioxide equivalent	

5.3.1 Determining Methane Emission Reductions

- If $CH_{4,destroyed}$ is less than ($BE_{CH4} – PE_{CH4}$) 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

[36] 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.

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.[37]

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

Carbon dioxide emissions from the combustion of biogas are considered biogenic emissions and are excluded from the GHG Assessment Boundary. .

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

[37] This is consistent with guidance in WRI's GHG Project Protocol regarding the treatment of significant secondary effects.

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[38]	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’[39]	GJ/yr
0.001	=	Conversion factor from kg to metric tons	

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

[38] Annual emissions factors from power generation calculated by the Mexico GHG Program (a public-private GHG accounting and reporting initiative from SEMARNAT-CESPEDES-WRI-WBCSD) are available at: http://www.geimexico.org/factor.html.

[39] If the quantity of fuel consumed is given in mass (kg or tones) or volume (lt 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 3.5.2).

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 Monitoring Requirements

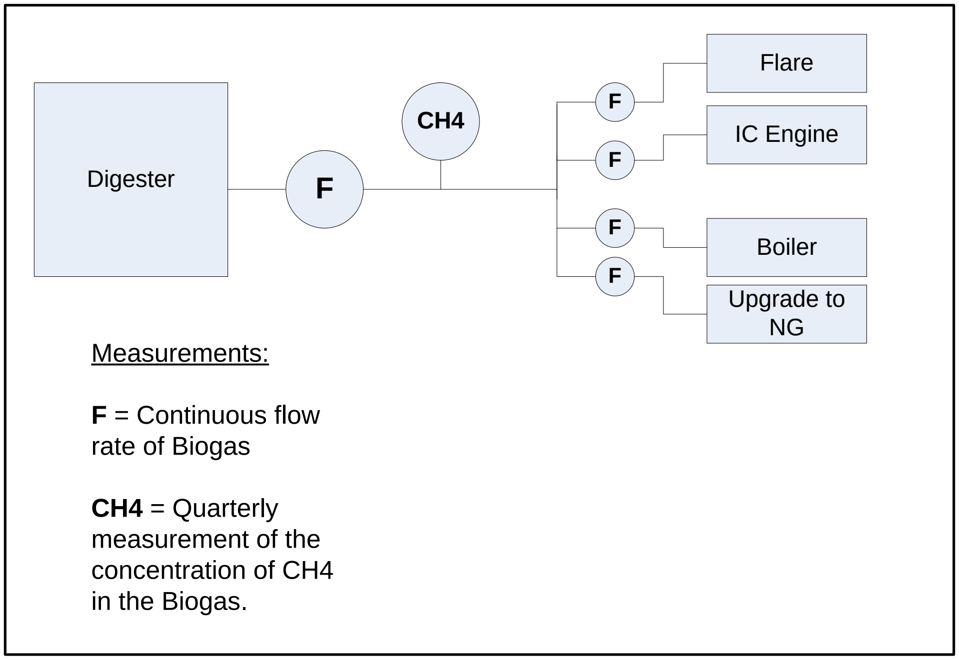
The methane capture and control system must be monitored with measurement equipment that directly meters:

- 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,[40] 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

Flow data must be corrected for temperature and pressure at $0^{o}C$ and 1 atm, either internally or by following the guidance in Equation 5.6.

Figure 6.1 represents the suggested arrangement of the biogas flow meters and methane concentration metering equipment.

[40] 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.

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%.

6.2 Biogas Measurement Instrument QA/QC

All gas flow meters[41] 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
- 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)[42] or

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

manufacturer specified guidance, at the end of but no more than two months prior to the end date of the reporting period[43]

- Calibrated by the manufacturer or a certified calibration service per manufacturer's guidance or every 5 years, whichever is more frequent

If the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment.

For the interval between the last successful field check and any calibration event confirming 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 until such time as the meter is properly calibrated.

1. For calibrations that indicate under-reporting (lower flow rates, or lower methane concentration), the metered values must be used without correction.
2. For calibrations that indicate over-reporting (higher flow rates, or higher methane concentration), the metered values must be adjusted based on the greatest calibration drift recorded at the time of calibration.

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.

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.

6.2.1 Missing Data

In situations where the flow rate or methane concentration monitoring equipment has failed a calibration test (tested to be outside of allowable 5% margin of error), or is missing data, the project developer should apply the data substitution methods provided in Appendix D. If for any reason the destruction device monitoring equipment is inoperable (for example, the thermal coupler on the flare), then no emission reductions can be credited for the period of inoperability.

[42] 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.

[43] 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.

6.3 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	Every verification period	Information used to demonstrate compliance with associated environmental rules, e.g. criteria pollutant and effluent discharge limits. *Verifier:* Determine regulatory agencies responsible for regulating livestock operation; Review regulations and site permits pertinent to livestock 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 herd management software;[44] Review federal, state or local air and water quality agency reporting submissions, if available.

[44] For swine operations and in case that the farm operator does not have a herd management software, it is recommended to use the software "PigMex" as a supporting tool.

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	Every reporting period	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	Every reporting period	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 (0^oC, 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, 0^oC). 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	Every reporting period	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	Every reporting period	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	Every reporting period	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	Every reporting period	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	Every reporting period	Emission factor for all non-BCS storage systems, differentiated by livestock category (see Equation 5.9). *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	Every reporting period	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	Every reporting period	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 Submittal Documentation

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

- Project Submittal form
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Opinion

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

- Verification Report
- Verification Opinion
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form

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 http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

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.

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 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 7.3.4). The end date 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 6 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) Site-visit verifications occur at two-year intervals; and (2) 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.

In order to utilize this option, there are two additional requirements that must be satisfied:

1. 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:

    a. 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
    b. 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
    c. 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

2. Desktop verifications must be conducted by the same verification body that conducted the most recent site-visit verification.

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), Table 7.1 below details what 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 http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/. 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), Table 7.2 below details what 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:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Mexico 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.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify livestock project reports. Verification bodies approved under other project protocol types are not permitted to verify livestock projects. 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 Mexico 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	Mexican farms	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 Mexico 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 7.3.3 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. While verification bodies are not expected to provide a reasonable level of assurance on the accuracy of the monitoring report as part of 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
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 21, 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 310, 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 Mexico 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.[45]
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 7.3.4). The end date of any verification period must correspond to the end date of a reporting period.

[45] 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 bio-gas 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.

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 (TAM) in kg
Dairy cattle	
Dairy and non-milking dairy cows (on feed in intensive systems)	550[a]
Heifers (on feed in intensive systems)	415[b]
Bulls (grazing in large areas)	450[b]
Calves (semi-intensive with grazing or dual-purpose in extensive systems)	151[c]
Heifers (semi-intensive with grazing or dual-purpose in extensive systems)	300[c]
Cows (semi-intensive with grazing or dual-purpose in extensive systems)	425[c]
Swine	
Nursery swine	14.6[d]
Growing swine	40[d]
Finished swine	78[d]
Male swine	163[d]
Non-breeding swine	150[d]
Breeding swine	182[d]
Lactating breeding swine	191[d]

[a] Average animal mass of dairy cows in Mexico. Sources: FIRCO-SAGARPA, *Potencial de biogás en México*, México and SAGARPA, *Generación y Aprovechamiento de biogas en Granjas Porcinas y Establos Lecheros*, México.
[b] Default values for North America (feedlot cattle) and for Latin America (adult males). Source: IPCC, 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*, Volumen 4, Chapter 10, Annex 10-A2. (Table 10A-2).
[c] Typical average animal mass at the national level: calves (0 – 1 year), heifers (average 1 – 3 years), cows (older than 3 years). Source: Ruiz-Suarez, L.G. and E. Gonzalez-Avalos, 1997, "Modeling methane emissions from cattle in Mexico" in *The Science of the Total Environment*, Elsevier, vol. 206, pp. 177-186 (Table 2).
[d] Consejo Mexicano de Porcicultura, 1997, *Manual para el manejo y control de aguas residuales y excretas porcinas en México*, project developed by E.P. Taiganides, R. Pérez-Espejo and E. Girón-Sánchez, México, D.F., México (Box 2.5).

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		
Dairy and non-milking dairy cows (in intensive systems in cool and temperate climate with an average annual temperature between 8°C and 23°C)	3.91[a]	0.188[b]
Dairy and non-milking dairy cows (in intensive systems in warm climate with an average annual temperature warmer than 24°C)	4.46[a]	0.188[b]
Heifers (intensive systems – feedlot cattle)	2.02[c]	0.17[c]
Bulls (grazing)	2.87[c]	0.10[c]
Calves and heifers (pasture or grazing in semi-intensive systems or dual-purpose)	2.14[c]	0.10[c]
Heifers (pasture or grazing in semi-intensive systems or dual-purpose)	2.14[c]	0.10[c]
Cows (grazing in semi-intensive systems in cold and temperate climate with an average annual temperature between 8°C and 23°C)	2.86[a]	0.10[c]
Dual-purpose cows (grazing in extensive systems in cold and temperate climate with an average annual temperature between 8°C and 23°C)	1.33[a]	0.10[c]
Dual-purpose cows (grazing in extensive systems in warm climate with an average annual temperature warmer than 24°C)	1.51[a]	0.10[c]
Swine		
Nursery swine	0.139[d]	0.48[e]
Growing swine	0.413[d]	0.48[e]
Finished swine	0.484[d]	0.48[e]
Male swine	0.272[d]	0.48[e]
Non-breeding swine	0.847[d]	0.48[e]
Breeding swine	0.405[d]	0.48[e]
Lactating breeding swine	1.139[d]	0.48[e]

[a.] Estimations based on a study that examined laboratory measurements and chemical analyses of cattle manure in the Central region of Mexico (applicable for the entire country). The volatile solids values were estimated multiplying the fresh manure rate by the difference between the dry matter and ash content in the manure.
Source: González-Ávalos, E. and L.G. Ruiz-Suárez, 2001. "Methane emission factors from cattle manure in Mexico" in *Bioresource Technology*, vol. 80, p. 63-71 (Table 2 – Chemical analyses of cattle manure - and Table 3 – Average daily fresh manure for various types of housing systems).
[b] González-Ávalos, E., 1999. *Determinación Experimental de los Factores de Emisión de Metano por Excretas de Bovino en México*, PhD thesis, Universidad Nacional Autónoma de México, México (page 76).
[c] Default values for North America (feedlot cattle) and for Latin America (adult males and young). Source: IPCC, 1996. *IPCC Guidelines for National Greenhouse Gas Inventories,* Chapter 4, Annex B (Table B-1)
[d] Estimations based on data of the software "PigMex" that uses excretion rate values for Mexico, VS values were calculated multiplying the total volatile solids (in kg TVS/100 kg. of animal live weight) by the typical animal mass for each swine animal category (from Table B.2). Source: Consejo Mexicano de Porcicultura, 1997, *Manual para el manejo y control de aguas residuales y excretas porcinas en México*, project developed by E.P. Taiganides, R. Pérez-Espejo and E. Girón-Sánchez, México, D.F., México (Box 3.9).
[e] Default values for North America. Source: IPCC, 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*, Volumen 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' [46]

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).

[46] 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 passenger car (without catalyst – Before 1990)	58.07
Gasoline passenger car (with oxidation 2-way catalyst – 1991-1992)	66.82
Gasoline passenger car (with used 3-way catalyst – open or closed cycle – 1993 – 1997)	70.07
Gasoline passenger car (with new 3-way closed cycle catalyst – After 1998)	71.07
Gasoline light duty trucks (without catalyst – Before 1990)	57.07
Gasoline light duty trucks (with improved technology, without catalyst – 1991-1992)	60.82
Gasoline light duty trucks (with used 3-way catalyst – open or closed cycle – 1993-1997)	68.97
Gasoline light duty trucks (with new 3-way catalyst – After 1998)	70.52
Gasoline heavy duty trucks and buses (without catalyst – Before 1992)	55.56
Gasoline heavy duty trucks and buses (with catalyst – After 1993)	60.87
Diesel vehicles (passenger cars, light and heavy trucks – with or without emissions control)	72.10
LPG vehicles (passenger cars and heavy trucks – without control and with 3-way catalyst)	61.23
Natural gas vehicles (passenger cars and heavy trucks – with 3-way catalyst)	56.10
Motorcycles (with or without emissions control)	72.10
Compressed natural gas vehicles (CNG) [c]	56.10
Liquefied natural gas vehicles (LNG) [c]	56.10
Airplanes (jet fuel) [c]	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] INE, 2005. Inventario Nacional de Emisiones de Gases de Efecto Invernadero 2002, Sector Transporte. INE-SEMARNAT, México. (Annexes, Tables 4-12, pages IA3-95 – IA3-99). Available on line: http://www.ine.gob.mx/cclimatico/inventario3.html
[c] IPCC, 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 2, Chapter 3, Mobile combustion, Table 3.2.1, pages 3.16.

Table B.6. Fossil Fuel Net Calorific Values

Fuel	Net calorific value
Solid fuels	
National thermal coal	19.405 GJ/metric tonne
National metallurgic coal	23.483 GJ/metric tonne
Petroleum coke	31.424 GJ/metric tonne
Coking coal	26.521 GJ/metric tonne
Liquid fuels [a]	
Crude oil	0.03871 GJ/liter
Gasoline	0.03161 GJ/liter
Kerosene	0.03381 GJ/liter
Diesel	0.03555 GJ/liter
Residual fuel oil	0.03944 GJ/liter
Liquefied Petroleum Gas (LPG) [b]	0.02627 GJ/liter
Naphtha	0.03161 GJ/liter
Lubricants	0.03888 GJ/liter
Gaseous fuels	
Natural gas [c]	0.03391 GJ/m^3

[a] 1 barrel = 158.9873 liters
[b] Fuel obtained from oil distillation and after processing the natural gas liquids. It mainly consists on propane, butane or a mixture of both. It is mainly used in the residential and commercial sectors as well as in vehicles for passenger and freight transportation.
[c] Found as "gas seco" in the Energy National Balance, which corresponds to the gaseous hydrocarbon obtained as a by-product in the natural gas processing plants and refineries after liquefied by-products has been extracted. This fuel is used in the residential, commercial, industrial, agriculture and public sectors as well as in power plants.
Sources: SENER, 2006. *Balance Nacional de Energía 2007*, Dirección General de Información y Estudios Energéticos, SENER, México. Box 21, page 100. Available at: http://www.energia.gob.mx/webSener/res/PE_y_DT/pub/Balance_2007.pdf (March 2009)

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. The 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] The 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 118,000kgCH_4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH_4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/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.[47]

[47] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007).

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 greenhouse gas (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 managing livestock manure. 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 Mexican-specific data on dairy and swine manure management systems. Ultimately, it recommended a practice-based/technology-specific GHG emissions performance standard – i.e. the installation of a manure digester (or biogas control system, more generally). The paper had the following sections:

- The livestock industry in Mexico
- GHG emissions from livestock manure management
- Data on livestock manure management practices in Mexico
- Mexican environmental regulations impacting manure management practices
- Recommendation for a performance threshold for livestock operations

C.1 Data of Livestock Operations in Mexico

According to the 2007-2012 National Livestock Program and to the SIAP (Agricultural, Livestock, Food and Fisheries Information System) of the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), the beef cattle has a population of approximately 28.9 million heads at nearly a million production units.[48] This activity is carried out mainly in extensive grazing production systems, covering more than 50% of the national territory. However, nearly 2.5 million head (8.7% of the total population) is raised in fattening/growing corrals, mainly in the arid and semi-arid northern regions of the country.

The total dairy herd had population of around 2.2 million head in 2005.[49] The states that concentrate around the 70% of the dairy cattle are: the Lagunera Region (Coahuila and Durango) (24.1%), Chihuahua (9.9%), Jalisco (9.8%), Hidalgo (8.5%), Puebla (7.9%) and Guanajuato (7.4%). Nearly 50.6% of milk production originates from specialized intensive farms; 21.3% from semi-intensive systems, 18.3% of double purpose systems and 9.8% of small back-yard farms.[50]

Swine operations had a population of around 15.2 million hogs in 2005. Almost 50% of swine population concentrates in the states of Jalisco (15.1%), Sonora (8.4%), Puebla (8.0%), Veracruz (7.2%), Guanajuato (6.7%) and Yucatán (6.5%),[51] 43.6% of this population is located

[48] Available on line: www.sagarpa.gob.mx/ganaderia/PNP/PNP260907.pdf and http://www.siap.sagarpa.gob.mx/ (March 2009)
[49] SIAP data from SAGARPA. Available on line: http://www.siap.sagarpa.gob.mx/ (March 2009)
[50] Gallardo-Nieto, JL. 2005. *Situación actual de la producción de leche de bovino en México 2004*. Coordinación General de Ganadería, SAGARPA, México.
[51] SIAP data from SAGARPA. Available on line: http://www.siap.sagarpa.gob.mx/ (March 2009)

in 4,286 specialized and semi-specialized farms, while the remaining 56.4% is located in more than 1.5 million small back-yard family farms.

Table C.1 illustrates the livestock population in Mexico and its possible distribution according their production systems.

Table C.1. Livestock Population Data for Mexico, 2005

	Total population[a] [head]	Extensive grazing or back-yard livestock operations		Modern and semi-modern intensive livestock operations	
		Population [head]	Production units [farms]	Population [head]	Production units [farm]
Beef cattle	28,836,622	23,366,622	n.a.	2,500,000[b]	n.a.
Dairy cattle	2,197,346	617,454[e]	n.a.	1,579,892[e]	3,000[c,d]
Swine	15,206,310	5,473,520[c]	1,501,672[c]	6,635,988[c]	4,286[c]

n.a. not available
[a] Sistema de Información Agrícola y Pecuaria (SIAP) http://www.siap.sagarpa.gob.mx/ (March 2009)
[b] SAGARPA, 2008. *Programa Nacional Pecuario 2007-2012,* SAGARPA, Mexico. http://www.sagarpa.gob.mx (March 2009)
[c] FIRCO-SAGARPA, *Potencial de biogás en México*. México.
[d] Dairy farms with herds greater than 100 head.
[e] Own estimations assuming that 50.6% of dairy cattle is in specialized farms, 21.3% in semi-specialized, 18.3% in double-purpose systems and 9.8% in back-yard farms.

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

Conditions for methane generation exist under manure treatment and storage, namely anaerobic lagoons and/or storage ponds. The distribution of livestock across different sized operations can be an important criterion when developing a livestock manure management performance standard. There is a general relationship between manure management practices and operation size, where larger operations (in terms of livestock numbers) tend to use manure management systems that treat and store waste in liquid form (i.e. flush or scrape/slurry systems), particularly in dairy and swine operations.

Because national level data for livestock manure management systems were not available, the analysis was conducted based on publications and data provided by Mexican institutions such as SAGARPA, FIRCO, reports, academic papers, and CDM project design documents related to dairy cattle and swine operations.

Swine Operations

According to data set provided by the Coordination of Livestock of the SAGARPA, there are 4,286 specialized and semi-modern farms with an approximate population of 6.6 million hogs. At the national level, 62% of these farms have small (from 1 to 100 heads) or medium-size herds (from 101 to 500 heads), while 38% of the farms have herds greater than 500 hogs. Small and medium semi-modern swine operations are predominant in states like Jalisco, Michoacán and Guanajuato. Although some of these farms may have modern technologies, several of them continue employing traditional manure management systems, such as liquid slurry, solid storage, composting and liquid treatment systems (complete lagoons systems, sedimentation lagoons and sedimentation and oxidation ponds).[52] On the other hand, intensive modern swine operations with herds greater than 2,000 hogs are mainly located in Sonora, Yucatán, Nuevo León and Sinaloa.

A study conducted by the National Autonomous University of Mexico (UNAM) and SEMARNAT examined the relation between farm size and manure treatment systems, among others variables, in order to analyze the cost-benefit of the NOM-001 in the quality of wastewater in swine farms. [53] In this study, the farm size is defined according to the organic load of the wastewater discharge based on the quantity of total suspended solids (TSS) as well as to the compliance dates of the norm as follows:

- Large swine operations that have the compliance date as of January 1, 2000 and with a wastewater generation with more than 3 tonnes per day of TSS are those with an approximate number of 833 “sows” [54] (around 8,330 hogs);
- Medium-sized operations having the compliance date as of January 1, 2005 and with a wastewater generation with 1.2 to 3 tonnes of TSS have between 333 and 833 “sows” (around 3,330 and 8,330 hogs); and
- Small-sized operations having the compliance date as of January 1, 2010 and with a wastewater generation with less than 1.2 tonnes of TSS with a herd smaller than 3,330 hogs.

According to this classification and to the database provided by SAGARPA, there are around 165 large farms (3.8% of the 4,286 formal farms) that concentrate around 40.6% swine population in these farms; 430 medium-sized farms (10% of the formal farms) with 32.2% of the population, and the 86.1% of the remaining farms (3,691 farms) are small-sized farms with 27.2% of the population.

In theory, large and medium-sized farms that discharge to water bodies would require tertiary treatment systems, which usually include a lagoon when using a biological process, to comply with the maximum contamination limits established in the NOM-001. In practice, there are not enough data or studies available to assure this, neither the degree of compliance with the standard. However, the above mentioned study describes that several of the analyzed farms had different types of treatment systems. In addition, experts coincide that modern and semi-modern swine farms generally have lagoon-based treatment systems.[55]

On the other hand, 69 CDM projects related to manure management in swine operations (registered in the CDM Executive Board by February 2009) were examined. These projects provide information of around 430 farms with a total population of 2.2 million hogs, where 73% of these farms have herds greater than 2,000 heads. According to these projects, the most common manure collection techniques are: scrapper, pull & plug, flush, pumping or a combination of them. As to manure treatment and storage methods, 95.8% of the farms reported to have open lagoons systems; 0.5%, use earthen basins, and the 2.6% reported to

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[52] Steinfeld, H., H. Menzi, P. Gerber, M. Sánchez, S. Gómez, G. Barrera, J.A. Espinosa, G. Salazar, J.G. Martínez, G. Mariscal, P. Jurado, J. González, R. Pérez-Espejo, 2003. *Reporte de la Iniciativa de la Ganadería, el Medio Ambiente y el Desarrollo (LEAD) - Integración por Zonas de la Ganadería y de la Agricultura Especializadas (AWI) - Opciones para el Manejo de Efluentes de Granjas Porcícolas de la Zona Centro de México*. FAO, Roma, Italia. http://www.fao.org/WAIRDOCS/LEAD/X6372S/X6372S00.HTM

[53] Pérez-Espejo, R., 2006. *Granjas porcinas y medio ambiente, Contaminación del agua en La Piedad, Michoacán*, Plaza y Valdés Editores, México, pp. 201. (Box 8, page 101)

[54] One “sow” is defined as a breeding swine with an approximate weight of 180 kg. that can give birth to 8 to 12 litters. Under this definition, an approximation of 10 hogs per sow is used.

[55] Experts’ opinion: personal communication with staff from the Electrical Research Institute (IIE by its Spanish acronym) and Colegio de la Frontera Norte (April 15, 2009).

flush the manure from the barns draining to concrete canals and subsequently discharged into agricultural canals.

Based on the examined CDM projects, academic papers and experts' opinion, it can be considered that treatment lagoon systems are the common practice in intensive systems at large and medium-sized modern and semi-modern swine farms. In addition, it is mentioned that open lagoon systems is the prevailing practice in Mexico due to the fact that it is the least expensive manure treatment which meets the requirements of local, state and federal wastewater legislation.

Dairy cattle

According to González-Ávalos and Ruiz-Suárez (2007),[56] anaerobic lagoons and slurry manure management systems are more likely to benefit milk production under intensive systems (50.6% of national milk production). Semi-intensive and dual-purpose production systems (31.1% of milk production) may use dry lot or solid storage systems where manure is stored for spreading later in agricultural fields as fertilizer.

In Mexico, there are around 3,000 dairy farms with herds greater than 100 head.[57] Although the most common herd size for large modern farms is between 100 and 500 head, the general trend in Mexico is toward total confinement production systems with increasingly large herds.[58] In the Lagunera Region (Coahuila and Durango) and Chihuahua, intensive operations with herds between 2,000 and 6,000 head can be found.

Seventeen CDM projects related to manure management in dairy farms (registered in the CDM Executive Board by February 2009) were examined. These projects provide information of 34 farms with a total population of 63,649 dairy cows. The herd size of these farms varied from 300 and 5,295 head. The most common collection techniques from corrals, milking parlors and holding areas were the use of scrapers, tractors and vacuum in 44% of the farms, while 41% of the farms mixed water with manure waste to flush it into the storage facilities. As to manure treatment and storage methods, 65% of the farms reported to have open lagoons systems; while the remaining 35% did not specify their current manure storage method, some of them stated to have anaerobic lagoons under construction or under planning. Based on the examined CDM projects and experts' opinion, it can be considered that open lagoon systems are the common practice in modern and semi-modern intensive dairy farms that have manure treatment systems. [59]

C.3 Current Digester Use in Mexico

Since the entry into force of the Kyoto Protocol in 2005 and the full operation of the CDM, methane recovery in large-scale swine farms has rapidly gained importance. Up to February 2009, around 69 swine breeding projects and 17 dairy operation projects for methane emissions reduction has been registered in the CDM Executive Board. Table C.2 illustrates the implementation of 431 digesters in different states through these CDM projects. In the case of

[56] González Ávalos, E. and L.G. Ruiz-Suárez, 2007. "Methane conversion factors from cattle manure in Mexico" in *Atmósfera*, vol. 20, no. 1, p. 83-92.
[57] FIRCO-SAGARPA, *Potencial de biogás en México*. México.
[58] Speir, J., M.A. Bowden, D. Ervin, J. McElfish, R. Pérez-Espejo, T. Whitehouse, C. Line Carpenter, 2003. *Comparative Standards for Intensive Livestock Operations in Canada, Mexico, and the United States*, Report prepared for the Commission of Environmental Cooperation. Available: http://www.cec.org/files/PDF/ECONOMY/Speir-etal_es.pdf
[59] Experts' opinion: personal communication with staff of the Electrical Research Institute and Colegio de la Frontera Norte (April 15, 2009).

swine farms, it was estimated that around 90% of the digesters mentioned in the CDM project design documents were actually implemented.[60]

Table C.2. Number of Digesters Implemented in Swine and Dairy Farms through CDM Projects

State	Total modern and semi-modern swine farms by state [farms][a]	Number of digesters in swine farms[b]	Number of digesters in dairy farms [b]
Sonora	344	146	0
Jalisco	1,352	102	0
Puebla	74	43	0
Veracruz	90	31	0
Tamaulipas	25	13	0
Yucatán	219	16	0
Nuevo León	142	12	0
Guanajuato	917	9	2
Sinaloa	26	6	0
Michoacán	357	4	0
Querétaro	60	4	0
Aguascalientes	26	4	2
Chiapas	80	3	0
Hidalgo	103	2	0
Estado de México	46	2	0
Durango	27	1	8
Coahuila	23	1	16
San Luis Potosí	17	1	0
Baja California	7	0	2
Chihuahua	1	0	1
Total	**3,936**	**400**	**31**

[a] Data set provided by the Livestock Coordination of SAGARPA
[b] Estimation based on CDM Project design documents, available on line: http://cdm.unfccc.int/Projects/registered.html (February 2009)

C.4 Performance Standard Recommendation

The performance standard recommended is a technology-specific threshold that dairy or swine operators would meet. The threshold should be the installation of a biogas control system (anaerobic digester).

With regard to swine operations, 43.6% of the total swine population is located in 4,286 specialized and semi-specialized farms, while the remaining 56.4% is located in small back-yard farms. The anaerobic digesters implemented and operating in 430 farms through CDM projects represent around 10% of all the formal farms, implying that around 3,716 modern and semi-modern farms may not have installed anaerobic digesters. Despite the fact that the farms operating digesters in certain states represent a significant percentage of their number of formal modern farms (for example, 47% of the farms in Puebla; 40% in Sonora; and 31% in Veracruz), the installation and use of digesters in swine operations is not a prevailing practice due to the following institutional, technological and financial barriers.[61]

[60] Experts' opinion: personal communication with staff of the Mexican Swine Confederation and an independent consultant (April 22 and May 11, 2009 respectively).
[61] SEMARNAT, 2008. *Methane to Markets, Mexico Profile, Animal Waste Management Methane Emissions*, México. Available on line: http://www.methanetomarkets.org/resources/ag/docs/mexico_profile.pdf

Institutional Barriers

- Lack of environmental laws related to livestock operations and the low enforcement of existing ones
- Weak national institutional capabilities to design and manage projects to reduce methane emissions derived from the livestock activity
- Without some kind of government guarantee or incentive, local commercial banks are not usually interested in financing the acquisition of anaerobic digesters, primarily because of lack of knowledge and experience with the technology

Technological Barriers

- Large heterogeneity among the livestock production units in relation to their size and use of technology
- High investment costs, engineering services, operational and maintenance costs
- These systems become progressively more expensive on a 'per animal' basis as farm size decreases
- Lack of comprehensive schemes to address the issue of livestock waste
- There is not a consolidated industry currently producing digesters on regular and systematic basis at a national level. It is necessary to import relevant digester components, such as covers and geo-membranes as well as monitoring instruments and enclosed flares

Economic Barriers

- Uncertainty with regards to profitability levels for the livestock producers
- There are not enough public and private funding schemes
- Critical economic situation of national breeders due to international prices. This makes it difficult for them to invest in waste treatment
- Odor benefits, potential water quality enhancements, and the incremental savings associated with heating cost avoidance, are rarely enough to compel farmers to upgrade to an anaerobic digestion system

Socio-cultural Barriers

- Low local capacity (qualified personnel) to construct, operate and/or maintain anaerobic digesters
- Cultural change of the farm operators is required in order that their farm cleaning practices as well as the animals' feeding do not affect the methane-producing bacteria population

With regard to dairy operations, the 31 digesters installed in these operations through CDM projects is low (around 1%) compared to number of estimated 3,000 production units greater than 100 dairy cows. In a similar manner to the case of swine operations, the main barrier inhibiting the installation and use of digesters is cost. According to a case study in the Delicias, Chihuahua, region, the installation cost of a digester can vary between $1,512,614 and $1,589,297 Mexican pesos for dairy cattle between 200 and 2,000 head respectively.[62]

It is important to note that although some municipalities recommend the use of particular manure management systems, the installation of anaerobic digesters is not mandatory in any of these municipalities.

[62] Casas, M., B.A. Rivas, M. Soto, A. Segovia, H.A. Morales, M.I. Cuevas, C.M. Keissling, 2009. "Estudio de Factibilidad para la puesta en marcha de digestores anaeróbicos en establos lecheros en la Cuenca de Delicias, Chihuahua" in *Revista Mexicana de Agronegocios*, volumen 24, Universidad Autónoma de la Laguna, México, p. 745-756.

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.

D.1 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.[63]

[63] 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.