METHODOLOGICAL DOCUMENT
WASTE SECTOR

Large-scale Consolidated Methodology

BCR0008. Biomethanisation Plants Animal Manure Management for Renewable Energy, Heat Generation, and CH_4 & N_2O Mitigation

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1. Introduction

In the global effort to combat climate change, reducing greenhouse gas (GHG) emissions is imperative. Among the various sectors contributing to GHG emissions, waste handling and disposal, as well as agriculture, play significant roles. To address emissions in these sectors, the implementation of robust methodologies is essential. This document presents a methodology tailored for the calculation of emission reductions and removals in GHG projects within the waste handling and disposal and agriculture sectors, within in BCR Standard.

This methodology is designed specifically for projects that utilize animal manure as their primary input. The process involves the collection of animal manure from diverse livestock farms, facilitated through tank trucks, pipelines, or pumps, and subsequently processed at a centralized treatment facility. The central aspect of this methodology revolves around the substitution of individual on-farm anaerobic manure treatment systems with a centralized treatment plant. This centralization enables the utilization of one or more Animal Waste Management Systems (AWMSs) renowned for emitting fewer greenhouse gases.

The methodology outlined herein is suitable for projects involving the substitution or modification of existing anaerobic manure management systems on animal farms. This encompasses a wide array of livestock, including dairy and beef cattle, buffalo, swine, turkeys, ducks, sheep, goats, and poultry. Such projects may entail the aggregation of manure from multiple farms at a centralized location, with the overarching objective of capturing methane for either flaring, combustion, or energy generation purposes.

The core emission mitigation actions outlined in this methodology revolve around the substitution or modification of current anaerobic manure management systems on animal farms. By centralizing the processing of manure and implementing efficient treatment technologies, projects can effectively reduce GHG emissions associated with animal husbandry practices.

2. Objectives

The objectives of this methodological document (hereinafter referred to as this Methodology) is set out:

(a) the methodological requirements necessary for the identification of the baseline for projects that utilize animal manure as the main input of anaerobic manure management systems on animal farms;

(b) the requests for the quantification of GHG emission reductions resulting from the collection of different livestock farms through tank trucks, pipelines, or pumps, and processed at a centralized treatment facility;

(c) the requirements for the quantification of GHG emission removals resulting from heat or exported electricity generated from biogas.

3. Version and validity

This version constitutes the Version 1.0. July 4, 2024.

This version may be updated from time to time and intended users should ensure that they use the most recent version of the document.

4. Scope

This document provides a methodology for baseline establishment, quantification of GHG emission reductions and/or removals, monitoring and leakage management of projects that utilize animal manure as the main input, collected from different livestock farms through tank trucks, pipelines, or pumps, and processed at a centralized treatment facility. It involves substituting individual on-farm anaerobic manure treatment systems with a central treatment plant utilizing one or more Animal Waste Management Systems (AWMSs) known for emitting fewer greenhouse gases. Furthermore, generation of heat or exported electricity from biogas.

This methodology should be used by GHG project holders only for certification and registration under the BCR STANDARD.

5. Applicability conditions

This Methodology is applicable under the following conditions:

(a) Farms where livestock populations, comprising of cattle, buffalo, swine, sheep, goats, and/or poultry, are managed under confined conditions;

(b) Farms where manure is not discharged into natural water resources (e.g. rivers or estuaries);

(c) Farms where animal residues are treated under anaerobic conditions;

(d) The annual average temperature in the site where the anaerobic manure treatment facility in the baseline existed is higher than 5°C;[1]

(e) In the cases where the baseline anaerobic treatment system is an open lagoon, the lagoon depth shall be greater than 1 m;[2]

(f) The retention time of the organic matter in the baseline anaerobic treatment systems should be at least 30 days;

(g) If residues are stored in between collection activities, storage tanks shall comprise outdoor open equipment;

(h) If the treated residue is used as fertilizer in the baseline, project proponents must ensure that this end use remains the same throughout the project activity;

(i) Sludge produced during the project activity shall be stabilized through thermal drying or composting, prior to its final disposition/application;

(j) The AWMS/process in the project case should ensure that no leakage of manure waste into ground water takes place, e.g., the lagoon should have a non-permeable layer at the lagoon bottom;

(k) Technical measures shall be used (including a flare for exigencies) to ensure that all biogas produced by the digester is used or flared;

(l) The storage time of the manure after removal from the animal barns, including transportation, should not exceed 45 days before being fed into the anaerobic digester. If the project proponent can demonstrate that the dry matter content of the manure when removed from the animal barns is larger than 20%, this time constraint will not apply.

(m) In the case that the project involves co-digestion of organic waste, emission reductions related to the organic waste portion of feed material shall be accounted as baseline leakage emission following the related procedures from described in the leakage section of this methodology. VCCs resulting from these emissions shall not be claimed.

(n) Projects that recover methane from landfills shall use "AMS-III.G Landfill methane recovery" and/or "ACM0001: Flaring or use of landfill gas" and projects for

[1] If monthly average temperature in a particular month is less than 5°C, this month is not included in the estimations, as it is assumed that no anaerobic activity occurs below such temperature.

[2] In particular, loading in the wastewater streams has to be high enough to assure that the lagoon develops an anaerobic bottom layer and that algal oxygen production can be ruled out.

wastewater treatment shall use "AMS-III.H Methane recovery in wastewater treatment" and/or "ACM0014 Treatment of wastewater".

VCCs shall be claimed by the Central Treatment Plant managing person/entity, only. Other parties involved must sign a legally binding declaration that they will not claim VCCs from the improved animal waste treatment practices. Such declarations shall be verified by the CAB during the validation, and these documents shall be valid throughout the whole crediting period.

In addition, the applicability conditions included in the tools referred to below apply.

This methodology is only applicable if the application of the procedure to identify the baseline scenario results in that anaerobic manure treatment systems without methane recovery in the farms are the most plausible baseline scenario.

5.1. Applicability of sectoral scopes

Conformity Assessment Bodies (CABs) are required to apply sectoral scopes 13 and 15 when validating and verifying project's activities using this methodology.

6. Normative References

The following references are indispensable for the application of this Methodology:

(a) The BCR STANDARD, in its most recent version;

(b) IPCC 2019, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 'Agriculture, Forestry and Other Land Use', Corrected Chapter 5 as of July 2023 'Emissions from Livestock and Manure Management';

(c) IPCC 2019, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5 'Waste', Chapter 3 'Solid Waste Disposal'

(d) National legislation in force, related to GHG projects, or those regulations that modify or update them, as applicable;

(e) The guidelines, other orientations and/or guides defined by BIOCARBON, in the scope of the projects in the Waste and AFOLU sector.

This methodology also refers to the latest approved versions of the following methodologies and tools:

(a) "AM0073: GHG emission reductions through multi-site manure collection and treatment in a central plant";

(b) "ACM0001: Flaring or use of landfill gas";

(c) "ACM0010: Consolidated baseline methodology for GHG emission reductions from manure management systems";

(d) "ACM0014: Treatment of wastewater"

(e) "AMS-III.D: Methane recovery in animal manure management systems";

(f) "AMS-III.F: Avoidance of methane emissions through composting";

(g) "AMS-III.G: Landfill methane recovery";

(h) "AMS-III.H: Methane recovery in wastewater treatment";

(i) "AMS-III.AO: Methane recovery through controlled anaerobic digestion".

This methodology also refers to the latest approved versions of the following tools:

(a) CDM Tool 02: Combined tool to identify the baseline scenario and demonstrate additionality;

(b) CDM Tool 03: Tool to calculate project or leakage CO2 emissions from fossil fuel combustion;

(c) CDM Tool 04: Emissions from solid waste disposal;

(d) CDM Tool 05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation;

(e) CDM Tool 06: Project emissions from flaring;

(f) CDM Tool 07: Tool to calculate the emission factor for an electricity system;

(g) CDM Tool 08: Methodological Tool: Tool to determine the mass flow of a greenhouse gas in a gaseous stream;

(h) CDM Tool 14: Project and Leakage Emissions from Anaerobic Digesters;

(i) CDM Tool 24: Methodological tool: Common practice;

(j) CDM Tool 27: Methodological tool: Investment analysis;

Likewise, it is essential to comply with the following ISO Standards:

(a) ISO 14064-2:2019(es). Greenhouse gases - Specification with guidance, at the project level, for the quantification, monitoring and reporting of emission reductions or enhancement of greenhouse gas removals, or that which updates it;

(b) ISO 14064-3:2019(es). Greenhouse gases - Part 3: Specification with guidance for validation and verification of greenhouse gas declarations, or that which updates it.

7. Terms and definitions

Additionality

Is the effect of the GHG Project activity to reduce anthropogenic GHG emissions below the level that would have occurred in the absence of the GHG Project activity.

Source: Adapted from Glossary CDM terms. Version 10.0

Agriculture, Forestry, and Other Land Use (AFOLU)

Sector comprising greenhouse gas emissions and/or removals attributable to project activities in the agriculture, forestry and other land use sector.

Baseline scenario

The scenario for the GHG project that reasonably represents the sum of carbon stock changes within the project boundary that would occur in the absence of the GHG project[3].

Project start date

Date on which activities that will result in actual GHG emission reductions or removals begin. For GHG projects applying this methodology, the start date corresponds to the date on which the implementation of project activities begins.

Permanence

The condition resulting from project activities whereby the system established within the project boundaries is continuously extended, ensuring that the function of conserving carbon stocks is maintained over time.

GHG Project (Greenhouse gases project)

Activity or activities that change the conditions of a GHG baseline and cause GHG emissions to be reduced or GHG removals to be increased[4].

Flaring

Combustion of biogas at an enclosed / open flare;

[3] Adapted of Glossary CDM terms. Version 10.0
4 ISO 14064-3:2019(es), 3.4.1.

Venting

Engineered or intentional releases of gases into the atmosphere, such as the venting of biogas from anaerobic digesters;

Co-digestion

Co-digestion is the simultaneous digestion of a homogenous mixture of two or more substrates from different sources, e.g. co-digestion of animal manure and MSW (municipal solid waste). The most common situation is when a major amount of a primary basic substrate (e.g. manure) is mixed and digested together with minor amounts of other substrates;

Effluent

Untreated effluent of the anaerobic digester;

Treated effluent

Effluent of the anaerobic digester that is stabilized through thermal drying treatment;

Residue

Effluent of the anaerobic digester that is stabilized through the composting process.

The definitions provided in the normative references given above, along with the Glossary of CDM Terms, shall be applicable. In case of any discrepancies in the definitions across the various normative references cited above, the definition from the latest normative reference shall be adopted.

8. Project boundaries

The spatial extent of the project boundary encompasses:

(a) The central treatment plant;

(b) The livestock farms[5];

(c) The site of the biogas combustion or energy generation facility (if existent);

(d) The manure storage tanks;

[5] Any changes to animal manure supplier farms, including the addition of new suppliers or the removal of existing ones, must be thoroughly justified and documented in the Project Document. The Designated Operational Entity (CAB) is responsible for assessing and validating whether the new animal manure supplier farms meet the baseline scenario's applicability conditions.

(e) The road itineraries and/or piping system between the feedstock collection points and the central treatment plant;

(f) The road itineraries between the central treatment plant where treated effluent is generated and the agricultural plots where it is applied.

8.1. Project temporal boundaries and analysis period

Project temporal boundaries correspond to the periods during which project activities are carried out and GHG emission reductions and removals are quantified.

The project temporal boundaries shall be defined considering the following:

(a) The start date of the project;

(b) The period of quantification of the reductions/removals; and the period of quantification of the reductions/removals.; and,

(c) The monitoring periods.

Project emission reductions are accounted for during the project's quantification period. That is, the period during which the project holder quantifies GHG reductions/removals, measured against the baseline, for the purpose of request the issuance of Verified Carbon Credits (VCCs).

The analysis period for the project area during verification corresponds to the monitoring period.

8.2. Carbon reservoirs

The greenhouse gases included in or excluded from the project boundary are shown in Table 1.

Table 1. Emissions sources included in or excluded from the project boundary

Source		Gas	Included / Excluded	Justification / Explanation
Baseline	Direct emissions from the manure treatment processes	CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted
		CH_4	Included	The major source of emissions in the baseline scenario
		N_2O	Included	Important source of emissions in the baseline scenario

Source		Gas	Included / Excluded	Justification / Explanation
	Emissions from electricity consumption / generation	CO_2	Included	Electricity may be consumed from the grid or generated onsite in the baseline scenario
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	Emissions from thermal energy generation	CO_2	Included	If thermal energy generation is included in the project activity
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
Project Activity	Emissions from thermal energy generation	CO_2	Included	May be an important emission source
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from on-site electricity use	CO_2	Included	May be an important emission source. If electricity is generated from collected biogas, these emissions are not accounted for.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Direct emissions	CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted.

Source		Gas	Included / Excluded	Justification / Explanation
	from the manure treatment processes	CH_4	Included	The emission from uncombusted methane, physical leakage, and minor CH_4 emissions from aerobic treatment.
		N_2O	Included	May be an important emission source.
	Emissions from animal manure (and treated effluent) transportation	CO_2	Included	May be an important emission source.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from sludge composting	CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted.
		CH_4	Included	May be an important emission source.
		N_2O	Included	May be an important emission source.
	Emissions from manure storage tanks	CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted.
		CH_4	Included	May be an important emission source.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.

The project proponents shall furnish the project document with a detailed diagrammatic representation of the project scenario, including all pre-treatment and treatment steps involved in managing manure waste, as well as its final disposal. This diagram should also highlight the fraction of volatile solids that degrade within the project's boundaries before disposal, as observed in the situation before the project's initiation. Furthermore, it needs to document the ultimate handling of any methane captured and the auxiliary energy required for the operation of project treatment steps, including pre-treatment processes.

The project developer shall clearly identify in the project document the precise locations of each farm supplying animal manure for the project activity. This includes the names of the farms, their distances in kilometers to the central treatment plant, the type of livestock they house, and their coordinates (e.g., using the Global Positioning System). This detailed information ensures transparency and traceability of the project's input sources.

9. Baseline and additionality

GHG project proponents shall demonstrate that emission reductions (or removals) do not correspond to emission reductions attributable to the implementation of legally required actions.

On the other hand, to demonstrate that project activities generate Verified Carbon Credits (VCCs) that represent additional GHG emission reductions or removals, the Project Holder shall follow the guidance contained in the BCR Guidance "Baseline and additionality"[6]. The guidance contains provisions relating to additionality and baseline for projects under the BCR Standard[7].

The baseline scenario and additionality of the project activity shall be demonstrated and assessed using the latest version of the Tool 02[8]: Combined tool to identify baseline scenario and demonstrate additionality.

When determining the baseline scenario, the requirements below shall be taken into account.

9.1 Identification of the Baseline Scenario for Manure Management

For existing facilities

In applying Step 1 of the Tool 02, baseline alternatives for managing the manure, shall take into consideration, inter alia, the complete set of existing/possible manure management systems listed in the 2019 Refinement to 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 4, Chapter 10, Table 10.17-updated). In drawing up a list of possible scenarios, possible combinations of AWMS shall be taken into account.

For greenfield facilities

For Greenfield facilities, the methodology only applies where the baseline scenario selected from the complete set of the list of the 2019 Refinement to 2006 IPCC Guidelines

[6] https://biocarbonstandard.com/tools/additionality.pdf
[7] The BCR Baseline and Additionality Guidance is a mandatory guidance covering the requirements established to ensure a realistic and conservative estimate of baseline emissions; it also provides requirements to ensure that activities are additional in all eligible sectors.
[8] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v7.0.pdf

for National Greenhouse Gas Inventories (Volume 4, Chapter 10, Table 10.17-updated), is an uncovered anaerobic lagoon.

The following two steps will define the baseline uncovered anaerobic lagoon:

a) Define several anaerobic lagoon design options for the particular manure stream that meet the relevant regulations and take into consideration local conditions (e.g. environmental legislation, ground water table, land requirement, temperature). Design specifications shall include average depth and surface area of the anaerobic lagoon, residence time of the organic matter, as well as any other key parameters. Document the different design options in a transparent manner and provide transparent and documented evidence of key assumptions and data used, and offer conservative interpretations of this evidence;
b) Carry out an economic assessment of the identified lagoon design option, as per Step 3 (investment analysis) of the latest approved version of the "Combined tool to identify the baseline scenario and demonstrate additionality" and additional guidance given below. Choose the least cost anaerobic lagoon design option from the options identified through Step (a) above. If several options with comparably low cost exist, choose the one with the lowest lagoon depth as the baseline lagoon design.

In applying Step 3 of the Tool 02, baseline alternatives for managing the manure shall take into consideration the following additional guidance to compare the economic or financial attractiveness for Step (b) above.

To compare the economic attractiveness without revenues from VCCs for all possible anaerobic lagoon design options that are identified, and in applying the investment analysis the IRR shall be used as an indicator. The following parameters inter alia should be explicitly documented:

(a) Land cost;

(b) Engineering, procurement and construction cost;

(c) Labour cost;

(d) Operation and maintenance cost;

(e) Administration cost;

(f) Fuel cost;

(g) Capital cost and interest;

(h) Revenue from electricity sales;

(i) All other costs of implementing the technology of each lagoon design option;

(j) All revenues generated by the implementation of the proposed technology (including energy savings due to captive use of biogas as fuel for either electricity or heat generation at the project site, revenue on account of avoided water consumption, fossil fuel replacement, sale of concentrated solids as fertilizers, subsidies/fiscal incentives etc.).

9.2 Identification of the Baseline Scenario for Electricity and Heat Generation

In addition to the alternative baseline scenarios identified for managing the manure, alternative scenarios for the use of gas generated from an anaerobic digester (biogas) shall also be identified if this is an aspect of the project activity:

For electricity generation, alternative(s) shall include, inter alia:

a) E1: Electricity generation from biogas, undertaken without being registered as BCR project activity;

b) E2: Electricity generation in existing or new renewable based captive power plant(s);

c) E3: Electricity generation in existing and/or new grid-connected power plant;

d) E4: Electricity generation in an off-grid fossil fuel fired captive power plant;

e) E5: Electricity generation in existing and/or new grid-connected power plant and fossil fuel fired captive power plant(s).

Baseline emissions due to electricity generation can be accounted for only if the baseline scenario is E3, E4 and E5.

For heat generation, alternative(s) shall include, inter alia:

(a) H1: Heat generation from biogas undertaken without being registered as BCR project activity;

(b) H2: Heat generation in existing or new fossil fuel fired cogeneration plant(s);

(c) H3: Heat generation in existing or new renewable based cogeneration plant(s);

(d) H4: Heat generation in existing or new on-site or off-site fossil fuel-based boiler(s) or air heater(s);

(e) H5: Heat generation in existing or new on-site or off-site renewable energy-based boiler(s) or air heater(s);

(f) H6: Any other source, such as district heat; and

(g) H7: Other heat generation technologies (e.g. heat pumps or solar energy);

(h) Baseline emissions due to heat generation can be accounted for only if the baseline scenario is H4;

(i) Baseline revision at renewal of crediting period.

At the start of the second and third crediting period for a project activity, the continued validity of the baseline scenario shall be assessed by applying the latest version of the tool “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period”.

9.3 Baseline emissions calculation

Baseline emissions are calculated as the sum of CH4 and N2O emissions that would occur in the baseline animal waste treatment system and CO2 emissions arising from heat and electricity consumption. Hence:

Equation 1

$$BE_y = BE_{CH4,y} + BE_{N2O,y} + BE_{\frac{elec}{heat},y}$$

Where:

BE_y	=	Total baseline emissions in year y, in $tCO_2e/year$
$BE_{CH4,y}$	=	Baseline methane emissions attributable to animal waste treatment in year y, in $tCO_2e/year$
$BE_{N2O,y}$	=	Baseline N_2O emissions attributable to animal waste treatment in year y, in $tCO_2e/year$
$BE_{\frac{elec}{heat},y}$	=	Baseline CO_2 emissions from electricity and/or heat generated/consumed in the baseline, in $tCO_2e/year$

9.3.1 Methane emissions from animal waste treatment ($BE_{CH4,y}$)

Baseline methane emissions from animal waste treatment may be calculated by using one of the following options:

a) Using the amount of waste that would decay anaerobically in the absence of the project activity. For this calculation, manure characteristics include the amount of volatile solids (VS) produced by the livestock as well as information on manure management systems is required.
b) Using the amount of manure that would decay anaerobically in the absence of the project activity based on the direct measurement of quantity of manure treated together with the volatile content of the treated manure ($VS_{manure,LT}$)

Calculation of $BE_{CH4,y}$ through option 34(a) shall be executed as follows:

Equation 2[9]

$$BE_{CH_{4,y}} = GWP_{CH_4} \times \rho_{CH_{4,n}} \times \sum_{j,LT} (MCF_j \times B_{0,LT} \times N_{LT,y} \times VS_{LT,y} \times MS\%_{Bl,j})$$

Where:

$BE_{CH_{4,y}}$	=	Annual baseline methane emissions in tCO_2e/y
GWP_{CH_4}	=	Global Warming Potential (GWP) of CH_4
$\rho_{CH_{4,n}}$	=	CH_4 density ($6.7x10^{-4}$ t/m^3 at room temperature (20ºC) and 1 atm pressure)
MCF_j	=	Annual methane conversion factor (MCF) for the baseline AWMS j from 2019. Refinement to the 2006 IPCC Guidelines (as updated in July 2023). the Table 10.17 (Updated), Chapter 10, Volume 4.[10]
$B_{0,LT}$	=	Maximum methane yield from manure for livestock type LT, in $m^3CH_4/kgVS$ from 2019 Refinement to the 2006 IPCC Guidelines (, as updated in July 2023), Table 10.16A(Updated), Chapter 10, Volume 4
$N_{LT,y}$	=	Annual average number of animals of type LT for the year y, expressed in numbers
$VS_{LT,y}$	=	Annual volatile solid for livestock LT entering all AWMS [on a dry matter weight basis (kg-VS-dm/animal/year)], as estimated below
$MS\%_{Bl,j}$	=	Fraction of manure handled in AWMS type *j* in the baseline scenario

Estimation of $VS_{LT,y}$, $B_{0,LT}$ and MCF_j:

[9] These emissions shall be separately estimated for each farm and then summed up.

[10] Annex 5 of this methodology.

These parameters should be determined in the following ways. If the default values are taken from the IPCC Guidelines, the latest refinement to the IPCC Guidelines shall be taken into consideration, and equivalent values shall be used.

$\boldsymbol{VS_{LT,y}}$ can be determined in one of the following ways, stated in the order of preference:

1) Using published country specific data. If the data is expressed in kg dm per day, multiply the value with nd_y (number of days the central treatment plant was operational in year y);
2) Estimation of VS based on dietary intake of livestock;

Equation 3

$$VS_{LT,y} = \left[GE_{LT} \times \left(1 - \frac{DE_{LT}}{100}\right) + (UE \times GE_{LE})\right] \times \left[\left(\frac{1 - ASH}{ED_{LT}}\right)\right] \times nd_y$$

Where:

$VS_{LT,y}$	=	Annual volatile solid excretions on a dry matter weight basis (kg-dm/animal/year)
GE_{LT}	=	Daily average gross energy intake in MJ/day; on dry matter basis (Calculated as per Equation 10.16. Chapter 10, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines (as updated in July 2023) or use default value of 18.45 MJ/kg of dry matter if field specific information is not available)
DE_{LT}	=	Digestible energy of the feed in percent (2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023, Table 10.2 (Updated), Chapter 10, Volume 4)
$UE \times GE_{LE}$	=	Urinary energy expressed as fraction of GE. Typically 0.04GE can be considered urinary energy excretion by most ruminants (reduce to 0.02 for ruminants fed with 85% or more grain in the diet or for swine). Use country-specific values where available
ASH	=	Ash content of manure calculated as a fraction of the dry matter feed intake. Use country-specific values where available
ED_{LT}	=	Energy density of the feed in MJ/kg (IPCC notes the energy density of feed, ED, is typically 18.45 MJ/kg-dm, which is relatively constant across a wide variety of grain based feeds.)

		fed to livestock type LT. The project proponent will record the composition of the feed to enable the CAB to verify the energy density of the feed
nd_y	=	Number of days the central treatment plant was operational in year *y*

3) Scaling default IPCC values VSdefault to adjust for a site-specific average animal weight as shown in equation below:

Equation 4

$$VS_{LT,y} = \left(\frac{W_{site}}{1000}\right) \times VS_{default} \times nd_y$$

Where:

$VS_{LT,y}$	=	Adjusted volatile solid excretion per year on a dry-matter basis for a defined livestock population at the project site in kg-dm/animal/yr
W_{site}	=	Average animal weight of a defined population at the project site (AWMS) in kg
$VS_{default}$	=	Default value (2019 Refinement to IPCC 2006, Table 10.13A (New), Chapter 10, Volume 4 as updated in July 2023 or US-EPA 2002, whichever is lower) for the volatile solid excretion per day on a dry-matter basis for a defined livestock population in kg-VS/1000 kg animal mass/day
nd_y	=	Number of days the central treatment plant was operational in year *y*

Annual Average number of animals (N_{LT}) can be determined in one of the following ways:

1) Annual stock of animals can be monitored for the estimation of annual average number of animals

Equation 5

$$N_{LT} = N_{da} \times \left(\frac{N_p}{365}\right)$$

Where:

N_{LT}	=	Annual average number of animals of type *LT* for the year *y*, expressed in numbers
N_{da}	=	Number of days animal is alive in the farm in the year *y*, expressed in numbers
N_p	=	Number of animals produced annually of type *LT* for the year *y*, expressed in numbers

2) If the project developer can monitor in a reliable and traceable way the daily stock of animals in the farm, discounting dead animals and animals discarded from the productive process from the daily stock, then the annual average number of animals (NLT) may be calculated as an average of the daily stock of animals in the farm without considering dead animals and discarded animals.

Equation 6

$$N_{LT} = \frac{\sum_{1}^{365} N_{AA}}{365}$$

Where:

N_{LT}	= Annual average number of animals of type *LT* for the year *y*, expressed in numbers
N_{AA}	= Daily stock of animals in the farm, discounting dead and discarded animals.

The following sources should be used to calculate baseline emissions:

1. 2019 Refinement to the 2006 IPCC Guidelines (IPCC 2019, as updated in July 2023), Volume 4, Chapter 10;
2. US-EPA 2002: Development Document for the Proposed Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations, Chapter 8.2[11]

Calculation of $BE_{CH4,y}$ through the Paragraph 34(b) shall be executed as follows:

Equation 7

$$BE_{CH4,y} = GWP_{CH4} \times \rho_{CH4} \times \sum_{j,LT} MCF_j \times B_{0,LT} \times 10^3 \times Q_{manure,j,LT,db,y} \times VS_{manure,LT}$$

[11] https://nepis.epa.gov/Exe/ZyPDF.cgi/20002UUV.PDF?Dockey=20002UUV.PDF

Where:

$Q_{manure,j,LT,db,y}$	=	Quantity of manure treated from livestock type *LT* and animal manure management system *j* (tonnes/year, dry basis)
$VS_{manure,LT}$	=	Volatile solid content of animal manure from livestock type *LT* and animal manure management system *j* in year *y* (tonnes/tonnes, dry basis)
MCF_j	=	Annual methane conversion factor (MCF) for the baseline AWMSj from 2019 Refinement to the 2006 IPCC Guidelines (as updated in July 2023) Table 10.17 (Updated), Chapter 10, Volume 4
$B_{0,LT}$	=	Maximum methane yield from manure for livestock type *LT*, in $m^3CH_4/kgVS$ from 2019 Refinement to the 2006 IPCC Guidelines (as updated in July 2023), Table 10.16A(Updated), Chapter 10, Volume 4

Maximum Methane Production Potential ($\boldsymbol{B_{0,LT}}$) can be determined in one of the following ways, stated in the order of preference:

1. Default value as per Tier 1 and 1a approach in 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 10.
   This value varies by livestock species and diet. Where default values are used, they should be taken from tables 10.16A (Updated) of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 10 specific to the country where the project is implemented. The selected $B_{o,LT}$ value should be clearly justified and reported in the project document.
2. Direct measurement of $B_{o,LT}$ as per Tier 2 approach in 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 10 :
   - ISO 11734:1995;[12]
   - ASTM E2170-01 (2008)[13] and;
   - ASTM D 5210-92.[14]

Methane conversion factors ($\boldsymbol{MCF_j}$):

[12] International Organization for Standardization. 1995. Water quality: Evaluation of the 'ultimate' anaerobic biodegradability of organic compounds in digested sludge ISO/DIS 11734. ISO, Geneva.
[13] ASTM E2170 - 01(2008) Standard Test Method for Determining Anaerobic Biodegradation Potential of Organic Chemicals Under Methanogenic Conditions.

[14] ASTM D5210 - 92(2007) Standard Test Method for Determining the Anaerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewage Sludge

1. The 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (as updated in July 2023) MCF values given in table 10.17 (Updated) (Chapter 10, Volume 4) should be used, which is attached here as Annex 4. MCF values depend on the climate zone where the anaerobic manure treatment facility in the baseline existed. Future revisions to the IPCC Guidelines for National Greenhouse Gas Inventories should be taken into account;
2. A conservativeness factor should be applied by multiplying MCF values (estimated as per above bullet) with a value of 0.94, to account for the 20% unVCCtainty in the MCF values as reported by IPCC 2006.
3. For subsequent treatment stages, the reduction of the volatile solids during a treatment stage is estimated based on referenced data for different treatment types. Emissions from the next treatment stage are then calculated following the approach outlined above, but with volatile solids adjusted for the reduction from the previous treatment stages by multiplying by (1 - R_{VS}), where R_{VS} is the relative reduction of volatile solids from the previous stage. The relative reduction (R_{VS}) of volatile solids depends on the treatment technology and should be estimated in a conservative manner. Default values for different treatment technologies can be found in Table 8.10 of chapter 8.2 in US-EPA (2002)[15]. These values are provided in Annex 1.

9.3.2 N2O emissions from manure management

Equation 8

$$BE_{N_2O,y} = GWP_{N_2O} \times CF_{N_2O-N,N} \times 10^{-3} \times \left(E_{N_2O,D,y} + E_{N_2O,ID,y}\right)$$

Equation 9

$$E_{N_2O,D,y} = \sum_{j,LT} \left(EF_{N_2O,D,j} \times NEX_{LT,j} \times N_{LT,y} \times MS\%_{Bl,j}\right)$$

Equation 10

$$E_{N_2O,ID,y} = \sum_{j,LT} \left(\left(EF_{4,j} + EF_{5,j}\right) \times F_{gasm} \times NEX_{LT,y} \times N_{LT,y} \times MS\%_{Bl,j}\right)$$

Where:

$BE_{N_2O,y}$	=	Annual baseline N_2O emissions in tCO_2e/yr
GWP_{N_2O}	=	Global Warming Potential (GWP) for N_2O

[15] https://nepis.epa.gov/Exe/ZyPDF.cgi/20002UUV.PDF?Dockey=20002UUV.PDF

$CF_{N_2O-N,N}$ = Conversion factor N_2O-N to N_2O (44/28)

$E_{N_2O,D,y}$ = Direct N_2O emissions in kg N_2O-N/year

$E_{N_2O,ID,y}$ = Indirect N_2O emissions in kg N_2O-N/year

$E_{N_2O,ID,y}$ = Direct N_2O emission factor for the treatment system j of the manure management system in kg N_2O-N/kg N (estimated with site-specific, regional or national data if such data is available, otherwise use default EF_3 from table 10.21, Chapter 10, Volume 4, in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, as updated in July 2023)

$NEX_{LT,j}$ = Is the annual average nitrogen excretion per head of a defined livestock population in kgN/animal/year estimated as described in Annex 6

$N_{LT,y}$ = Number of animals of type *LT* for the year *y*, expressed in numbers

$MS\%_{Bl,j}$ = Fraction of manure handled in system *j*, in %

F_{gasm} = Percent of managed manure nitrogen for livestock category that volatilises as NH_3 and NOx in the manure management system

$EF_{4,j}$ = Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N- N_2O / (kg NH_3-N + NOx-N volatilized)], estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines (as updated in July 2023) (0.01 kg N2O-N/(kg NH3-N +NOx-N volatilised)

$EF_{5,j}$ = Emission factor for indirect emission of N_2O from runoff in kg N_2O-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3(Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines (as updated in July 2023) can be used (0.0075 kg N2O-N/(kg N leaching/runoff)

For subsequent treatment stages, the reduction of the nitrogen during a treatment stage is estimated based on referenced data for different treatment types. Emissions from the next treatment stage are then calculated following the approach outlined above, but with nitrogen adjusted for the reduction from the previous treatment stages by multiplying by (1 - RN), where RN is the relative reduction of nitrogen from the previous stage. The relative reduction (RN) of nitrogen depends on the treatment technology and should be estimated in a conservative manner. Default values for different treatment technologies can be found in Chapter 8.2 in USEPA (2002)[16]. These values are provided in Annex 1.

9.3.3. CO2 emissions from electricity and heat within the project boundary

Equation 11

$$BE_{elect/heat,y} = EG_{Bl,y} \times CEF_{Bl,elec,y} + EG_{d,y} \times CEF_{grid} + HG_{Bl,y} \times CEF_{Bl,therm,y}$$

Where:

$BE_{elect/heat,y}$	=	Baseline CO_2 emissions from electricity and/or heat used in the baseline, in tCO_2e/year
$EG_{Bl,y}$	=	Amount of electricity in the year y that would be consumed in the absence of the project activity (MWh) for operating all AWMs facilities
$CEF_{Bl,elec,y}$	=	Carbon emissions factor for electricity consumed at the project site in the absence of the project activity (tCO_2e/MWh)
$EG_{d,y}$	=	Amount of electricity generated utilizing the biogas collected during project activity and exported to the grid during the year y (MWh)
CEF_{grid}	=	Carbon emissions factor for the grid in the project scenario (tCO_2e/MWh)
$HG_{Bl,y}$	=	Quantity of thermal energy that would be consumed in year y in the absence of the project activity (MJ) using fossil fuel for operating all AWMSs
$CEF_{Bl,therm,y}$	=	CO_2 emissions intensity for thermal energy generation (tCO_2e/MJ)

Determination of $CEF_{Bl,elec}$ and CEF_{grid}:

[16] https://nepis.epa.gov/Exe/ZyPDF.cgi/20002UUV.PDF?Dockey=20002UUV.PDF

CEF_{grid} and $CEF_{Bl,elec}$ shall be calculated according to relevant procedure in the "Tool to calculate the emission factor for an electricity system".

Determination of $CEF_{Bl,therm}$:

$CE_{FBl,therm}$ is the CO_2 emissions intensity for thermal energy generation (tCO_2e/MJ). This parameter shall be determined.

Baseline electricity and thermal energy consumption shall be estimated as the average of the historical 3 years' consumption.

10. Quantification of project activity emissions

The project activity may employ one or a combination of technologies to treat manure. For instance, the effluent mix could be initially treated in an anaerobic digester/reactor, followed by further processing of the treated waste using an aerobic pond. Each processing step should be considered as a distinct treatment stage.

Project emissions are estimated as follows:

Equation 12

$$PE_y = PE_{AD,y} + PE_{Aer,y} + PE_{Comp,y} + PE_{N_2O,y} + PE_{PL,y} + PE_{flare,y} + PE_{\frac{elec}{heat},y} + PE_{CO_2,Trans,y} + PE_{storage,y}$$

Where:

PE_y	=	Project emissions (tCO_2e/yr)
$PE_{AD,y}$	=	Leakage from treatment stage that captures methane (tCO_2e/yr)
$PE_{Aer,y}$	=	Methane emissions from the aerobic treatment stage (tCO_2e/yr)
$PE_{Comp,y}$	=	Total project emissions due to composting (tCO_2e/yr)
$PE_{N2O,y}$	=	Nitrous oxide emission from project treatment system (tCO_2e/yr)
$PE_{PL,y}$	=	Physical leakage of emissions from biogas network to flare the captured methane or supply to the facility where it is used for heat and/or electricity generation (tCO_2e/yr)
$PE_{flare,y}$	=	Project emissions from flaring of the residual gas stream (tCO_2e/yr)

$PE_{elec/heat,y}$	=	Project emissions from use of heat and/or electricity in the project case (tCO2e/yr)
$PE_{CO_2,Trans,y}$	=	Project emissions from manure road transportation (tCO_2e/yr)
$PE_{storage,y}$	=	Project emissions from manure storage (tCO_2e/yr)

11. Quantification project activity emissions

10.1. Methane emissions from AWMS where gas is captured ($PE_{AD,y}$)

For the calculation of methane emissions from AWMS, refer to the relevant procedure in the methodological tool "Project and leakage emissions from anaerobic digesters". In the relevant tool, PEAD,y is equivalent to $PE_{CH4,y}$.

10.2. Methane emissions from aerobic treatment ($PE_{Aer,y}$)

Methane emissions from aerobic treatment can be determined in one of the following ways, stated in the order of preference. For the calculations, IPCC guidelines specify emissions from aerobic lagoons as 0.1% of total methane generating potential of the waste processed.

Option 1:

Equation 13

$$E_{Aer,y} = GWP_{CH_4} \cdot \rho_{CH_4,n} \cdot MCF_{Aer} \sum_{m=1}^{12} \left(Q_{EM,Aer,m} \cdot VS_{EM,Aer,m} \cdot B_{0,EM,m}\right)$$

Where:

$PE_{Aer,y}$	=	Methane emissions from the aerobic treatment stage in tCO_2e/yr
GWP_{CH_4}	=	Global Warming Potential (GWP) of CH_4
$\rho_{CH_4,n}$	=	CH_4 density (6.7×10^{-4} t/m^3 at room temperature (20 ºC) and 1 atm pressure)
$Q_{EM,Aer,m}$	=	Monthly volume of the effluent entering the aerobic treatment step (m^3/month)

$VS_{EM,Aer,m}$	=	Average monthly volatile solids (VS) concentration of the effluent entering the aerobic treatment step (ton VS/m^3)
$B_{0,EM,m}$	=	Average monthly CH_4 production capacity of effluent manure entering the aerobic treatment stage (m^3CH_4/ton-VS)
MCF_{Aer}	=	Methane Conversion Factor (MCF) for aerobic system (0.1%)

Option 2:

Equation 14

$$PE_{Aer,y} = GWP_{CH4} \times \rho_{CH4} \times 0.001 \times F_{Aer} \times \left[\prod_{n=1}^{N}(1 - R_{VS,n})\right] \times \sum_{j,LT}(B_{0,LT} \times N_{LT} \times VS_{LT,y} \times MS\%_j)$$

Where:

GWP_{CH4}	=	Global Warming Potential (GWP) of CH_4 (t CO_2e/tCH_4)
$R_{VS,n}$	=	Fraction of volatile solid degraded in AWMS treatment method *n* of the *N* treatment steps prior to waste being treated (fraction)
ρ_{CH4}	=	Density of CH_4 (t/m^3)
F_{Aer}	=	Fraction of volatile solid directed to aerobic system (fraction)
LT	=	Type of livestock[17]
$B_{0,LT}$	=	Maximum methane producing potential of the volatile solid generated by animal type *LT* (m^3CH_4/kg dm)

[17] For the main categories of livestock types, refer to Table 10.1 (Updated) in Volume 4, Chapter 10, of the IPCC 2019 guidelines.

$VS_{LT,y}$	=	Annual volatile solid excretion livestock type LT entering all AWMS on a dry matter weight basis in (kg - dm/animal/yr)
N_{LT}	=	Annual average number of animals of type LT for the year y (number)
$MS\%_j$	=	Fraction of manure handled in system j in the project activity (fraction)

The project activity may result in sludge accumulation. Sludge requires removal and has VS. Sludge must be treated through thermo-mechanical drying or composting prior to its final disposal/usage. The same procedure shall be applied to suspended solids removed during the treatment process. No GHG emissions are expected from the thermo-mechanical drying process, except those from eventual fossil fuel consumption.

10.3. Methane emissions from composting ($PE_{comp,y}$)

Methane emissions from composting shall be estimated as follows:

Equation 15

$$PE_{Comp,y} = PE_{Comp,CH_4,y} + PE_{Comp,N_2O,y}$$

Equation 16

$$PE_{Comp,CH_4,y} = GWP_{CH_4} \times \rho_{CH_4,n} \times MCF_{res} \times \sum_{m=1}^{12} (Q_{Comp,m}^{in} \times VS_{res,m} \times B_{0,res,m})$$

Where:

$PE_{Comp,CH_4,y}$	=	Methane emissions from composting in tCO_2e/yr
GWP_{CH_4}	=	Global Warming Potential (GWP) of CH_4
$Q_{Comp,m}^{in}$	=	Monthly quantity of residues entering the composting plant in a dry matter basis (ton/month)
$B_{0,res,m}$	=	Average monthly CH_4 production capacity of residues entering the composting step, in m^3 CH_4/ton-VS
MCF_{res}	=	Methane Conversion Factor (MCF) for composting system as per 2019 Refinement to the 2006 IPCC Guidelines for

		National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Volume 4, Chapter 10, Table 10.17 (Updated)
$VS_{res,m}$	=	Average monthly volatile solids (VS) concentration of the residue entering the composting step (ton VS/ton)
$\rho_{CH_4,n}$	=	Density of methane at normal (at room temperature 20°C and 1 atm pressure) conditions (6.7x10^{-4} t/m^3)

The measure of the residues B_0 should be directly done as described in:

- ISO 11734:1995;[18]
- ASTM E2170-01 (2008)[19] and;
- ASTM D 5210-92.[20]

If the project activity involves the treatment of animal wastes N_2O emissions may occur during the composting process and shall be accounted as follows:

Equation 17

$$PE_{Comp,N_2O,y} = GWP_{N_2O} \times CF_{N_2O-N,N} \times \left(PE_{Comp,N_2O,D,y} + PE_{Comp,N_2O,ID,y}\right)$$

Equation 18

$$PE_{Comp,N_2O,D,y} = EF_{N_2O,Comp,D} \times 10^{-3} \times \sum_{m=1}^{12} [N]_{Comp,m}^{in})$$

Equation 19

$$PE_{Comp,N_2O,ID,y} = (EF_4 + EF_5) \times 10^{-3} \times \left\{\sum_{m=1}^{12} \left[\left(Q_{Comp,m}^{in} \times [N]_{Comp,m}^{in}\right) - \left(Q_{Comp,m}^{out} \times [N]_{Comp,m}^{out}\right)\right] - PE_{Comp,N_2O,D,y}\right\}$$

Where:

$PE_{Comp,N_2O,y}$	=	Total project N_2O emissions due to composting in tCO_2e/yr

[18] International Organization for Standardization. 1995. Water quality: Evaluation of the 'ultimate' anaerobic biodegradability of organic compounds in digested sludge ISO/DIS 11734. ISO, Geneva.

[19] ASTM E2170 - 01(2008) Standard Test Method for Determining Anaerobic Biodegradation Potential of Organic Chemicals Under Methanogenic Conditions.

20 ASTM D5210 - 92(2007) Standard Test Method for Determining the Anaerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewage Sludge.

$PE_{Comp,N_2O,D,y}$	=	Total project direct N_2O emissions due to composting in tN-N_2O/yr
$PE_{Comp,N_2O,ID,y}$	=	Total project indirect N_2O emissions due to composting in tN-N_2O/yr
GWP_{N_2O}	=	Global Warming Potential (GWP) for N_2O
$CF_{N_2O-N,N}$	=	Conversion factor N_2O-N to N_2O (44/28)
$EF_{N_2O,Comp,D}$	=	Direct N_2O emission factor for composting in kg N_2O-N/kg N (estimated with site-specific, regional or national data if such data is available. Otherwise use default EF_3 in Volume 4, Chapter 10, Table 10.21 (Updated) in 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023)
EF_4	=	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N- N_2O / (kg NH_3-N + NOx-N volatilized)], estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023 (0.01 kg N2O-N/(kg NH3-N +NOx-N volatilised)
EF_5	=	Emission factor for indirect emission of N_2O from runoff in kg N_2O-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3, Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023 can be used (0.0075 kg N2O-N/(kg N leaching/runoff)
$Q_{Comp,m}^{in}$	=	Monthly quantity of residues entering the composting plant in a dry matter basis (ton/month)
$[N]_{Comp,m}^{in}$	=	Monthly total nitrogen concentration in the residues entering the composting plant (kg N/ton residue)
$Q_{Comp,m}^{out}$	=	Monthly quantity of composted residues produced, in a dry matter basis (ton/month)
$[N]_{Comp,m}^{out}$	=	Monthly total nitrogen concentration in composted residues produced (kg N/ton residue)

10.4. N2O emission from the central treatment plan ($PE_{N_2O,y}$)

Equation 20

$$PE_{N_2O,y} = GWP_{N_2O} \times CF_{N_2O-N,N} \times 10^{-3} \times \left(E_{N_2O,D,y} + E_{N_2O,ID,y}\right)$$

Equation 21

$$E_{N_2O,D,y} = \sum_{n} EF_{N_2O,D,n} \times \sum_{m=1}^{12} \left(Q_{EM,m} \times [N]_{EM,m}\right)$$

Equation 22

$$E_{N_2O,ID,y} = EF_{N_2O,ID} \times \sum_{n} F_{gasm,j} \times \sum_{m=1}^{12} \left(Q_{EM,m} \times [N]_{EM,m}\right)$$

Where:

$PE_{N_2O,y}$	=	Annual project N_2O emissions in tCO_2e/yr
GWP_{N_2O}	=	Global Warming Potential (GWP) for N_2O
$CF_{N_2O-N,N}$	=	Conversion factor N_2O-N to N_2O (44/28)
$E_{N_2O,D,y}$	=	Direct N_2O emission in kg N_2O-N/year
$E_{N_2O,ID,y}$	=	Indirect N_2O emission in kg N_2O-N/year
$EF_{N_2O,D,n}$	=	Direct N_2O emission factor for the treatment stage n of the central treatment plant in kg N_2O-N/kg N (estimated with site-specific, regional or national data if such data is available. Otherwise use default EF_3 in Volume 4, Chapter 10, table 10.21 (Updated) in 2019 Refinement to the 2006 IPCC guidelines, as updated in July 2023)
$Q_{EM,m}$	=	Monthly volume of the feedstock entering the central plant (m^3/month)

$[N]_{EM,m}$ = Monthly total nitrogen concentration in the feedstock (kg N/m^3) entering the treatment plant

$EF_{N_2O,ID}$ = Indirect N_2O emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N_2O-N/kg NH_3-N and NOx-N emitted, estimated with site-specific, regional or national data if such data is available. Otherwise, default values for EF_4 from table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC guidelines, as updated in July 2023 can be used

$F_{gasm,j}$ = Percent of total nitrogen that volatilises as NH_3 and NOx in the treatment stage *j*

For subsequent treatment stages, the nitrogen reduction during each stage is estimated based on referenced data for different treatment types. Emissions from the following treatment stage are then calculated using the approach detailed above, adjusting the nitrogen content to account for the reduction from prior stages. This is done by multiplying the remaining nitrogen by (1-RN), where RN represents the relative reduction of nitrogen from the preceding stage. The relative reduction (RN) of nitrogen is contingent upon the treatment technology and should be conservatively estimated. Default values for RN are provided in Annex 1. Alternatively, RN can be determined through direct monitoring of the nitrogen concentration in the effluent mix after each treatment step.

10.5. Physical leakage from distribution network of the captured methane in ($PE_{PL,y}$)

This clause addresses biogas leakage within the biogas process. The total captured methane directed to the flare, gas engines, and boiler—as measured according to the monitoring plan—must be reconciled annually with the total methane production, as metered at the output of the methane-generating digester. Any discrepancy between the measured value of produced methane and the sum of that utilized in flaring, electricity generation, or heating is to be accounted for as leakage from the pipeline system.

In addition, any leakage due to venting from the digester valves shall be accounted for as leakage from biogas process. For this purpose, anaerobic digester valves shall be equipped with flow meters.

Physical leakage from the pipeline and venting system determination in the project document shall be conducted using one of the following three options:

If the biogas is solely flared and the pipeline from the collection point to the flare is short (i.e., less than 1 km, for onsite delivery only), a single flow meter can be used. In such cases, physical leakage may be assumed to be negligible.

If national and/or sectoral legislation and regulations mandate stringent leak prevention throughout the pipeline and require regular inspections, physical leakage may be deemed negligible. However, the Designated Operational Entity (CAB) must validate this assumption.

In scenarios where the biogas pipeline system operates under negative pressure (e.g., with blowers installed on the biogas line), leakage from the pipeline system would technically not be feasible, and thus physical leakage may be considered negligible. The presence of a negative pressure environment must be validated by the CAB through the assessment of technical documents and process flows.

10.6. Project emissions from flaring of the residual gas stream ($PE_{Flare,y}$)

The combustion of biogas methane may give rise to significant methane emissions as a result of incomplete or inefficient combustion.

Project emissions from flaring of the residual gas stream should be determined following the procedure described in the "Methodological Tool: Project emissions from flaring". If the flare is used only in emergency, and the quantity of flared biogas is monitored via flow meter/s, the emissions resulting from flaring might be excluded from the project emissions calculations. In such cases, the flared biogas would not be claimed into the project's ERR calculation.

10.7. Project emissions from heat use and electricity use ($PE_{elec/heat,y}$)

Project emissions from heat and electricity use shall be accounted for as follows:

Equation 23

$$PE_{\frac{elec}{heat},y} = PE_{Elec,y} + \sum_{j} PE_{heat,j,y}$$

Where:

$PE_{Elec,y}$ = Are the emissions from consumption of electricity in the project case. The project emissions from electricity consumption ($PE_{Elec,y} = PE_{EC,y}$) will be calculated following the latest version of "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation". In case, the electricity consumption is not measured then the electricity consumption shall be estimated as follows:

$EC_{PJ,y} = \sum_i CP_{i,y} \times 8760$, where $CP_{i,y}$ is the rated capacity (in MW) of electrical equipment *i* used for project activity

$PE_{heat,j,y}$ = Are the emissions from consumption of heat in the project case. The project emissions from fossil fuel combustion ($PE_{heat,j,y}$ = $PE_{FC,j,y}$) will be calculated following the latest version of "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". For this purpose, the processes j in the tool corresponds to all fossil fuel combustion in the plant established as part of the project activity, as well as any other on-site fuel combustion for the purposes of the project activity

10.8. Project emissions from road transportation ($PE_{CO2,trans,y}$)

The project emissions from manure transportation should account for all movements including the transport of feedstocks, including other organic co-digested materials, from their collection points to the central treatment plant, as well as the distribution of treated effluent or residue from the plant to the agricultural fields for application. These emissions are to be calculated based on the total quantity of consumed fuel and the applicable fuel emission factors, as follows:

Project emissions from manure transportation from the collection points to the central treatment plant, and vice versa, are to be calculated using total quantity of consumed fuel and the fuel emission factor, as follows:

Equation 24

$$PE_{CO_2,Trans,y} = \left\{ \sum_i (FC_{i,f}) \times \left[\sum_f NCV_f \times EF_{CO_2,f} \times \rho_{i,f} \right] \right\}$$

Where:

$PE_{CO_2,Trans,y}$ = Project emissions from manure (and treated effluent) road transportation in tCO_2e/yr

$FC_{i,f}$ = Total quantity of consumed fuel type f in volume units in year y (liter)

NCV_f = Net calorific value of fuel type f in TJ per volume or mass units

$EF_{CO_2,f}$ = CO_2 emission factor of the fossil fuel type f used in transportation vehicles, (tCO_2e/TJ)

$\rho_{i,f}$	=	Density of fuel type f in mass per volume units (kg/liter)

Emissions resulting from the road transportation of treated manure should be calculated as previously described. These emissions are considered project emissions if the final destination and the routes between the treatment plant and the farms are within the project boundary. If not, such emissions should be categorized as leakage ($LE_{CO2,Trans,y}$), which is to be calculated using the same method outlined above.

10.9. Project emissions from manure storage ($PE_{storage,y}$)

In instances where tank trucks are utilized for residue collection, there may be a necessity to temporarily store these materials in tanks between collection intervals. This methodology is applicable only when residues are stored in **outdoor open tanks** and if the manure remains in these tanks for more than 24 hours. Should project participants opt for alternative storage solutions, they are advised to submit proposed amendments to this methodology. Methane emissions that occur during the storage of residues must be calculated as follows:

Equation 25

$$PE_{storage,y} = GWP_{CH_4} \times \rho_{CH_4,n} \times \sum_{LT,l} \left[\frac{365}{AI_l} \sum_{d=1}^{AI} \left(N_{LT} \times VS_{LT,d} \times MS\%_l \times \left(1 - e^{-k(AI_l - d)}\right) \times MCF_l \times B_{0LT} \right) \right]$$

Where:

$PE_{storage,y}$	=	Annual project emission in manure storage tanks in tCO_{2e}/yr
GWP_{CH_4}	=	Global warming potential of methane
$\rho_{CH_4,n}$	=	Density of methane (6.7×10^{-4} t/m^3 at room temperature (20ºC and 1 atm pressure)
AI_l	=	Annual average interval between manure collection procedures at a given storage tank l (days)
N_{LT}	=	Number of animals of type *LT* during a year *y*, expressed in numbers
$VS_{LT,d}$	=	Amount of volatile solid production by type of animal *LT* in a day (kg VS/head/d)

$MS\%_l$	=	Fraction of volatile solids (%) handled by storage tank l
k	=	Degradation rate constant (0.069)
d	=	Days for which cumulative methane emissions are calculated; d can vary from 1 to 45 and to be run from 1 up to AI (average interval between manure collection procedure)
MCF_l	=	Annual methane conversion factor for the project manure storage tank l from 2019 Refinement to the 2006 IPCC Guidelines (as updated in July 2023) Table 10.17 (Updated), Chapter 10, Volume 4
B_{0LT}	=	Maximum methane yield from manure for livestock type LT, in m^3CH_4/kgVS from 2019 Refinement to the 2006 IPCC Guidelines (as updated in July 2023), Table 10.16A(Updated), Chapter 10, Volume 4

12. Leakage

Leakage covers the emissions from land application of treated effluent / residues, together with the baseline emissions from decomposition of other organic matters co-digested with animal manure in anaerobic digester(s)/reactor(s), outside the project boundary. These emissions are estimated as net of those released under project activity and those released in the baseline scenario. Net leakage of N_2O and CH_4 are only considered if, they are positive.

CO_2 emissions due to the road transportation of sludge or treated effluent outside the project boundary may also be considered as leakage if it is possible to monitor the amount of diesel utilized for transportation of treated effluent separately. Such emissions are calculated in the same as depicted in the project emissions section.

Equation 26

$$LE_y = (LE_{P,N2O} - LE_{B,N2O}) + (LE_{P,CH4} + LE_{B,CH4,CD} - LE_{B,CH4})$$

Where:

LE_y	=	Leakage emissions for the year y, in tCO_2e/year
$LE_{P,N2O,y}$	=	N_2O emissions released during project activity from land application of the treated residues, in tCO_2e/year

$LE_{B,N2O,y}$	=	N_2O emissions released during baseline scenario from land application of the treated manure, in tCO_2e/year
$LE_{P,CH4,y}$	=	CH_4 emissions released during project activity from land application of the treated residues, in tCO_2e/year
$LE_{B,CH4,y}$	=	CH_4 emissions released during baseline scenario from land application of the treated manure, in tCO_2e/year
$LE_{B,CH4,CD,y}$	=	CH_4 emissions occurring in year *y* generated from waste disposal at a solid waste disposal site (SWDS) during a time period ending in year *y*, in tCO_2e/year

12.1. Estimation of leakage N_2O emissions

The baseline case N_2O emissions are estimated according to the sum of nitrogen excretion of the livestock types included in the project boundary and to the nitrogen removal capacity of the baseline AWMS, by using the equations below

Equation 27

$$LE_{B,N_2O} = GWP_{N_2O} \times CF_{N_2O-N,N} \times 10^{-3} \times \left(LE_{B,N_2O,land} + LE_{B,N_2O,runoff} + LE_{B,N_2O,vol}\right)$$

Equation 28

$$LE_{B,N_2O,land} = EF_1 \times \prod_{n=1}^{N}\left(1 - R_{N,n}\right) \times \sum_{j,LT}\left(N_{LT,y} \times NEX_{LT} \times MS\%_{Bl,j}\right)$$

Equation 29

$$LE_{B,N_2O,runoff} = EF_5 \times F_{leach} \times \prod_{n=1}^{N}\left(1 - R_{N,n}\right) \times \sum_{j,LT}\left(N_{LT,y} \times NEX_{LT} \times MS\%_{Bl,j}\right)$$

Equation 30

$$LE_{B,N_2O,vol} = EF_4 \times F_{gasm} \times \prod_{n=1}^{N}\left(1 - R_{N,n}\right) \times \sum_{j,LT}\left(N_{LT,y} \times NEX_{LT} \times MS\%_{Bl,j}\right)$$

Where:

LE_{B,N_2O}	=	N_2O emissions released during baseline scenario from land application of the treated manure, in tCO_2e/year
GWP_{N_2O}	=	Global Warming Potential (GWP) for N_2O
$CF_{N_2O-N,N}$	=	Conversion factor (= 44/28)
$LE_{B,N_2O,land}$	=	Baseline direct N_2O emissions from application of manure waste, in kg N_2O-N/year
$LE_{B,N_2O,runoff}$	=	Baseline N_2O emissions due to leaching and run-off, in kg N_2O-N/year
$LE_{B,N_2O,vol}$	=	Baseline N_2O emissions due to nitrogen volatilization as NH_3 and NOx, in kg N_2O-N/year
F_{gasm}	=	Fraction of total N that volatizes as NH_3 and NOx in kg NH_3-N and NOx-N per kg of N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines (as updated in July 2023) can be used
$N_{LT,y}$	=	Number of animals of type LT for the year y, expressed in numbers
NEX_{LT}	=	Is the annual average nitrogen excretion per head of a defined livestock population in kg N/animal/year estimated as described in Annex 6
$MS\%_{Bl,j}$	=	Fraction of manure handled in system j in the baseline scenario
EF_1	=	Emission factor for direct emission of N_2O from soils in kg N_2O-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.1 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines (as updated in July 2023) can be used
$R_{N,n}$	=	Fraction of N that is reduced in the Baseline AWMS. The relative reduction of nitrogen depends on the treatment technology and should be estimated in a conservative

		manner. Default values for different treatment technologies can be found in Annex 1
EF_5	=	Emission factor for indirect emission of N_2O from runoff in kg N_2O-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023 can be used
F_{leach}	=	Fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff should be estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023 can be used
EF_4	=	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N- N_2O / (kg NH_3-N + NOx-N volatilized)], estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023.

In contrast, the project case N_2O emissions are estimated through the direct measurement of the treated effluent disposed outside the project boundary, by using the following equations:

Equation 31

$$LE_{P,N_2O} = GWP_{N_2O} \times CF_{N_2O-N,N} \times 10^{-3} \times \left(LE_{P,N_2O,land} + LE_{P,N_2O,runoff} + LE_{P,N_2O,vol}\right)$$

Equation 32

$$LE_{P,N_2O,land} = EF_1 \times \sum_{m=1}^{12} \left(Q_{DE,m} \times [N]_{DE,m}\right)$$

Equation 33

$$LE_{P,N_2O,runoff} = EF_5 \times F_{leach} \times \sum_{m=1}^{12} (Q_{DE,m} \times [N]_{DE,m})$$

Equation 34

$$LE_{P,N_2O,vol} = EF_4 \times F_{gasm} \times \sum_{m=1}^{12} (Q_{DE,m} \times [N]_{DE,m})$$

Where:

$LE_{P,N_2O,y}$	=	N_2O emissions released during project scenario from land application of the treated residues, in tCO_2e/year
GWP_{N_2O}	=	Global Warming Potential (GWP) for N_2O
$CF_{N_2O-N,N}$	=	Conversion factor (44/28)
$LE_{P,N_2O,land}$	=	Project case direct N_2O emission from application of treated effluent, in kg N_2O-N/year
$LE_{P,N_2O,runoff}$	=	Project case N_2O emission due to leaching and run-off, in kg N_2O-N/year
$LE_{P,N_2O,vol}$	=	Project case N_2O emissions due to nitrogen volatilization as NH_3 and NOx, in kg N_2O-N/year
F_{gasm}	=	Fraction of total N that volatizes as NH_3 and NOx in kg NH_3-N and NOx-N per kg of N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023 can be used
$Q_{DE,m}$	=	Total monthly quantity of treated effluent / residue disposed outside the project boundary (DE) (tons of dry matter)
$[N]_{DE,m}$	=	Mean monthly nitrogen concentration of treated effluent / residue disposed outside the project boundary (DE) (kg N/m^3 or kg N/ton of dry matter)
EF_1	=	Emission factor for direct emission of N_2O from soils in kg N_2O-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default

values from Table 11.1 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023 can be used

EF_5 = Emission factor for indirect emission of N_2O from runoff in kg N_2O-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023 can be used

F_{gasm} = Fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff should be estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023 can be used

EF_4 = Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N- N_2O / (kg NH_3-N + NOx-N volatilized)], estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3 (Updated), Chapter 11, Volume 4 of 2019 Refinement to the 2006 IPCC Guidelines, as updated in July 2023

12.2. Methane emissions from disposal of treated residues

Leakage methane emissions from land application of treated residues are calculated as follows:

Equation 35

$$LE_{B,CH_4,y} = GWP_{CH4} \times \rho_{CH4,n} \times MCF_d \times \left[\prod_{n-1}^{N}(1 - R_{VS,n})\right] \sum_{j,LT}\left(B_{0,LT} \times N_{LT,y} \times VS_{LT,y} \times MS\%_{BL,j}\right)$$

Equation 36

$$LE_{P,CH_4,y} = GWP_{CH_4} \times \rho_{CH_4,n} \times MCF_d \cdot \sum_{m=1}^{12}\left(Q_{DE,m} \times VS_{DE,m}\right) \times 10^3 \times \frac{\sum_{LT}\left(B_{0,LT} \cdot N_{LT,y} \cdot VS_{LT,y}\right)}{\sum_{LT}\left(N_{LT,y} \cdot VS_{LT,y}\right)}$$

In the case of utilizing option (b) for $BE_{CH4,y}$ calculations, methane emissions from disposal of treated residues must be calculated as follows:

Leakage methane emissions from land application of treated residues are calculated as follows:

Equation 37

$$LE_{B,CH_{4,y}} = GWP_{CH4} \times \rho_{CH4,n} \times MCF_d \times \left[\prod_{n-1}^{N}(1 - R_{VS,n})\right] \sum_{j,LT}(B_{0,LT} \times Q_{manure,j,LT,db,y} \times VS_{manure,LT} * 1000)$$

Equation 38

$$LE_{P,CH_4,y} = GWP_{CH_4} \times \rho_{CH_4,n} \times MCF_d \cdot \sum_{m=1}^{12}(Q_{DE,m} \times VS_{DE,m}) \times 10^3 \times \frac{\sum_{LT}(B_{0,LT} \cdot Q_{manure,j,LT,db,y} \times VS_{manure,LT})}{\sum_{LT}(Q_{manure,j,LT,db,y} \times VS_{manure,LT})}$$

Where:

$LE_{B,CH_4,y}$	=	Methane leakage emissions in the baseline (tCO_2e/yr)
$LE_{P,CH_4,y}$	=	Methane leakage emissions in the project case (t CO_2e/yr)
$R_{VS,n}$	=	Fraction of volatile solid degraded in AWMS n prior to sludge being treated. Values for R_{VS} should be taken from Annex 1
GWP_{CH4}	=	Global Warming Potential (GWP) of CH_4
$\rho_{CH_4,n}$	=	CH_4 density [$6.7x10^{-4}$ t/m^3 at room temperature (20 ºC) and 1 atm pressure]
$B_{0,LT}$	=	CH_4 production capacity from manure for livestock type LT, in m3 CH_4/kg-VS, to be chosen based on procedure provided for in the baseline methodology section
$N_{LT,y}$	=	Number of animals of type LT for the year y, expressed in numbers
$VS_{LT,y}$	=	Annual volatile solid for livestock LT entering all AWMS [on a dry matter weight basis (kg-dm/animal/year)]

$MS\%_{BL,j}$	=	Fraction of manure handled in system j in the baseline scenario
$Q_{DE,m}$	=	Total monthly volume of treated effluent / residue disposed outside the project boundary (DE) (tons of dry matter)
$VS_{DE,m}$	=	Monthly volatile solids concentration of the disposed treated effluent / residue (ton VS/m^3or ton VS/ton of dry matter)
MCF_d	=	Methane conversion factor for leakage calculation assumed to be equal 1

13. Emission reductions

The emission reduction (ER_y) by the project activity during a given year or the relevant monitoring periods of the project activity is the difference between the baseline emissions (BEy) and the sum of project emissions (PE_y) and leakage (LE_y), as follows:

Equation 39

$$\boldsymbol{ER_y = BE_y - PE_y - LE_y}$$

Where:

ER_y	=	Emission reductions in year *y* (t CO_2e/yr)
BE_y	=	Baseline emissions in year *y* (t CO_2e/yr)
PE_y	=	Project emissions in year *y* (t CO_2/yr)
LE_y	=	Leakage emissions in year *y* (t CO_2/yr)

Further, in calculating emissions reductions for Verified Carbon Credits (VCCs) claims, if baseline CH_4 emissions (in tCO_2e) exceed the measured CH_4 emissions (in tCO_2e) from the anaerobic digester(s) in the project scenario, then the latter, which is derived from the product of the biogas flow at the digester(s) outlet and the methane fraction in the biogas, should be used for emissions reduction calculations. Therefore, the actual methane captured from the anaerobic digester(s)/reactor(s) should be compared to the baseline emissions minus project emissions from the anaerobic digester(s) and any potential leakage $(BE_{CH4,y} - PE_{AD,y} - PE_{PL,y})$. If the actual captured methane (MDy – CD_{CH4}) (in tCO_2e) is lower, then this value should replace the corresponding component of $BE_y - PE_y - LE_y$ in Equation 39 to calculate the net emissions reduction.

Actual methane captured can be determined based on the following methods:

a) If the amount of biogas utilized in monitored through flow meters, MDy shall be determined based on equipment efficiency.

Equation 40

$$MD_y = BG_{utilized} \times fv_{CH4,RG,h} \times \rho_{CH4} \times EE_y \times GWP_{CH4}$$

Where;

MD_y	=	Actual methane captured (tCO_2)
$BG_{utilized}$	=	Biogas utilized (m^3)
$fv_{CH4,RG,h}$	=	Methane content in biogas in year *y* (volume fraction)
$EE_{j,y}$	=	Energy conversion efficiency of the project equipment *j* which is determined by adopting one of the following criteria: - Specification provided by the equipment manufacturer. The equipment shall be designed to utilize biogas as fuel, and efficiency specification is for this fuel. If the specification provides a range of efficiency values, the highest value of the range shall be used for the calculation; - Default efficiency of 40% for electricity or heat generation, default efficiency for flare should be determined as per the tool "Project emissions from flaring".

b) Alternatively, if project activities utilize the recovered methane for electricity generation and/or heat generation, MD_y may be calculated as follows, based on the sum of monitored electricity generation, and/or heat generation without monitoring methane flow and concentration.

Equation 41

$$MD_y = \frac{EG_y \times 3600 + HG_y}{NCV_{CH4} \times EE_{j,y}} \times \rho_{CH4} \times GWP_{CH4}$$

Where;

EG_y	= Total electricity generated from the recovered biogas in year y (MWh)
HG_y	= Total heat generated from the recovered biogas in year y (MJ)
3600	= Conversion factor (1 MWh = 3600 MJ)
NCV_{CH4}	= NCV of methane (MJ/Nm^3) (use default value: 35.9 MJ/Nm^3)

The effect of co-digested organic waste shall be determined as follows:

Equation 42

$$\boldsymbol{CD_{CH4} = \varphi_y \times (1 - f_y) \times GWP_{CH4} \times \sum_{x=1}^{y} Default_x \times W_x)}$$

Where;

CD_{CH4}	=	Methane generation potential of the organic waste anaerobically co-digested by the project activity during the year x from the beginning of the project activity (x=1) up to the year y (t CO2e/yr)
W_x	=	Amount of organic waste type *j* prevented from disposal in the SWDS in the year *x* (t)
φ_y	=	Model correction factor to account for model uncertainties for year *y*
f_y	=	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year *y*

14. Data and parameters not monitored

In addition to the parameters listed in Annex 8, this methodology also applies to data and parameters not monitored in the tools.

15.Monitoring plan

Project holders shall submit a monitoring plan in accordance with the standard and additionally describe the procedures for monitoring project activities and GHG emission reductions within the project boundary.

The GHG Project holder shall demonstrate that emission reductions or removals are quantified, monitored, reported and verified, through the application of the BCR Tool "Monitoring, reporting and verification (MRV)"[21].

In order to ensure that the animal manure entering the central treatment plant are indeed originated from the sites included in the project boundary, it must be ensured that:

1) In the case where residues are collected with tank trucks, the precise location of manure collection points shall be identified in the project document (e.g., coordinates using global positioning system) and the road distances of the itineraries between them and the manure central treatment plant shall be documented using information from official sources. CABs shall validate this information and the origin of animal manure during the site visit.

2) In the cases where residues are led to the central treatment plant though pipes, the piping system shall be detailed in the project document. The quantity of residues collected through the pipes system should be measured (m^3). It shall be depicted in the project document whether the residues are continuously directed to the central treatment plant or not.

3) CABs shall perform site visits on the central treatment plant during project validation and verification. All documentation which shall be checked by the CAB, referring to every farm, must be available during the validation and verification (sales records, feed formulation, etc.). However, CABs are not requested to perform site visits in all farms included in the project boundary. Instead, the CABs and project participants may proceed as described in the following section.

4) Prior to the validation and verification, project proponents shall calculate the baseline emission from each site separately. Then, project participants shall ordinate, in decreasing order, the sites where most of the baseline emissions would occur. CAB shall perform site visits on the sites that are individually responsible for an amount of baseline emissions equal or higher than 900 tCO_2e ("upper rank"). This guarantees that the most preponderant baseline GHG sources are properly validated and/or verified. For the remaining sites ("lower rank"), CABs

[21] https://biocarbonstandard.com/wp-content/uploads/BCR_Monitoring-reporting-and-verification.pdf

shall perform site visits on a number n of randomly selected sites, being n determined as:

Equation 43

$$n = \frac{N}{1 + NE^2}$$

Where:

n	=	Number of "lower rank" sites to be visited by CAB
N	=	Total number of "lower rank" sites
E	=	Tolerable sampling error (10%)

Then, a CH4 emission reduction deviation factor (DF_{site}) shall be calculated for each "lower rank" site.

Equation 44

$$DF_{site} = \frac{BE_{site}^{obs}}{BE_{site}^{claimed}}$$

Where:

DF_{site}	=	Deviation factor for the "lower rank" sites visited by the CAB (dimensionless)
BE_{site}^{obs}	=	Baseline emissions verified by CAB after site inspection (tCO_2e)
$BE_{site}^{claimed}$	=	Baseline emissions claimed by project proponents for a given "lower rank" site (tCO_2e)

The largest value DF_{site} can assume is 1.

Then, an average baseline emissions deviation factor ($\overline{DF}$) shall be calculated:

Equation 45

$$\overline{DF} = \frac{\sum_{site}\left(DF_{site} \times BE_{site}^{obs}\right)}{\sum_{site} BE_{site}^{obs}}$$

Where:

$\overline{DF}$ = Average deviation factor for the "lower rank" sites visited by the CAB (dimensionless);

DF_{site} = Deviation factor for the "lower rank" sites visited by the CAB (dimensionless);

BE_{site}^{obs} = Baseline emissions verified by CAB after "lower rank" sites inspection (tCO_2e)

Then, the baseline emissions from the "lower rank" sites shall be corrected as follows:

Equation 46

$$BE_{LR,total}^{corrected} = \overline{DF} \times \sum_{site} BE_{site}^{claimed}$$

Where:

$BE_{LR,total}^{corrected}$ = Total corrected baseline emissions from the "lower rank" sites (tCO_2e)

$\overline{DF}$ = Deviation factor for the "lower rank" sites visited by the CAB (dimensionless)

$BE_{site}^{claimed}$ = Baseline emissions claimed by project proponents for a given "lower rank" site (tCO_2e)

Then, total baseline emissions shall be calculated as follows:

Equation 47

$$BE_{total} = BE_{LR,total}^{corrected} + BE_{UR,total}$$

Where:

BE_{total} = Total baseline emissions (tCO_2e)

$BE_{LR,total}^{corrected}$ = Total corrected baseline emissions from "lower rank" sites (tCO_2e)

$BE_{UR,total}$ = Total baseline emissions from "upper rank" sites (tCO_2e) (no correction values shall be applied – absolute verified values must be used)

For the lower rank farms that have not been visited a virtual inspection shall be performed by the CAB.

During the site visits, for both validation and verification site visits, CAB shall participate in a meeting with the stakeholders in order to assess the application of the project activity and its impact on the environment.

Options for site visit:

i. The physical site visit of project site and all farms included in the project boundary is mandatory for validation.
ii. Any alterations in animal manure supplier farms, including the addition of new suppliers or the exclusion of current ones, must be thoroughly justified and reported in the project document. CAB shall assess and validate the eligibility of the new animal manure supplier farms to baseline scenario by physical site visit.
iii. For crediting renewal period that physical site visit of animal manure supplier farms is not mandatory, CAB can choose to conduct site visits remotely, the following three criteria are met:
    a) In case a physical site visit is not possible for any of the farms within the project boundary, except the new animal manure supplier farms,
    b) The feasibility of remote audits of the farms,
    c) The appropriateness of the use of remote audit technique.

iv. The number of farms that can be visited remotely shall be determined by CAB according to the latest version of the *CDM Guidelines: Sampling and Surveys for CDM Project Activities and Programs of Activities*.

    This approach involves leveraging advanced information and communication technology (ICT) to collect pertinent information, conduct interviews with farm owners, and adhere to the established guidelines of the ISO 19011 standard. CAB shall collect key evidence with ICT that supports the scope of the assessment. The integration of suitable technology for remote audit techniques includes handheld devices, laptops, desktop computers, smartphones, drones, video cameras, and more. These tools are employed to collect, store, retrieve, process, analyze, and transmit information for auditing and assessments, both locally and remotely. The reason for the remote site visit shall be described in the validation or verification report as the alternative means used and justify that they are credible and sufficient for validation or verification.

15.1. Monitoring procedure

The monitoring plan for the project activity shall be described in the project document. The key elements of the monitoring plan are:

(a) Monitored parameters and method to monitor/record,

(b) Monitoring equipment,

(c) Quality Control/Quality Assurance (QA/QC) procedures (Staff trainings, procedure in case of failure of the monitoring equipment, emergency preparedness and more),

(d) Sampling plan,

(e) Organizational scheme of the project activity and responsibilities to ensure the real, reliable, and traceable measurement of the GHG emission reductions, which shall be validated by CAB.

For each monitored parameter, monitoring equipment, a description of the method to monitor/record, and be responsible should be illustrated transparently and completely, as shown in **¡Error! No se encuentra el origen de la referencia.**2.

Table 2. Description of monitoring plan

Monitored Parameter	Monitoring Equipment	Description of Method to Monitor/Record	Responsible

The monitoring equipment will undergo maintenance/calibration subject to appropriate industry standards and/or regional/national standards. This maintenance/calibration practice should be clearly stated in the project document.

Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period:

At the start of each verification period for a project activity, the validity of the baseline scenario shall be assessed by the CAB by applying the latest version of the *CDM Methodological Tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period*".

15.2. Data and parameters monitored

Data and parameters that shall be monitored as indicated Annex 9. Any additional monitoring parameter related to utilized methodological tools shall be clearly provided in the project document in accordance the following reporting structure.

Annex 1: Anaerobic Unit Process Performance

Table 8-10. Anaerobic Unit Process Performance

Anaerobic Treatment	HRT	COD	TS	VS	TN	P	K
	days	Percent Reduction					
Pull plug pits	4-30	—	0-30	0-30	0-20	0-20	0-15
Underfloor pit storage	30-180	—	30-40	20-30	5-20	5-15	5-15
Open top tank	30-180	—	—	—	25-30	10-20	10-20
Open pond	30-180	—	—	—	70-80	50-65	40-50
Heated digester effluent prior to storage	12-20	35-70	25-50	40-70	0	0	0
Covered first cell of two cell lagoon	30-90	70-90	75-95	80-90	25-35	50-80	30-50
One-cell lagoon	>365	70-90	75-95	75-85	60-80	50-70	30-50
Two-cell lagoon	210+	90-95	80-95	90-98	50-80	85-90	30-50
HRT=hydraulic retention time; COD=chemical oxygen demand; TS=total solids; VS=volatile solids; TN=total nitrogen; P=phosphorus; K= potassium; — =data not available.							

Source: Moser and Martin, 1999

Annex 2: Method for determination of Volatile Solid in animal waste

From: USDA. Agricultural Waste Management Field Handbook. Chapter 4 - Agricultural Waste

Characteristics. Page 2.

<u>Definitions</u>

- Total Solids: Residue remaining after water is removed from waste material by evaporation; dry matter;
- Volatile Solids: The part of total solids driven off as volatile (combustible) gases when heated to 600ºC; organic matter;
- Fixed Solids: The part of total solids remaining after volatile gases driven off at 600ºC; ashes.

<u>Determination method</u>

1. Evaporate free water on steam able and dry in oven at 103°C for 24 hours or until constant weight to obtain the Total Solids.

2. Place Total Solids residue in furnace at 600ºC for at least 1 hour. Volatile Solids are determined from weight difference of total and Fixed Solids.

Equation 48

$$\boldsymbol{Volatilematter(drybasis)} = \frac{\boldsymbol{W_2 - W_f}}{\boldsymbol{W_2 - W_1}}$$

Where W1 is the weight of sample container, W2 is combined weight of the sample container and oven dried sample, Wf is the combined constant weight of the sample container and sample after heating at 600ºC

Annex 3: Determination of Total Nitrogen in animal waste

Definitions

- Ammoniacal nitrogen (total ammonia): Both NH_3 and NH_4 nitrogen compounds;
- Ammonia nitrogen: A gaseous form of ammoniacal nitrogen;
- Ammonium nitrogen: The positively ionized (cation) form of ammoniacal nitrogen;
- Total Kjeldahl nitrogen: The sum of organic nitrogen and ammoniacal nitrogen;
- Nitrate nitrogen: The negatively ionized (anion) form of nitrogen that is highly mobile;
- Total nitrogen: The summation of nitrogen from all the various nitrogen compounds listed above.

Principles and guidelines for Total Nitrogen Determination:

Total Kjeldahl nitrogen (TKN) can be an accurate predictor of total N content, because the inorganic N content in manure generally is very small when compared to the total N content (Paul and Beauchamp, 1993; Eghball, 2000).

Total Kjeldahl nitrogen is a wet oxidation procedure used to determine the organic N present as NH_3 in soils, plants and organic residues, such as manure. The three main steps of the Kjeldahl method are: (1) digestion, (2) separation of ammonia, and (3) determination of ammonia. In some techniques the separation stage is omitted and the ammonia is determined directly on the digest. Separation of ammonia may be effected by steam distillation, aeration, or diffusion, steam distillation being conventional. With automated procedures this separation step is invariably omitted (Fleck, 1969).

The determination of ammonia may be by: (1) simple titration, (2) iodometric methods, (3) coulometric methods or (4) colorimetric methods. Without separation of ammonia from the digest simple titration cannot be utilized (Fleck, 1969).

The remaining three techniques can, however, be applied directly to the digest. Iodometric and analogous methods have disadvantages (McKenzie & Wallace, 1954 APUD Fleck, 1969) and are not popular. Coulometric methods are not widely applied. Colorimetry remains as the only well-tried approach for automation (Fleck, 1969).

The three popular colorimetric methods of NH_3, determination are: ninhydrin, Nessler, and the phenol-hypochlorite or Berthelot reaction. The ninhydrin method has been successfully applied following sealed-tube digestion (Jacobs, 1965 APUD Fleck, 1969). The Nessler method, although excellent for simple aqueous ammonia solutions, is not advisable when ammonia is to be determined in Kjeldahl digestion mixtures (Fleck & Munro, 1965 APUD Fleck, 1969).

The most important aspect of the Kjeldahl method is digestion, which may be carried out in an open tube or in a sealed tube. The critical factors are: (I) temperature,(2)catalyst, (3) time, (4) reflux and (5) decomposition of the ammonia-catalyst complex. The optimum temperature for sealed-tube digestion is in the region of 450ºC and the main advantage is that no catalyst or other additions are required.

The more commonly utilized open-tube digestion requires a temperature close to 400°C for adequate decomposition of nitrogenous compounds to ammonia. The evidence for this is clear (Bradstreet, 1965; Fleck & Munro, 1965 APUD Fleck, 1969), as is the evidence that the only satisfactory means of attaining this temperature is to add the appropriate amounts of K_2SO_4. When the temperature exceeds 400°C the digest solidifies on cooling (Bradstreet, 1957 APUD Fleck, 1969). This is an important practical point because temperatures in excess of 400ºC lead to loss of nitrogen (as well as loss of acid which leads to the solid cold digest).

With regard to the catalyst, mercury is indicated as the only 'safe' catalyst, with which no losses have been reported (Bradstreet, 1965; Fleck & Munro, 1965APUD Fleck, 1969). The disadvantage of mercury is that it forms a mercury-ammonium complex which must be decomposed before determining ammonia. This decomposition may be achieved by using sodium thiosulphate or zinc dust (Fleck, 1969).

The use of oxidizing can cause loss of nitrogen (Peters & Van Slyke, 1932). There the use of such agents is not recommended for the purposes of the project activities employing this methodology.

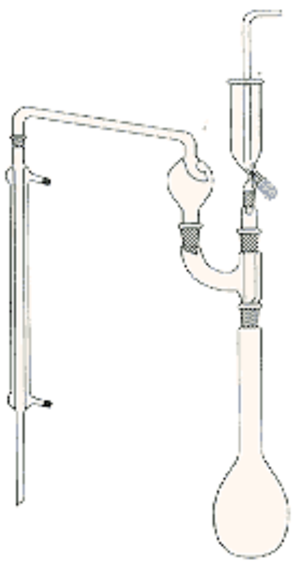
For manual determination PPs shall follow the protocol depicted below (adapted from Mendham et al., 2002):

1. Homogenize manure sample through intense agitation;
2. Before sample precipitates pipette a certain volume (a mL) which contains approximately 0.04 g of nitrogen (based on previous experience) and transfer it to a long-necked Kjeldahl digestion tube;
3. Add 0.7 g mercury oxide (II), 15 gof potassium sulfate and 40 mL of concentrated sulfuric acid;
4. Gently heat the digestion tube, keeping it slightly tilted. Frothing may occur. If needed frothing may be controlled through the use of anti-frothing agents;
5. Once frothing ceases, boil reagents during 2 hours;
6. After cooling add 200 mL of water and 25 mL of sodium thiosulphate solution (0.5 M). Perform this step under agitation;
7. Add a few glass beads to the mixture;
8. Carefully introduce in the digestion tube a sodium hydroxide solution (11 M). Before mixing the reagents, connect the digestion tube to a distillation apparatus (see figure below). Keep the outlet of the condenser immersed into a known volume of 0.1 M HCl solution. Be certain that the contents of the digestion tube are well mixed;
9. Boil until the 150 mL of the distilled liquid has been collected in the receptor tube;
10. Add indicator Methyl Red to the receptor tube. Titrate with 0.1 M NaCl (b mL). Titrate a blank using the same volume of 0.1 M HCl (c mL).

With the quantities and concentrations of reagents provided above, the nitrogen concentration in the sample (kg N/m^3) is given as follows:

Equation 49

$$[N] = \frac{(c-b) \cdot 0.1 \cdot 14}{a} \cdot 10^3$$



Assembly of the Kjeldahl apparatus.

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USDA. Agricultural Waste Management Field Handbook. Chapter 4 - Agricultural Waste Characteristics. Page 2.

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Annex 4: Guidance on sample extraction procedures

For the purposes of the essays described in Annex 2 and 3, project participants shall observe the following guidance on sample extraction procedure:

1. For liquid material, samples should be preferably collected using continuous-flow samples at the entrance or exit point of the pertinent treatment stage;
2. Samples should be collected in clean wide-mouth glass bottles;
3. Samples should be analysed as soon as possible. If samples need to be stored, storage shall be performed at 4ºC;
4. It should be checked that the suspended matter does not adhere to the walls, prior to the analysis procedure;
5. If results must be expressed in a dry matter basis, dry matter content shall be determined after oven-drying at 103°C for 24 hours or until constant weight is obtained;
6. Uncertainty range shall not exceed 20% under a 90% confidence interval, which is calculated as depicted in the formula below:

Equation 50

$$\bar{x} \pm \frac{t \cdot s}{\sqrt{n}}$$

Where:

$\bar{x}$ Sample average;

t *t* student value for *n*– – 1 (v) degrees of freedom (see table 3);

s Sample standard deviation;

n Number of samples.

Table 3. Values for t-distributions with v degrees of freedom for a range of one-sided confidence intervals.											
v	**75%**	**80%**	**85%**	**90%**	**95%**	**97.5%**	**99%**	**99.5%**	**99.75%**	**99.9%**	**99.95%**
1	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	127.3	318.3	636.6
2	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	14.09	22.33	31.60
3	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	7.453	10.21	12.92
4	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
50	0.679	0.849	1.047	1.299	1.676	2.009	2.403	2.678	2.937	3.261	3.496
60	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
80	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	2.887	3.195	3.416
100	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	2.871	3.174	3.390
120	0.677	0.845	1.041	1.289	1.658	1.980	2.358	2.617	2.860	3.160	3.373
∞	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

Annex 5: Table 10.17 from 2019 Refinement to IPCC 2006

TABLE 10.17 (UPDATED)
METHANE CONVERSION FACTORS FOR MANURE MANAGEMENT SYSTEMS

System[4]		MCFs by climate zone									
		Cool				Temperate		Warm			
		Cool Temp. Moist	Cool Temp. Dry	Boreal Moist	Boreal Dry	Warm Temp. Moist	Warm Temp. Dry	Tropical Montane	Tropical Wet	Tropical Moist	Tropical Dry
Uncovered anaerobic lagoon[7]		60%	67%	50%	49%	73%	76%	76%	80%	80%	80%
Liquid/Slurry, and Pit storage below animal confinements[1]	1 Month	6%	8%	4%	4%	13%	15%	25%	38%	36%	42%
	3 Month[8]	12%	16%	8%	8%	24%	28%	43%	61%	57%	62%
	4 Month[9]	15%	19%	9%	9%	29%	32%	50%	67%	64%	68%
	6 Month[9]	21%	26%	14%	14%	37%	41%	59%	76%	73%	74%
	12 Month[9]	31%	42%	21%	20%	55%	64%	73%	80%	80%	80%
Cattle and Swine deep bedding[5]	> 1 month[10]	21%	26%	14%	14%	37%	41%	59%	76%	73%	74%
	< 1 month[11]	2.75%				6.50%		18%			
Solid storage[6,12]		2.00%				4.00%		5.00%			
Solid storage – Covered/compacted[6,13]		2.00%				4.00%		5.00%			
Solid storage – Bulking agent addition[6,14]		0.50%				1.00%		1.50%			
Solid storage – Additives[6,15]		1.00%				2.00%		2.50%			
Dry lot[16]		1.00%				1.50%		2.00%			
Daily spread[17]		0.10%				0.50%		1.00%			
Composting - In-vessel[4,18]		0.50%									
Composting - Static pile (Forced aeration)[4,6,19]		1.00%				2.00%		2.50%			
Composting - Intensive windrow[4,20]		0.50%				1.00%		1.5%			
Composting – Passive windrow (Unfrequent turning)[3,4,6,21]		1.00%				2.00%		2.50%			

TABLE 10.17 (UPDATED) (CONTINUED)
METHANE CONVERSION FACTORS FOR MANURE MANAGEMENT SYSTEMS

System[4]	MCFs by climate zone									
	Cool				Temperate		Warm			
	Cool Temp. Moist	Cool Temp. Dry	Boreal Moist	Boreal Dry	Warm Temp. Moist	Warm Temp. Dry	Tropical Montane	Tropical Wet	Tropical Moist	Tropical Dry
Pasture/Range/Paddock[2]	0.47%									
Poultry manure with and without litter[22]	1.50%									
Aerobic treatment[23]	0.00%									
Burned for fuel[24]	10.00%									
Anaerobic Digester[25], Low leakage, High quality gastight storage, best complete industrial technology	1.00%									
Anaerobic Digester[25], Low leakage, High quality industrial technology, low quality gastight storage technology	1.41%									
Anaerobic Digester[25], Low leakage, High quality industrial technology, open storage	3.55%				4.38%		4.59%			
Anaerobic Digester[25], High leakage, low quality technology, high quality gastight storage technology	9.59%									
Anaerobic Digester[25], High leakage, low quality technology, low quality gastight storage technology	10.00%									
Anaerobic Digester[25], High leakage, low quality technology, open storage	12.14%				12.97%		13.17%			

Annex 6: Procedure for estimating NEX

Equation 51

$$NEX = N_{int\,ake} \cdot (1 - N_{retention})$$

Where:

$N_{\text{int}\,ake}$	=	The annual N intake per animal – kg N/animal-year
$N_{retention}$	=	The portion of that N intake that is retained in the animal (default values are reported in Table 10.20 in IPCC 2006 guidelines, volume 4, chapter 10).

$N_{\text{int}\,ake}$ may be calculated using:

Equation 52

$$N_{int\,ake} = \left(\frac{GE}{18.45}\right) \cdot \left(\frac{CP \cdot 0.01}{6.25}\right)$$

Where:

CP	=	Crude percent of protein (percent)
GE	=	Gross energy intake of the animal, in enteric model, based on digestible energy, milk production, pregnancy, current weight, mature weight, rate of weight gain, and IPCC constants, MJ/day
18.45	=	Conversion factor for dietary GE per kg of dry matter (MJ/kg). This value is relatively constant across a wide range of forage and grain-based feeds commonly consumed by livestock
6.25	=	Conversion from kg of dietary protein to kg of dietary N, kg feed protein (kg N)-1

In absence of availability of project specific information on Protein intake, which should be justified in the project document, site-specific national or regional data should be used for the nitrogen excretion NEX, if available.

In the absence of national data, default values from table 10.19 (updated) of the 2019 Refinement to IPCC 2006, volume 4, chapter10) may be used and should be corrected for the animal weight at the project site in the following way:

Equation 53

$$NEX_{site} = \frac{W_{site}}{1000} \cdot NEX_{IPCC,default}$$

Where:

NEX_{site}	=	Is the adjusted annual average nitrogen excretion per head of a defined livestock population in kg N/animal/year
W_{site}	=	Is the average animal weight of a defined population at the project site in kg
$NEX_{IPCC,default}$	=	Is the default value (IPCC 2006 or US-EPA 2002) for the nitrogen excretion per head of a defined livestock population in kg N/animal/year

Annex 7: Default values for simplified estimation of CH_4 emissions from co-digested organic waste.

x	Tropical wet	Tropical dry	Boreal/ temperate wet	Boreal/temperate dry
1	0.005800	0.001856	0.003382	0.001399
2	0.004212	0.001724	0.002913	0.001325
3	0.003093	0.001601	0.002511	0.001254
4	0.002275	0.001487	0.002163	0.001188
5	0.001657	0.001381	0.001861	0.001125
6	0.001198	0.001281	0.001599	0.001065
7	0.000867	0.001189	0.001371	0.001008

x	Tropical wet	Tropical dry	Boreal/ temperate wet	Boreal/temperate dry
8	0.000635	0.001103	0.001174	0.000954
9	0.000474	0.001024	0.001004	0.000904
10	0.000362	0.000950	0.000859	0.000855
11	0.000284	0.000881	0.000734	0.000810
12	0.000228	0.000817	0.000629	0.000766
13	0.000189	0.000757	0.000539	0.000725
14	0.000160	0.000702	0.000463	0.000687
15	0.000138	0.000651	0.000399	0.000650
16	0.000122	0.000603	0.000344	0.000615
17	0.000109	0.000559	0.000298	0.000582
18	0.000098	0.000518	0.000259	0.000551
19	0.000090	0.000480	0.000226	0.000521
20	0.000082	0.000445	0.000197	0.000493
21	0.000076	0.000413	0.000173	0.000467

Annex 8: Data and parameters not monitored

Data / Parameter Table 1

Parameter:	$R_{VS,n}$
Data unit:	Fraction
Description:	Relative reduction of volatile solids from the previous stage
Source of data:	Refer to Annex 1.
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	Estimated from Table provided in Annex 1. The most conservative value for the given technology must be used.

Data / Parameter Table 2

Parameter:	EFN2O,ID
Data unit:	kg N2O-N/ kg NH3-N and NOx-N
Description:	Indirect N2O emission factors
Source of data:	2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Table 11.3 (Updated), Volume 4, Chapter 11
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	2019 Refinement to the 2006 IPCC Guidelines default values may be used, if country specific or region-specific data are not available. In the case of utilizing IPCC default values, latest refinement to IPCC Guidelines shall be taken into consideration in defining the default values to be applied.

Data / Parameter Table 3

Parameter:	Fgasm
Data unit:	Fraction
Description:	Percent of total nitrogen that volatilises as NH3 and NOx in the treatment stage j
Source of data:	2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Table 11.3 (Updated), Volume 4, Chapter 11
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	2019 Refinement to the 2006 IPCC Guidelines default values may be used if country specific or region-specific data are not available. In the case of utilizing IPCC default values, latest refinement to IPCC Guidelines shall be taken into consideration in defining the default values to be applied.

Data / Parameter Table 4

Parameter:	EF1, EF4 and EF5
Data unit:	kg N2O-N/ kg N for EF1and EF5; kg N2O-N/ kg NH3-N and NOx-N for EF4
Description:	N2O emission factor from soil and runoff water
Source of data:	2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Table 11.26 (Updated) and Table 11.3, Volume 4, Chapter 11
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	2019 Refinement to the 2006 IPCC Guidelines default values may be used if country specific or region-specific data are not available. In the case of utilizing IPCC default values, latest refinement to IPCC Guidelines shall be taken into consideration in defining the default values to be applied.

Data / Parameter Table 5

Parameter:	Fleach
Data unit:	Fraction
Description:	Fraction of N leached
Source of data:	2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Table 11.3 (Updated), Volume 4, Chapter 11
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	2019 Refinement to the 2006 IPCC Guidelines default values can be used. In the case of utilizing IPCC default values, latest refinement to IPCC Guidelines shall be taken into consideration in defining the default values to be applied.

Data / Parameter Table 6

Parameter:	EGBl,y
Data unit:	MWh
Description:	Electricity consumption by Baseline AWMSs
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically for the duration of project plus 5 years
Any comment:	Estimation is based on an average of the historical 3 years consumption prior to start of the project. Electricity meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company. Uncertainty of the meters to be obtained from the manufacturers. This uncertainty to be included in a conservative manner while calculating VCCs and procedure for doing so should be described in the project document.

Data / Parameter Table 7

Parameter:	HGBl,y
Data unit:	MJ
Description:	Heat used by baseline AWMSs
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronic for the duration of project plus 5 years
Any comment:	Estimation is based on an average of the historical 3 years consumption prior to start of the project. Fuel purchase records to be cross checked with estimates.

Data / Parameter Table 8

Parameter:	GWPCH4 and GWPN2O
Data unit:	Dimensionless
Description:	Global warming potential for CH4 and N2O, respectively.
Source of data:	IPCC Fifth Assessment Report, Chapter 8, Table 8.A.1
Measurement procedures (if any):	28 and 265, respectively. Shall be determined according to latest version of IPCC Guidelines.
Any comment:	---

Data / Parameter Table 9

Parameter:	$\rho_{CH4,n}$
Data unit:	t/m3

Description:	Density of methane at normal (at room temperature 20°C and 1 atm pressure) conditions
Source of data:	ACM0010: Consolidated baseline methodology for GHG emission reductions from manure management systems, Version 8.0 & AM0073: GHG emission reductions through multi-site manure collection and treatment in a central plant, Version 01
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	0,00067 t/m3

Data / Parameter Table 10

Parameter:	MCFd
Data unit:	---
Description:	Methane conversion factor for leakage calculation assumed to be equal 1
Source of data:	See Leakage section
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	---

Data / Parameter Table 11

Parameter:	CFN2O-N,N
Data unit:	---
Description:	Conversion factor = 44/28
Source of data:	AM0073: GHG emission reductions through multi-site manure collection and treatment in a central plant, Version 01
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	---

Data / Parameter Table 12

Parameter:	ρf
Data unit:	t/m3
Description:	Density of fuel type f at normal conditions
Source of data:	Source of data shall be determined in the preference order below Values provided by the fuel supplier in invoices Regional or national default values
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	In the case of utilizing regional and national default values appropriateness of these values shall be assessed annually and most conservative value shall be used. This parameter may be utilized for the purpose of unit consistency.

Data / Parameter Table 13

Parameter:	MCFAer
Data unit:	---
Description:	Methane Conversion Factor (MCF) for aerobic system
Source of data:	0.1
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	---

Data / Parameter Table 14

Parameter:	MCFres

Data unit:	---
Description:	Methane Conversion Factor (MCF) for composting system
Source of data:	2019 Refinement to the 2006 IPCC Guidelines Table 10.17 (Updated), Volume 4 Chapter 10
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	In the case of utilizing IPCC default values, latest refinement to IPCC Guidelines shall be taken into consideration in defining the default values to be applied.

Data / Parameter Table 15

Parameter:	VSdefault
Data unit:	kg-VS-dm/1000 kg animal mass/day
Description:	Default value for the volatile solid excretion per day on a dry-matter basis for a defined livestock population
Source of data:	2019 Refinement to the 2006 IPCC Guidelines (IPCC 2019, as updated in July 2023), Table 10.13A (New), Chapter 10, Volume 4 or US-EPA 2002, whichever is lower
Measurement procedures (if any):	---
Any comment:	In the case of utilizing IPCC 2006 default values, latest refinement to IPCC Guidelines shall be taken into consideration in defining the default values to be applied.

Data / Parameter Table 16

Parameter:	EEj,y
Data unit:	%
Description:	Energy Conversion Efficiency of the project equipment j
Source of data:	Project proponents
Measurement procedures (if any):	This parameter shall be determined via the specification provided by the equipment manufacture. The equipment shall be designed to utilize biogas as fuel, and the efficiency specification is for this fuel. If the specification provides a range of efficiency values, the most conservative value of the range shall be used for the calculation
Any comment:	---

Data / Parameter Table 17

Parameter:	k
Data unit:	Unitless
Description:	Degradation rate constant
Source of data:	0.069
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	---

Data / Parameter Table 18

Parameter:	φdefault
Data unit:	Unitless
Description:	Default value for the model correction factor to account for model uncertainties
Source of data:	Tool 4: Emissions from solid waste disposal sites
Value to be applied:	1
Measurement procedures (if any):	---

Any comment:	For the sake of conservativeness, the highest default value shall be applied.

Data / Parameter Table 19

Parameter:	fy
Data unit:	Unitless
Description:	Default value for the fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y
Source of data:	AMS-III.AO: Methane recovery through controlled anaerobic digestion
Value to be applied:	0.0
Measurement procedures (if any):	---
Any comment:	It is assumed that no biogas is captured, flared or used at the SWDS in the baseline scenario for the sake of conservativeness.

Data / Parameter Table 20

Parameter:	Defaultx
Data unit:	Unitless
Description:	Default value for simplified estimation
Source of data:	Refer to Annex 7
Value to be applied:	---
Measurement procedures (if any):	---
Any comment:	Estimated from Table provided in Annex 7. Note: MAT – mean annual temperature, MAP – Mean annual precipitation, PET – potential evapotranspiration. MAP/PET is the ratio between the mean annual precipitation and the potential evapotranspiration.

Annex 9: Data and parameters monitored

Data / Parameter Table 21

Data / Parameter:	MCFj
Data unit:	Fraction
Description:	Methane Conversion Factor for the stage j of the baseline AWMS
Source of data:	2019 Refinement to IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Volume 4, Chapter 10, Table 10.17 (Updated)
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	The factor MCF shall be taken from 2019 Refinement to the 2006 IPCC Guidelines in accordance with the related climate zone for the project activity. A conservativeness factor should be applied by multiplying MCF values with a value of 0.94, to account for the 20 percent uncertainty in the MCF values as reported IPCC 2006.

Data / Parameter Table 22

Data / Parameter:	MCFl
Data unit:	Fraction
Description:	Annual methane conversion factor for the project manure storage tank l
Source of data:	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023) - Table 10.17, Chapter 10, Volume 4
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	

Data / Parameter Table 23

Data / Parameter:	Bo,LT
Data unit:	m3 CH4/kg_VS_dm
Description:	Maximum methane producing potential of the volatile solid generated
Source of data:	2019 Refinement to the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Volume 4, Chapter 10, Table 10.16A (Updated) or directly measured
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	See guidance on how to estimate this parameter in the methodology. In the case of utilizing IPCC default values, latest refinement to IPCC Guidelines shall be taken into consideration and equivalent values shall be used.

Data / Parameter Table 24

Data / Parameter:	ndy
Data unit:	Number

Description:	Number of days the central treatment plant was operational in year y
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically for the duration of project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	The number of days that correspond to the months in which the average temperature is below 5°C shall be deducted from this parameter.

Data / Parameter Table 25

Data / Parameter:	QEM,Aer,m
Data unit:	m3/month
Description:	Monthly volume of the effluent entering the aerobic treatment step
Source of data:	Project proponents
Measurement procedures (if any):	This parameter shall be monitored by using a flow meter/s Archive electronically during project plus 5 years
Monitoring frequency:	This parameter shall be continuously monitored
QA/QC procedures:	Flow meters will undergo maintenance/calibration subject to appropriate industry standards. This maintenance/calibration practice should be clearly stated in the project document.
Any comment:	---

Data / Parameter Table 26

Data / Parameter:	QEM,m
Data unit:	m3/month
Description:	Monthly volume of the feedstock entering the central treatment plant
Source of data:	Project proponents
Measurement procedures (if any):	This parameter shall be monitored via flow meter/s installed just before anaerobic digesters. Archive electronically during project plus 5 years
Monitoring frequency:	This parameter shall be continuously monitored
QA/QC procedures:	Flow meters will undergo maintenance/calibration subject to appropriate industry standards. This maintenance/calibration practice should be clearly stated in the project document.
Any comment:	---

Data / Parameter Table 27

Data / Parameter:	Qmanure,j,LT,wb,y
Data unit:	tonnes/year, wet basis
Description:	Quantity of manure treated from livestock type LT and animal manure management system j
Source of data:	Project proponents
Measurement procedures (if any):	This parameter shall be directly monitored via weighbridge records for every manure acceptance. Alternatively, manure volume can be measured together with the density determined from representative sample (90/10 precision). Archive electronically during project plus 5 years
Monitoring frequency:	Annually, based on daily measurement and monthly aggregation
QA/QC procedures:	Weighbridge will undergo maintenance/calibration subject to appropriate industry standards. This maintenance/calibration practice should be clearly stated in the project document.
Any comment:	This parameter shall be adjusted to dry basis for unit consistency

Data / Parameter Table 28

Data / Parameter:	Qmanure,j,LT,db,y
Data unit:	tonnes/year, wet basis
Description:	Quantity of manure treated from livestock type LT and animal manure management system j
Source of data:	Project proponents
Measurement procedures (if any):	This parameter shall be adjusted to dry basis utilizing the following equation. $Q_{manure,j,LT,db,y} = Q_{manure,j,LT,wb,y} \times DM_{manure,LT}$
Monitoring frequency:	Annually, based on daily measurement and monthly aggregation
QA/QC procedures:	Weighbridge will undergo maintenance/calibration subject to appropriate industry standards. This maintenance/calibration practice should be clearly stated in the project document.
Any comment:	---

Data / Parameter Table 29

Data / Parameter:	DMmanure,LT
Data unit:	Fraction
Description:	Dry matter content of manure from livestock type LT
Source of data:	Project proponents
Measurement procedures (if any):	Source of data shall be determined via the options provided below Direct measurement at the project site Regional or national default values USDA. Agricultural Waste Management Field Handbook. Chapter 4 - Agricultural Waste Characteristics
Monitoring frequency:	Discontinuous daily measurement aggregated monthly
QA/QC procedures:	The related equipment for direct measurement will undergo maintenance/calibration subject to appropriate industry standards. This maintenance/calibration practice should be clearly stated in the project document.
Any comment:	In the case of direct measurement dry matter content of animal manure for each manure supplier farm shall be measured separately. In the case of regional or national default values and default values taken from the USDA guidance, appropriateness of these values shall be assessed by the DOE.

Data / Parameter Table 30

Data / Parameter:	QDE,m
Data unit:	Tons of dry matter/month
Description:	Monthly quantity of treated effluent / residue disposed outside the project boundary
Source of data:	Project proponents
Measurement procedures (if any):	This parameter shall be monitored via weighbridge data recorded for every batch disposed Archive electronically during project plus 5 years
Monitoring frequency:	Discontinuous daily measurement aggregated monthly
QA/QC procedures:	---
Any comment:	This parameter shall be adjusted to dry basis if needed for unit consistency

Data / Parameter Table 31

Data / Parameter:	DMDE,m
Data unit:	Fraction

Description:	Dry matter content of treated effluent disposed outside the project boundary
Source of data:	Project proponents
Measurement procedures (if any):	Dry matter content of the disposed residue shall be monitored via sampling before the separator or after the combined line after the anaerobic digesters. Archive electronically during project plus 5 years
Monitoring frequency:	Discontinuous daily measurement aggregated monthly
QA/QC procedures:	The related equipment for direct measurement will undergo maintenance/calibration subject to appropriate industry standards. This maintenance/calibration practice should be clearly stated in the project document.
Any comment:	---

Data / Parameter Table 32

Data / Parameter:	$Q_{Comp,m}^{in}$
Data unit:	Tons dry matter/month
Description:	Monthly quantity of residues entering the composting plant in a dry matter basis
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Discontinuous daily measurement aggregated monthly
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 33

Data / Parameter:	$Q_{Comp,m}^{out}$
Data unit:	Tons dry matter/month
Description:	Monthly quantity of produced compost in the project scenario
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Discontinuous daily measurement aggregated monthly
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 34

Data / Parameter:	VSres,m
Data unit:	Ton VS/ton residue
Description:	Average monthly volatile solids (VS) concentration of the residue entering the composting step
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Weekly aggregated for monthly average
QA/QC procedures:	Volatile solids determination should be performed according to the guidance provided in Annex 2
Any comment:	---

Data / Parameter Table 35

Data / Parameter:	VSEM,Aer,m
Data unit:	Ton VS/m3

Description:	Average monthly volatile solids (VS) concentration of the effluent entering the aerobic treatment step
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Weekly aggregated for monthly average
QA/QC procedures:	Volatile solids determination should be performed according to the guidance provided in Annex 2
Any comment:	---

Data / Parameter Table 36

Data / Parameter:	VSmanure,LT
Data unit:	kg-VS-dm per kg of dry manure
Description:	Average VS in the manure excreted by a defined population at the project site
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Weekly, aggregated monthly and annually
QA/QC procedures:	Volatile solids determination should be performed according to the guidance provided in Annex 2
Any comment:	---

Data / Parameter Table 37

Data / Parameter:	VSDE,m
Data unit:	Ton VS/ton of residue in dry basis
Description:	Monthly volatile solids concentration of the disposed effluent / residue
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Weekly aggregated for monthly average
QA/QC procedures:	Volatile solids determination should be performed according to the guidance provided in Annex 2
Any comment:	---

Data / Parameter Table 38

Data / Parameter:	[N]EM,m
Data unit:	kg N/m3
Description:	Monthly total nitrogen concentration in the effluent mix entering the central treatment plant
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Weekly aggregated for monthly average
QA/QC procedures:	Sample collection procedures shall be performed as described in Annex 4. Total nitrogen determination should be performed according to the guidance provided in annex 3
Any comment:	The effluent mix shall be collected after the effluent admittance point or after the equalization tanks (if existent)

Data / Parameter Table 39

Data / Parameter:	[N]DE,m
Data unit:	kg N/m3

Description:	Monthly total nitrogen concentration of the treated effluent / residue disposed outside the project boundary
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Every batch disposed
QA/QC procedures:	Total nitrogen determination should be performed according to the guidance provided in Annex 3
Any comment:	---

Data / Parameter Table 40

Data / Parameter:	ρresidue
Data unit:	kg/m3
Description:	Density of the treated effluent mix disposed outside the project boundary
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Every batch disposed
QA/QC procedures:	---
Any comment:	This parameter shall be utilized to achieve unit conversion in the calculation of leakage project N2O emissions.

Data / Parameter Table 41

Data / Parameter:	$[N]_{Comp,m}^{in}$
Data unit:	kg N/ton residue
Description:	Monthly total nitrogen concentration of the residues entering the composting plant
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Weekly aggregated for monthly average
QA/QC procedures:	Total nitrogen determination should be performed according to the guidance provided in Annex 3
Any comment:	---

Data / Parameter Table 42

Data / Parameter:	$[N]_{Comp,m}^{out}$
Data unit:	kg N/ton residue
Description:	Monthly total nitrogen concentration of the residues leaving the composting plant
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Weekly aggregated for monthly average
QA/QC procedures:	Total nitrogen determination should be performed according to the guidance provided in Annex 3
Any comment:	---

Data / Parameter Table 43

Data / Parameter:	CEFBl,elec,y
Data unit:	tCO2/MWh

Description:	Emission factor of baseline electricity use
Source of data:	Refer to baseline methodology
Measurement procedures (if any):	Calculated according to relevant procedure in the "Tool to calculate the emission factor for an electricity system" Archive electronically during project plus 5 years
Monitoring frequency:	At start of project
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 44

Data / Parameter:	CEFgrid
Data unit:	tCO_2/MWh
Description:	Emission factor of exported electricity
Source of data:	Refer to baseline methodology
Measurement procedures (if any):	Calculated according to relevant procedure in the "Tool to calculate the emission factor for an electricity system" Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 45

Data / Parameter:	CEFBl,therm,y
Data unit:	tCO_2/MJ
Description:	Emission factor for thermal energy
Source of data:	Refer to baseline methodology
Measurement procedures (if any):	Source of data shall be determined in the preference order below On-site measurement data Regional or national default values IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories Archive electronically during project plus 5 years
Monitoring frequency:	At the start of the project activity
QA/QC procedures:	---
Any comment:	If heat used is produced using biogas, the factor is zero

Data / Parameter Table 46

Data / Parameter:	EGd,y
Data unit:	MWh
Description:	Electricity exported to grid in a year y
Source of data:	Project proponents
Measurement procedures (if any):	The receipts issued by the purchasing power company, that the produced electricity is sold, are the primary source for quantification of this parameter. Electricity meter readings shall be considered for crosscheck purposes. Archive electronically during project plus 5 years
Monitoring frequency:	Monthly, aggregated annually

QA/QC procedures:	Also, electricity meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company. Uncertainty of the meters to be obtained from the manufacturers. This uncertainty to be included in a conservative manner while calculating VCCs and procedure for doing so should be described in the project document.
Any comment:	---

Data / Parameter Table 47

Data / Parameter:	CPi,y
Data unit:	MWh
Description:	Rated capacity of electrical equipment i
Source of data:	Project proponents
Measurement procedures (if any):	The rated capacity of electrical equipment shall be determined based on the technical data sheet supplied by the manufacturing company Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	Any future changes of installed equipment shall be reported in the project document.

Data / Parameter Table 48

Data / Parameter:	BGutilized
Data unit:	m3
Description:	Volume of utilized biogas
Source of data:	Project proponents
Measurement procedures (if any):	The amount of biogas recovered and utilized, flared or used gainfully shall be monitored ex post, using flow meters. If the biogas flared and or utilized is continuously monitored separately, the two fractions can be added to determine the biogas recovered. In that case, recovered biogas need not be monitored separately. The system should be built and operated to ensure that there is no air ingress into the biogas pipeline. The methane content measurement shall be carried out close to a location in the system where a biogas flow measurement takes place, and on the same basis (wet or dry) Archive electronically during project plus 5 years
Monitoring frequency:	Annually, based on continuous flow measurement with accumulated volume recording (e.g. hourly/daily accumulated reading)
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 49

Data / Parameter:	HGy
Data unit:	MJ
Description:	Heat generated using biogas
Source of data:	Project proponents
Measurement procedures (if any):	This parameter shall be measured from the heat received by the heated process. Alternatively, this parameter should be determined as the difference of the enthalpy of the heat (steam or hot water) generated by the heat generators(s) minus the enthalpy of the feedwater, the boiler blow-down and any condensate return. The respective enthalpies should be determined based on the mass (or volume) flows, the temperatures and, in case of superheated steam, the pressure.

	Steam tables or appropriate thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure. Archive electronically during project plus 5 years
Monitoring frequency:	Monthly, aggregated annually
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 50

Data / Parameter:	EGy
Data unit:	MWh
Description:	Electricity generated using biogas
Source of data:	Project proponents
Measurement procedures (if any):	This parameter shall be monitored via electricity meter/s Archive electronically during project plus 5 years
Monitoring frequency:	Monthly, aggregated annually
QA/QC procedures:	Electricity meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company. Uncertainty of the meters to be obtained from the manufacturers. This uncertainty to be included in a conservative manner while calculating VCCs and procedure for doing so should be described in the project document.
Any comment:	---

Data / Parameter Table 51

Data / Parameter:	RN,n
Data unit:	Fraction
Description:	Nitrogen degradation factor
Source of data:	Project proponents or Annex 1
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly
QA/QC procedures:	If no appropriate default values are available, project proponents shall used site specific data in order to calculate this parameter. The data used for this purpose shall be included in the monitoring plan of the project document. Project holder may directly measure the ratio of the total nitrogen content in the effluents entering and leaving a given treatment stage. Total nitrogen determination should be performed according to the guidance provided in Annex 3.
Any comment:	For baseline and project emissions calculations this parameter may be estimated from Table provided in Annex 1. The most conservative value for the given technology must be used.

Data / Parameter Table 52

Data / Parameter:	EFN2O,D,n
Data unit:	kg N2O-N/ kg N
Description:	Direct N2O emission factor for treatment stage n
Source of data:	Project proponents or 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Volume 4, Chapter 10, Table 10.21 (Updated)
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly

QA/QC procedures:	If no appropriate default values are available, for project emission calculations, project proponents shall used site specific data in order to calculate this parameter. The data used for this purpose shall be included in the monitoring plan of the project document.
Any comment:	2019 Refinement to the 2006 IPCC Guidelines default values may be used, if country specific or region specific data are not available

Data / Parameter Table 53

Data / Parameter:	EFN2O,Comp,D
Data unit:	kg N2O-N/ kg N
Description:	Direct N2O emission factor for composting
Source of data:	Project proponents or 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023)
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly
QA/QC procedures:	If no appropriate default values are available, for project emission calculations, project proponents shall used site specific data in order to calculate this parameter. The data used for this purpose shall be included in the monitoring plan of the project document.
Any comment:	2019 Refinement to the 2006 IPCC Guidelines default values may be used, if country specific or region-specific data are not available

Data / Parameter Table 54

Data / Parameter:	T
Data unit:	ºC
Description:	Monthly average ambient temperature at the livestock farms included in the project boundary.
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Daily aggregated for monthly average
QA/QC procedures:	---
Any comment:	Used to select the annual MCF_j from 2019 Refinement to the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Volume 4, Chapter 10, Table 10.17 (Updated)

Data / Parameter Table 55

Data / Parameter:	T2,m
Data unit:	Kelvin
Description:	Monthly average ambient temperature at the manure storage tanks
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Daily aggregated for monthly average
QA/QC procedures:	---
Any comment:	

Data / Parameter Table 56

Data / parameter:	FCi,f
Data unit:	volume unit (liter)

Description:	Total quantity of consumed fuel type f in volume units in year y
Source of data:	Project proponents
Measurement procedures (if any):	The receipts issued by the fuel supplier firm for the fuel type f are the primary source for the quantification of this parameter. Data will be acquired based on the measurement of the quantity of fuel type used.
Monitoring frequency:	Monthly
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 57

Data / Parameter:	NCVf
Data unit:	TJ/t or TJ/m3
Description:	Net calorific value of fuel type f in TJ per volume or mass units
Source of data:	Source of data shall be determined in the preference order below Values provided by the fuel supplier in invoices Regional or national default values IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	In the case of utilizing regional and national default values appropriateness of these values shall be assessed annually In the case of utilizing IPCC 2006 default values, latest refinement to IPCC Guidelines shall be taken into consideration and equivalent values shall be used.

Data / Parameter Table 58

Data / Parameter:	EFCO2,f
Data unit:	tCO2e/TJ
Description:	CO2 emission factor of the fossil fuel type f used in transportation vehicles
Source of data:	Source of data shall be determined in the preference order below Values provided by the fuel supplier in invoices Regional or national default values IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	In the case of utilizing regional and national default values appropriateness of these values shall be assessed annually and most conservative value shall be used. In the case of utilizing IPCC 2006 default values, latest refinement to IPCC Guidelines shall be taken into consideration and equivalent values shall be used.

Data / Parameter Table 59

Data / parameter:	NEXLT,y
Data unit:	kg N/animal/year
Description:	Annual average nitrogen excretion per head of a defined livestock population in kg N/animal/year estimated as described in Annex 6
Source of data:	Refer to Annex 6
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 60

Data / parameter:	VSLT,y
Data unit:	Kg-VS-dry matter/animal/year
Description:	Volatile solid excretion per animal per day
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually, estimated or based on published information such as IPCC
QA/QC procedures:	---
Any comment:	If the default value is taken from the IPCC Guidelines, the most up-to-date version shall be used.

Data / Parameter Table 61

Data / parameter:	NLT,y
Data unit:	Number
Description:	Average livestock population used in both baseline and project case emissions estimation.
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly aggregated annually
QA/QC procedures:	---
Any comment:	The PDD should describe the system on monitoring the number of livestock population. The consistency between the value and indirect information (records of sales, records of food purchases) should be assessed

Data / Parameter Table 62

Data / parameter:	Nda
Data unit:	Number
Description:	Number of days animal is alive in the farm in the year y
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly aggregated annually
QA/QC procedures:	---
Any comment:	The PDD should describe the system on monitoring the number of days animal is alive in the farm.

Data / Parameter Table 63

Data / parameter:	Np
Data unit:	Number
Description:	Number of animals produced annually of type LT for the year y
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly
QA/QC procedures:	---
Any comment:	The PDD should describe the system on monitoring the number of livestock population

Data / Parameter Table 64

Data / parameter:	NAA
Data unit:	Number
Description:	Daily stock of animals in the farm, discounting dead and discarded animals
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly aggregated annually
QA/QC procedures:	---
Any comment:	This parameter is only used if the project developer can monitor in a reliable and traceable way the daily stock of animals in the farm, discounting dead animals and animals discarded from the productive process from the daily stock. In the case that monthly data is not available, the average of available data may be utilized. Alternatively, any official records sourced from authorized entities may be utilized. Appropriateness of these alternative methods shall be validated by the DOE.

Data / Parameter Table 65

Data / parameter:	Wsite
Data unit:	kg
Description:	Weight of livestock
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly
QA/QC procedures:	---
Any comment:	This parameter is used in equation 17 for estimating VSLT,y using option 3, and in option 3 (appendix 6) for estimating NEXLT,y when using 2019 Refinement to IPCC 2006 default values. Sampling procedures can be used to estimate this variable, taking into account the following guidance: To ensure representativeness, each defined livestock population should be classified into a minimum of three age categories; For each defined livestock population, a minimum of one monthly sample per age category should be taken; When estimating baseline emissions and emissions released during baseline scenario from land application of the treated manure in the leakage section, the lower bound of the 95% confidence interval obtained from the sampling measurements should be used; When estimating project emissions and emissions released during project activity from land application of the treated manure in the leakage section, the

	upper bound of the 95% confidence interval obtained from the sampling measurements should be used. The PDD should describe the system of random sampling taking into account stratification of each livestock population into a minimum of three weight categories as described above

Data / Parameter Table 66

Data / parameter:	GELT
Data unit:	MJ/day
Description:	Daily average gross energy intake on dry matter basis
Source of data:	Calculated as per Equation 10.16. of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023), Volume 4, Chapter 10, or use default value of 18.45 MJ/kg of dry matter if field specific information is not available
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 67

Data / parameter:	DELT
Data unit:	Fraction
Description:	Digestible energy of the feed in percent
Source of data:	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2019, as updated in July 2023) Table 10.2
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	---
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 68

Data / parameter:	$UE \times GE_{LT}$
Data unit:	Fraction
Description:	Urinary energy expressed as fraction of GE
Source of data:	Typically 0.04GE can be considered urinary energy excretion by most ruminants (reduce to 0.02 for ruminants fed with 85% or more grain in the diet or for swine). Use country-specific values where available
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	---
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 69

Data / parameter:	ASH
Data unit:	Fraction
Description:	Ash content of manure calculated as a fraction of the dry matter feed intake
Source of data:	Use country-specific values where available

Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 70

Data / parameter:	EDLT
Data unit:	MJ/kg
Description:	Energy density of the feed fed to livestock type LT
Source of data:	---
Measurement procedures (if any):	Archive electronically during project plus 5 years. The project proponent will record the composition of the feed to enable the DOE to verify the energy density of the feed
Monitoring frequency:	---
QA/QC procedures:	The project proponent will record the composition of the feed to enable the DOE to verify the energy density of the feed
Any comment:	IPCC notes the energy density of feed, ED, is typically 18.45 MJ/kg-dm, which is relatively constant across a wide variety of grain-based feeds

Data / Parameter Table 71

Data / parameter:	N
Data unit:	-
Description:	Total numbers of farms
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter Table 72

Data / parameter:	Bo,EM,m
Data unit:	m3CH4/ton-VS
Description:	Average monthly CH4 production capacity of effluent manure entering the aerobic treatment stage
Source of data:	Project proponents
Measurement procedures (if any):	Measured as per: ISO 11734:1995; ASTM E2170-01 (2008) and; ASTM D 5210-92.
Monitoring frequency:	Weekly aggregated for monthly average
QA/QC procedures:	
Any comment:	

Data / Parameter Table 73

Data / parameter:	$B_{0,res,m}$
Data unit:	m3CH4/ton-VS
Description:	Average monthly CH4 production capacity of residues entering the composting step

Source of data:	Project proponents
Measurement procedures (if any):	Measured as per: ISO 11734:1995; ASTM E2170-01 (2008) and; ASTM D 5210-92.
Monitoring frequency:	Weekly aggregated for monthly average
QA/QC procedures:	
Any comment:	

Data / Parameter Table 74

Data / parameter:	All
Data unit:	Days
Description:	Annual average interval between manure collection procedures at a given storage tank l
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Discontinuous daily for estimating annual average
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 75

Data / parameter:	MS%l
Data unit:	Fraction
Description:	Fraction of volatile solids (%) handled by storage tank l
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Monthly averaged for annual value
QA/QC procedures:	---
Any comment:	---

Data / Parameter Table 76

Data / Parameter:	MS%Bl,j
Data unit:	Fraction
Description:	Fraction of manure handled in system j in the baseline
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	The PDD should describe the system on monitoring the fraction of manure handled in system j in the baseline.

Data / Parameter Table 77

Data / Parameter:	MS%,j
Data unit:	Fraction
Description:	Fraction of manure handled in system j in the project activity
Source of data:	Project proponents

Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	The PDD should describe the system on monitoring the fraction of manure handled in system j in the project activity.

Data / Parameter Table 78

Data / Parameter:	FAer
Data unit:	Fraction
Description:	Fraction of volatile solids directed to aerobic treatment
Source of data:	-
Measurement procedures (if any):	Archive electronically during project plus 5 years
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	The PDD should describe the system on monitoring the fraction of volatile solids directed to aerobic treatment

Data / Parameter Table 79

Data / Parameter:	Wx
Data unit:	tonnes/year, wet basis
Description:	Total amount of organic waste type j prevented from disposal in the SWDS through co-digestion with animal manure in the anaerobic digester(s)/reactor(s) in the year x
Source of data:	Project proponents
Measurement procedures (if any):	Measure on wet basis. This parameter shall be directly monitored via weighbridge records for every organic waste type j acceptance.
Monitoring frequency:	Continuously, aggregated at least annually for year x
QA/QC procedures:	Weighbridge will undergo maintenance/calibration subject to appropriate industry standards. This maintenance/calibration practice should be clearly stated in the project document.
Any comment:	-

Document History

Document type. **Methodological document.**

Biomethanisation Plants: Animal Manure Management for Renewable Energy, Heat Generation, and CH4 & N2O Mitigation

Version	***Date***	***Document nature***
Internal consultation	March 27, 2024	Initial version Document submitted for internal review
Document for public consultation	May 24, 2024	Document submitted for public consultation
Version 1.0	July 4, 2024	Version issued after public consultation