The GoldStandard
Revised Consolidated Baseline Methodology for
GHG Emission Reductions from
Manure Management Systems and Municipal Solid Waste

December 2013

This methodology is based on the approved CDM methodologies; Consolidated baseline methodology for GHG emission reductions from manure management systems, (ACM 0010), Version 7, Alternative waste treatment processes (ACM 0022) -Version 1.0 and GHG emission reductions through multi-site manure collection and treatment in a central plant (ACM 0073) Version 1.0.
I. SOURCE, DEFINITIONS AND APPLICABILITY

Sources

This consolidated baseline methodology is based on elements from the following methodologies:

- AM0006: “GHG emission reductions from manure management systems”;
- AM0016: “Greenhouse gas mitigation from improved Animal Waste Management Systems in confined animal feeding operations”;
- ACM0022: “Alternative waste treatment processes”
- AM0073: GHG emission reductions through multi-site manure collection and treatment in a central plant --- Version 1.0

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

- “Project emissions from flaring”;
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”;
- “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”;
- “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period”;
- “Combined tool to identify the baseline scenario and demonstrate additionality”;
- “Project and leakage emissions from anaerobic digesters”;
- “Project and leakage emissions from composting”;
- “Tool to determine the baseline efficiency of thermal or electric energy generation systems”;
- “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”;
- “Project and leakage emissions from transportation of freight”.

For more information regarding the proposed new methodologies and the tools as well as their consideration by the Executive Board (hereinafter referred to as the Board) of the clean development mechanism (CDM) please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

Selected approach from paragraph 48 of the CDM modalities and procedures

“Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment”

Applicability

This methodology is applicable to manure management on one or multiple livestock farms where the existing anaerobic manure treatment system, within the project boundary, is replaced by one or a combination of more than one animal waste management systems (AWMSs) that result in less GHG emissions compared to the existing system. The project activities where manure is collected by tank trucks, canalized and/or pumped from multiple livestock farms and the collected material is subsequently treated in a single central treatment plant may also claim emission reductions. In addition,
the methodology is also applicable to the activities that involve co-digestion and/or co-composting of multiple organic matters that would have otherwise been left to decay anaerobically in an animal waste management system (AWMS) or a solid waste disposal site (SWDS). The methodology is applicable to both Greenfield and existing facilities.

This methodology is applicable to manure management projects under the following conditions:

- Farms where livestock populations, comprising of cattle, buffalo, swine, sheep, goats, and/or poultry, is managed under confined conditions;
- Farms where manure is not discharged into natural water resources (e.g. rivers or estuaries);
- In case of anaerobic lagoons treatments systems, the depth of the lagoons used for manure management under the baseline scenario should be at least 1m;
- The annual average ambient temperature at the site where the anaerobic manure treatment facility in the baseline existed is higher than 5°C;
- In the baseline case, the minimum retention time of manure waste in the anaerobic treatment system is greater than 1 month;
- The AWMS(s) in the project case results in no leakage of manure waste into ground water, e.g. the lagoon should have a non-permeable layer at the lagoon bottom.
- If residues are stored in between collection activities, storage tanks shall comprise outdoor open equipments;
- If the manure/ treated residue is used as fertilizer in the baseline, project proponents must ensure that this end use remains the same throughout the project activity;
- In case residual waste from the digestion is handled aerobically and/or submitted to soil application, the proper conditions and procedures (not resulting in methane emissions) for storage and transportation and soil application must be ensured.
- In case of co-digestion, for one or more sources of substrates, it cannot be demonstrated that the organic matter would otherwise have been left to decay anaerobically, baseline emissions related to such organic matter shall be accounted for as zero, whereas project emissions shall be calculated according to the procedures presented in this methodology for all co-digested substrates;
- CERs 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 CERs from the improved animal waste treatment practices. The DOE shall check such declaration during the validation (during verification if new parties added after project registration) and these documents shall be valid throughout the whole crediting period.

The general as well as treatment specific applicability conditions and other general requirements of ACM022 also apply to the project activities that involve co-digestion of MSW. In addition, the applicability conditions included in the tools referred above also apply.

II. BASELINE METHODOLOGY PROCEDURE

Identification of the baseline scenario and demonstration of additionality

Baseline scenario should be identified from the perspective of the owner of central treatment plant, as well as from the perspective of the multiple livestock farms owners.

Identify the baseline scenario and demonstrate additionality using the “Combined tool to identify the baseline scenario and demonstrate additionality”, following the requirements below.
**Baseline scenario for managing the manure**

(i) For existing facilities

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

(ii) For Greenfield facilities

For Greenfield facilities, the methodology only applies where the baseline scenario selected from the complete set of the list of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 4, Chapter 10, Table 10.17), 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, 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 CERs 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:

- Land cost;
- Engineering, procurement and construction cost;
- Labour cost;
- Operation and maintenance cost;
- Administration cost;
- Fuel cost;
- Capital cost and interest;
- Revenue from electricity sales;
- All other costs of implementing the technology of each lagoon design option;
• 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.).

**Baseline scenario for MSW disposal**

To identify baseline alternatives for the treatment of the fresh waste, the following alternatives or combinations of these alternatives shall, inter alia, be considered:

M1: The project activity without being registered as a CDM project activity (i.e. any (combination) of the waste treatment options; Composting, Co-composting or anaerobic digestion);

M2: Disposal of the fresh waste in a SWDS with a partial capture of the LFG and flaring of the captured LFG;

M3: Disposal of the fresh waste in a SWDS without a LFG capture system;

M4: Part of the fresh fraction of the solid waste is recycled and not disposed in the SWDS;

M5: Part of the fresh fraction of the solid waste is treated aerobically and not disposed in the SWDS;

M6: Part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS;

M7: Part of the organic fraction of the solid waste is gasified and not disposed in the SWDS;

M8: Part of the organic fraction of the solid waste is treated in an anaerobic digester and not disposed in the SWDS;

M9: Part of the organic fraction of the solid waste is mechanically or thermally treated to produce RDF/SB and not disposed in the SWDS.

The methodology is only applicable if the procedure for the selection of the most plausible baseline scenario results in that the baseline scenario is the disposal of the fresh waste in a SWDS with or without a partial LFG capture system (M2 or M3);

**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:

E1: Electricity generation from biogas, undertaken without being registered as CDM project activity;

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

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

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

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:

H1: Heat generation from biogas undertaken without being registered as CDM project activity;
H2: Heat generation in existing or new fossil fuel fired cogeneration plant(s);
H3: Heat generation in existing or new renewable based cogeneration plant(s);
H4: Heat generation in existing or new on-site or off-site fossil fuel based boiler(s) or air heater(s);
H5: Heat generation in existing or new on-site or off-site renewable energy based boiler(s) or air heater(s);
H6: Any other source, such as district heat; and
H7: Other heat generation technologies (e.g. heat pumps or solar energy).

Baseline emissions due to heat generation can be accounted for only if the baseline scenario is H4.

**Project boundary**

The spatial extent of the project boundary encompasses the site of the AWMS(s) and/or solid waste disposal site (if applicable), treatment facility and/or central treatment facility including the storage tanks (if applicable) and the site where the residual waste from biological treatment or products from those treatments, like slurry, are handled, disposed, submitted to soil application, or treated thermally/mechanically. The boundary also includes the onsite flare or energy and/or heat generation equipment and the power/heat source. The road itineraries and/or piping system between the manure collection points, waste/residue transportation (if applicable), the central treatment plant and solid waste disposal site (if applicable) are also part of project boundary. Diagrams for each alternative waste treatment combination illustrating which aspects should be included in the project boundary are included in appendix 6.

**Table 2: Emissions sources included in or excluded from the project boundary**

<table>
<thead>
<tr>
<th>Source</th>
<th>Gas</th>
<th>Included?</th>
<th>Justification/Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions from the waste treatment processes</td>
<td>CH₄</td>
<td>Yes</td>
<td>The major source of emissions in the baseline</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Yes</td>
<td>Direct and indirect N₂O emissions are accounted</td>
</tr>
<tr>
<td></td>
<td>CO₂</td>
<td>No</td>
<td>CO₂ emissions from the decomposition of organic waste are not accounted</td>
</tr>
<tr>
<td>Emissions from electricity consumption/generation</td>
<td>CO₂</td>
<td>Yes</td>
<td>Electricity may be consumed from the grid or generated onsite in the baseline scenario</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>No</td>
<td>Excluded for simplification. This is conservative</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>No</td>
<td>Excluded for simplification. This is conservative</td>
</tr>
<tr>
<td>Emissions from thermal energy generation</td>
<td>CO₂</td>
<td>Yes</td>
<td>If thermal energy generation is included in the project activity</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>No</td>
<td>Excluded for simplification. This is conservative</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>No</td>
<td>Excluded for simplification. This is conservative</td>
</tr>
<tr>
<td>Project Activity</td>
<td>CO₂</td>
<td>Yes</td>
<td>May be an important emission source</td>
</tr>
<tr>
<td>Emissions from thermal energy use</td>
<td>CH₄</td>
<td>No</td>
<td>Excluded for simplification. This emission source is assumed to be very small</td>
</tr>
</tbody>
</table>
The project proponents shall provide a clear diagrammatic representation in the CDM-PDD of the project scenario showing all the manure waste treatments steps as well as its final disposal. This shall include the final use of methane, if any is captured, and also the auxiliary energy used to run project treatments steps. The diagrammatic representation shall also indicate the fraction of volatile solids degraded within the project boundary in the pre-project situation before disposal.

The precise location of the farm(s) where the project activity takes place shall be identified in the CDM-PDD (e.g. co-ordinates of farm(s) using global positioning system).

**Baseline emissions**

The baseline emissions are the amount of methane emitted from the decay of the degradable organic carbon in the biomass i.e., organic fraction of MSW including animal manure.

\[
BE_y = BE_{\text{MSW},y} + BE_{\text{manure},y} \quad (1)
\]

Where;

- \( BE_{\text{MSW},y} \): Baseline emissions from degradable organic carbon in MSW.
- \( BE_{\text{manure},y} \): Baseline emissions from animal manure.
Where applicable, yearly baseline emission from the solid waste co-digested by the project activity shall be calculated following procedures provided in the ACM 0022. Please note that the \( B_{\text{MSW},y} \) represents the Baseline emissions in year \( y \) (t CO\(_2\)e), i.e., \( (B_E) \) for the ACM0022.

\( B_{\text{manure},y} \)

Where applicable, baseline emissions from the manure co-digested by the project activities, calculated as per the relevant procedures provided below.

**Baseline Emissions from animal waste treatment**

The baseline is the AWMSs identified through the baseline selection procedure, as well as, when relevant, the baseline for the use of gas generated from the anaerobic digester.

Baseline emissions are:

\[
B_{\text{Manure},y} = B_{\text{CH}_4,y} + B_{\text{N}_2\text{O},y} + B_{\text{elec / heat},y}
\]  

Where:

- \( B_{\text{manure},y} \) = Baseline emissions in year \( y \) (t CO\(_2\)yr)
- \( B_{\text{CH}_4,y} \) = Baseline CH\(_4\) emissions in year \( y \) (t CO\(_2\)yr)
- \( B_{\text{N}_2\text{O},y} \) = Baseline N\(_2\)O emissions in year \( y \) (t CO\(_2\)yr)
- \( B_{\text{elec / heat},y} \) = Baseline CO\(_2\) emissions from electricity and/or heat used in the baseline (t CO\(_2\)yr)

\((i)\) **Baseline CH\(_4\) emissions from manure treatment** \( (B_{\text{CH}_4,y}) \)

The manure management system in the baseline could be based on different livestock, treatment systems and on one or more stages. Therefore:

\[
B_{\text{CH}_4,y} = GWP_{\text{CH}_4} \times D_{\text{CH}_4} \times \sum_{j,L,T} \left( MCF_j \times B_{0,L,T} \times N_{LT} \times VS_{LT,y} \times MS\%_{\text{Bl},j} \right)
\]  

Where:

- \( B_{\text{CH}_4,y} \) = Baseline CH\(_4\) emissions (t CO\(_2\)yr)
- \( GWP_{\text{CH}_4} \) = Global Warming Potential (GWP) of CH\(_4\) (t CO\(_2\)e/t CH\(_4\))
- \( D_{\text{CH}_4} \) = Density of CH\(_4\) (t/m\(^3\))
- \( MCF_j \) = Annual methane conversion factor (MCF) for the baseline AWMS\(_j\)
- \( B_{0,L,T} \) = Maximum methane producing potential of the volatile solid generated by animal type LT (m\(^3\)CH\(_4\)/kg -dm)
- \( N_{LT} \) = Annual average number of animals of type LT for the year \( y \) (number)
- \( VS_{LT,y} \) = Annual volatile solid excretions for livestock LT entering all AWMS on a dry matter weight basis (kg -dm/animal/yr)
- \( MS\%_{\text{Bl},j} \) = Fraction of manure handled in system \( j \) in the baseline
- \( LT \) = Type of livestock
- \( j \) = Type of treatment system
Estimation of various variables and parameters used in the above equation:

\((A)\) \( V_{SLT,y} \) shall be determined in one of the following ways, presented in the order of preference

**Option 1:**

Using published country specific data. If the data is expressed in kilogram volatile solid excretion per day on a dry-matter basis (kg -dm per day), multiply the value with \( nd_y \) (number of days treatment plant was operational in year \( y \)).

**Option 2:**

Estimation of \( V_{SLT,y} \) based on dietary intake of livestock:

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

(4)

Where:

- \( V_{SLT,y} \) = Annual volatile solid excretions for livestock LT entering all AWMS on a dry matter weight basis (kg -dm/animal/yr)
- \( GE_{LT} \) = Daily average gross energy intake (MJ/animal/day)
- \( DE_{LT} \) = Digestible energy of the feed (percent)
- \( UE \) = Urinary energy (fraction of \( GE_{LT} \))
- \( ASH \) = Ash content of manure (fraction of the dry matter feed intake).
- \( ED_{LT} \) = Energy density of the feed fed to livestock type LT (MJ/kg -dm).
- \( nd_y \) = Number of days treatment plant was operational in year \( y \)

**Option 3:**

Scaling default IPCC values \( V_{Sdefault} \) to adjust for a site-specific average animal weight as shown in equation below:

\[
V_{SLT,y} = \left( \frac{W_{site}}{W_{default}} \right) \times V_{Sdefault} \times nd_y
\]

(5)

Where:

- \( V_{SLT,y} \) = Annual volatile solid excretions for livestock LT entering all AWMS on a dry matter weight basis (kg -dm/animal/yr)
- \( W_{site} \) = Average animal weight of a defined livestock population at the project site (kg)
- \( W_{default} \) = Default average animal weight of a defined population (kg)
- \( V_{Sdefault} \) = Default value for the volatile solid excretion per day on a dry-matter basis for a defined livestock population (kg -dm/animal/day)
- \( nd_y \) = Number of days treatment plant was operational in year \( y \)

**Option 4:**

Utilizing published IPCC defaults for \( V_{SLT} \) (IPCC 2006 guidelines, volume 4, chapter 10), multiply the value by \( nd_y \) (number of days in year \( y \)).

Developed countries \( V_{SLT,y} \) values may be used provided the following conditions are satisfied:
• The genetic source of the production operations livestock originate from an Annex I Party;
• The farm use formulated feed rations (FFR) which are optimized for the various animal(s), stage of growth, category, weight gain/productivity and/or genetics;
• The use of FFR can be validated (through on-farm record keeping, feed supplier, etc.); and
• The project specific animal weights are more similar to developed country IPCC default values.

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 appendix 1 (values for VS).

**(B) Annual average number of animals of type LT \(N_{LT}\) shall be determined in one of the following ways, presented in order of preference:**

**Option 1:**

\[
N_{LT} = N_{da,LT} \times \left( \frac{N_{p,LT}}{365} \right)
\]

Where:
\(N_{LT}\) = Annual average number of animals of type LT for the year \(y\) (number)
\(N_{da,LT}\) = Number of days animal of type LT is alive in the farm in the year \(y\) (number)
\(N_{p,LT}\) = Number of animals of type LT produced annually for the year \(y\) (number)

**Option 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 \(N_{LT}\) may be calculated as follows:

\[
N_{LT} = \frac{\sum_{t=1}^{365} N_{AA,LT}}{365}
\]

Where:
\(N_{LT}\) = Annual average number of animals of type LT for the year \(y\) (number)
\(N_{AA,LT}\) = Daily stock of animals of type LT in the farm, discounting dead and discarded animals (number)
(ii) Baseline \( \text{N}_2\text{O} \) emissions (\( BE_{N2O,y} \))

\[
BE_{N2O,y} = GWP_{N2O} \times CF_{N2O-N,N} \times \frac{1}{1000} \times (E_{N2O,D,y} + E_{N2O,ID,y})
\]

Where:
- \( BE_{N2O,y} \) = Annual baseline \( \text{N}_2\text{O} \) emissions in (tCO\(_2\)e/yr)
- \( GWP_{N2O} \) = Global Warming Potential (GWP) for \( \text{N}_2\text{O} \) (tCO\(_2\)e/t\( \text{N}_2\text{O} \))
- \( CF_{N2O-N,N} \) = Conversion factor \( \text{N}_2\text{O}-\text{N} \) to \( \text{N}_2\text{O} \) (44/28)
- \( E_{N2O,D,y} \) = Direct \( \text{N}_2\text{O} \) emission in year \( y \) (kg \( \text{N}_2\text{O}-\text{N}/\text{year} \))
- \( E_{N2O,ID,y} \) = Indirect \( \text{N}_2\text{O} \) emission in year \( y \) (kg \( \text{N}_2\text{O}-\text{N}/\text{year} \))

\[
E_{N2O,D,y} = \sum_{j,LT} EF_{N2O,D,j} \times NEX_{LT,y} \times N_{LT} \times MS\%_{Bl,j}
\]

Where:
- \( E_{N2O,D,y} \) = Direct \( \text{N}_2\text{O} \) emission in year \( y \) (kg \( \text{N}_2\text{O}-\text{N}/\text{yr} \))
- \( EF_{N2O,D,j} \) = Direct \( \text{N}_2\text{O} \) emission factor for the treatment system \( j \) of the manure management system (kg \( \text{N}_2\text{O}-\text{N}/\text{kg} \text{ N} \))
- \( NEX_{LT,y} \) = Annual average nitrogen excretion per head of a defined livestock population (kg \( \text{N}/\text{animal}/\text{yr} \)) estimated as described in appendix 2
- \( MS\%_{Bl,j} \) = Fraction of manure handled in system \( j \) (fraction)
- \( N_{LT} \) = Annual Average number of animals of type LT for the year \( y \) estimated as per equation (5.a) or (5.b) (number)

\[
E_{N2O,ID,y} = \sum_{j,LT} EF_{N2O,ID} \times F_{gasMS,j,LT} \times NEX_{LT,y} \times N_{LT} \times MS\%_{Bl,j}
\]

Where:
- \( E_{N2O,ID,y} \) = Indirect \( \text{N}_2\text{O} \) emission in year \( y \) (kg \( \text{N}_2\text{O}-\text{N}/\text{year} \))
- \( EF_{N2O,ID} \) = Indirect \( \text{N}_2\text{O} \) emission factor for \( \text{N}_2\text{O} \) emissions from atmospheric deposition of nitrogen on soils and water surfaces (kg \( \text{N}_2\text{O}-\text{N}/\text{kg} \text{ NH}_3\text{-N} \) and \( \text{NO}_X\text{-N} \))
- \( NEX_{LT,y} \) = Annual average nitrogen excretion per head of a defined livestock population (kg \( \text{N}/\text{animal}/\text{year} \)) estimated as described in appendix 2
- \( MS\%_{Bl,j} \) = Fraction of manure handled in system \( j \) (fraction)
- \( F_{gasMS,j,LT} \) = Default values for nitrogen loss due to volatilisation of \( \text{NH}_3 \) and \( \text{NO}_X \) from manure management (fraction)
- \( N_{LT} \) = Annual average number of animals of type LT for the year \( y \) estimated as per equation (5.a) or (5.b) (number)
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 \((1 - R_{N})\), where \(R_{N}\) is the relative reduction of nitrogen from the previous stage. The relative reduction \((R_{N})\) 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 appendix 1 (values for TN).

(iii) Baseline \(CO_2\) emission from electricity and/or heat used in the baseline

\[
BE_{\text{elec/heat},y} = BE_{EC,y} + BE_{HG,y}
\]

Where:
\[
BE_{\text{elec/heat},y} \quad = \quad \text{Baseline } CO_2 \text{ emissions from electricity and/or heat used in the baseline (t} CO_2/\text{yr)} \\
BE_{EC,y} \quad = \quad \text{Baseline emissions associated with electricity generation in year } y \text{ (t} CO_2/\text{yr)} \\
BE_{HG,y} \quad = \quad \text{Baseline emissions associated with heat generation in year } y \text{ (t} CO_2/\text{yr)}
\]

Baseline emissions associated with electricity generation \((BE_{EC,y})\)

The baseline emissions associated with electricity generation in year \(y\) \((BE_{EC,y})\) shall be calculated using the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”. When applying the tool:

(a) The electricity sources \(k\) in the tool correspond to the sources of electricity identified in the selection of the most plausible baseline scenario;

(b) \(EC_{BL,k,y}\) in the tool is equivalent to the net amount of electricity generated using biogas in year \(y\) \((EG_{d,y})\).

Baseline emissions associated with heat generation \((BE_{HG,y})\)

The baseline emissions associated with heat generation in year \(y\) \((BE_{HG,y})\) are determined based on the amount of biogas which is sent to the heat generation equipment in the project activity (boiler or air heater), as follows:

\[
BE_{HG,y} = \sum_{k} \frac{HG_{PJ,k,y} \times EF_{CO2,BL,HG,k}}{\eta_{HG,BL,k}}
\]

Where:
\[
BE_{HG,y} \quad = \quad \text{Baseline emissions associated with heat generation in year } y \text{ (t} CO_2/\text{yr)} \\
HG_{PJ,k,y} \quad = \quad \text{Net quantity of heat generated with biogas by equipment type } k \text{ in the project in year } y \text{ (TJ/yr)} \\
EF_{CO2,BL,HG,k} \quad = \quad \text{CO}_2 \text{ emission factor of the fossil fuel type used for heat generation by equipment type } k \text{ in the baseline (t } CO_2/\text{TJ)} \\
\eta_{HG,BL,k} \quad = \quad \text{Efficiency of the heat generation equipment type } k \text{ used in the baseline} \\
k \quad = \quad \text{Heat generation equipment (boiler or air heater or kiln)}
\]

Determination of \(EF_{CO2,BL,HG,k}\)

For existing facilities:
• Project participants shall choose the fossil fuel with the lowest emission factor among all the fuel options that were being used in the existing facility for heating purposes in the heat generation equipment.

For Greenfield facilities:

• Project participants shall identify what is the most common fuel used in the identified baseline scenario and use it as the baseline fuel. Detailed justifications shall be provided and documented in the CDM-PDD for the selected baseline fuel.

To estimate the baseline energy efficiency of an air heater or boiler ($\eta_{HG,BL}$) project participants shall apply the “Tool to determine the baseline efficiency of thermal or electric energy generation systems”.

**Project emissions**

Project emissions in year $y$ are calculated for alternative waste treatment option implemented in the project activity as follows;

$$PE_y = PE_{AD,y} + PE_{Aer,y} + PE_{Comp,y} + PE_{N2O,y} + PE_{EC/FC,y} + PE_{Tran,y} + PE_{Storage,y}$$  \hspace{1cm} (12)

Where:

- $PE_y$ = Project emissions in year $y$
- $PE_{AD,y}$ = Project emissions associated with the anaerobic digester/ co-digestion in year $y$ (tCO$_2$/yr)
- $PE_{Aer,y}$ = Project CH$_4$ emissions from aerobic AWMS treatment (tCO$_2$/yr)
- $PE_{Comp,y}$ = Project CH$_4$ emissions from composting/ co-composting (tCO$_2$/yr)
- $PE_{N2O,y}$ = Project N$_2$O emissions in year $y$ (t CO$_2$/yr)
- $PE_{EC/FC,y}$ = Project emissions from electricity consumption and fossil fuel combustion (tCO$_2$/yr)
- $PE_{Tran,y}$ = Project emissions from manure transportation in the year $y$ (tCO$_2$/yr)
- $PE_{Storage,y}$ = Project emissions from manure storage (tCO$_2$/yr)

(i) **Project emissions associated with the anaerobic digester in year $y$ ($PE_{AD,y}$)**

$PE_{AD,y}$ is determined using the methodological tool “Project and leakage emissions from anaerobic digesters”.

(ii) **Project CH$_4$ emissions from aerobic AWMS treatment ($PE_{Aer,y}$)**

IPCC guidelines specify emissions from aerobic lagoons as 0.1% of total methane generating potential of the waste processed, which can be used as a default for all types of aerobic AWMS treatment.

$$PE_{Aer,y} = GWP_{CH4} \times D_{CH4} \times 0.001 \times F_{Aer} \times \left[ \prod_{n=1}^{N} \left(1 - R_{VS,n} \right) \right] \times \sum_{j,L,T} \left( B_{0,L,T} \times N_{LT} \times V_{S_{LT,y}} \times MS\% \right) + PE_{Sl,y}$$  \hspace{1cm} (13)

Where:

- $GWP_{CH4}$ = Global Warming Potential (GWP) of CH$_4$ (tCO$_2$/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)
- $D_{CH4}$ = Density of CH$_4$ (t/m$^3$).
- $F_{Aer}$ = Fraction of volatile solid directed to aerobic system (fraction)
- $LT$ = Type of livestock

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\[ B_{0,LT} = \text{Maximum methane producing potential of the volatile solid generated by animal type LT (m}^3\text{CH}_4/\text{kg dm}) \]

\[ VS_{LT,y} = \text{Annual volatile solid excretion livestock type LT entering all AWMS on a dry matter weight basis in (kg -dm/animal/yr)} \]

\[ N_{LT} = \text{Annual average number of animals of type LT for the year } y \text{ (number) as estimated in equation (5.a) or (5.b).} \]

\[ PE_{Sl,y} = \text{Project CH}_4 \text{ emissions from sludge disposed of in storage pit prior to disposal during the year } y \text{ (tCO}_2\text{e/yr)} \]

\[ MS\%_j = \text{Fraction of manure handled in system } j \text{ in the project activity (fraction)} \]

Aerobic treatment results in large accumulations of sludge. Sludge requires removal and has large VS values. It is important to identify the following management process for the sludge and estimate the emissions from that management process. If the sludge ponds are not within the project boundary, the emissions should be included as leakage. The emissions from sludge ponds shall be estimated as follows:

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

Where:

\[ GWP_{CH4} = \text{Global Warming Potential (GWP) of CH}_4 \text{ (tCO}_2\text{e/tCH}_4) \]

\[ R_{VS,n} = \text{Fraction of volatile solid degraded in AWMS treatment method } n \text{ of the } N \text{ treatment steps prior to waste (sludge) being treated. (fraction)} \]

\[ D_{CH4} = \text{Density of CH}_4 \text{ (t/m}^3\text{)} \]

\[ F_{Aer} = \text{Fraction of volatile solid directed to aerobic system (fraction)} \]

\[ LT = \text{Type of livestock} \]

\[ B_{0,LT} = \text{Maximum methane producing potential of the volatile solid generated by animal type LT (m}^3\text{CH}_4/\text{kg dm}) \]

\[ VS_{LT,y} = \text{Annual volatile solid excretion livestock type LT entering all AWMS on a dry matter weight basis in (kg -dm/animal/yr)} \]

\[ N_{LT} = \text{Annual average number of animals of type LT for the year } y \text{ (number) as estimated as per equation (5.a) or (5.b)} \]

\[ MS\%_j = \text{Fraction of manure handled in system } j \text{ in the project activity (fraction)} \]

\[ MCF_{sl} = \text{Methane conversion factor (MCF) for the sludge stored in sludge pits (fraction)} \]
(iii) Project emissions associated with the composting in the year y (PE\textsubscript{Comp,y})

The project CH\textsubscript{4} emission from composting shall be estimated as follows.

a. The project CH\textsubscript{4} emission from MSW and or digestate treatment through composting shall be calculated as per the latest version of Project and leakage emissions from composting.

b. The project CH\textsubscript{4} emission from composting shall be equivalent to the methane conversion factor as suggested in IPCC guidelines for various type of composting technology. The relevant MCF value shall be sourced form table 10.17 provided in Appendix 1 of this methodology. The eq 13. shall be applied to estimate project emissions by replacing the 0.1% factor with appropriate MCF value from Table 10.17. The relative reduction (R\textsubscript{VS}) of volatile solids depends on the treatment technology and should be estimated in a conservative manner. The reduction of the volatile solid during the treatment stage is estimated based on referenced data/ literature for different treatment types and substrate used for composting. The parameter (PE\textsubscript{sl,y}) Project CH\textsubscript{4} emissions from sludge disposed of in storage pit prior to disposal during the year y (tCO\textsubscript{2}e/yr) because the emissions due to anaerobic storage has been accounted under leakage sections.

If the project involves the co-composting of various substrate for example, digestate and animal manure, the project emission will be the sum of emissions from both component as estimated above iii. a. and iii.b.

(iv) Project N\textsubscript{2}O emissions in year y (PE\textsubscript{N2O,y})

a. The project N\textsubscript{2}O emission from MSW and or digestate treatment through composting shall be calculated as per the latest version of Project and leakage emissions from composting.

b. The Project N\textsubscript{2}O emission from animal manure shall be estimated as follows;

\[
PE_{N2O,y} = GWP_{N2O} \times CF_{N2O-N,N} \times \frac{1}{1000} \times (E_{N2O,D,y} + E_{N2O,ID,y})
\]

Where:

- \(PE_{N2O,y}\) = Project N\textsubscript{2}O emissions in year y (tCO\textsubscript{2}/yr)
- \(GWP_{N2O}\) = Global Warming Potential (GWP) for N\textsubscript{2}O (tCO\textsubscript{2}e/tN\textsubscript{2}O)
- \(CF_{N2O-N,N}\) = Conversion factor N\textsubscript{2}O-N to N\textsubscript{2}O (44/28)
- \(E_{N2O,D,y}\) = Direct N\textsubscript{2}O emission in year y (kg N\textsubscript{2}O-N/year)
- \(E_{N2O,ID,y}\) = Indirect N\textsubscript{2}O emission in year y (kg N\textsubscript{2}O-N/year)

Option 1:

\[
E_{N2O,D,y} = \sum_{j,LT} EF_{N2O,D,j} \times NEX_{LT,y} \times N_{LT} \times MS\%_{j}
\]

Where:

- \(E_{N2O,D,y}\) = Direct N\textsubscript{2}O emission in year y (kg N\textsubscript{2}O-N/yr)
- \(EF_{N2O,D,j}\) = Direct N\textsubscript{2}O emission factor for the treatment system j of the manure management system (kg N\textsubscript{2}O-N/kg N)
- \(NEX_{LT,y}\) = Annual average nitrogen excretion per head of a defined livestock population (kg N/animal/yr) estimated as described in appendix 2
- \(MS\%_{j}\) = Fraction of manure handled in system j in the project activity (fraction)
- \(N_{LT}\) = Annual average number of animals of type LT for the year y estimated as per equation (5.a) or (5.b) (number)
\[ E_{\text{N}_2\text{O},\text{ID},y} = \sum_{j,LT} EF_{\text{N}_2\text{O},\text{ID},j} \times F_{\text{gasMS},j,LT} \times NEX_{LT,y} \times N_{LT} \times MS\%_j \]  

(17)

Where:

- \( E_{\text{N}_2\text{O},\text{ID},y} \) = Indirect \( \text{N}_2\text{O} \) emission in year \( y \) (kg \( \text{N}_2\text{O}-\text{N/year} \))
- \( EF_{\text{N}_2\text{O},\text{ID}} \) = Indirect \( \text{N}_2\text{O} \) emission factor for \( \text{N}_2\text{O} \) emissions from atmospheric deposition of nitrogen on soils and water surfaces (kg \( \text{N}_2\text{O}-\text{N/kg NH}_3\text{-N and NO}_X\text{-N} \))
- \( NEX_{LT,y} \) = Annual average nitrogen excretion per head of a defined livestock population (kg N/animal/yr) estimated as described in appendix 2
- \( MS\%_j \) = Fraction of manure handled in system \( j \) in the project activity (fraction)
- \( F_{\text{gasMS},j,LT} \) = Default values for nitrogen loss due to volatilisation of \( \text{NH}_3 \) and \( \text{NO}_X \) from manure management (fraction)
- \( N_{LT} \) = Annual average number of animals of type LT for the year \( y \) estimated as per equation (5.a) or (5.b) (number)

Option 2:

\[ E_{\text{N}_2\text{O},\text{D},y} = \sum_{j} EF_{\text{N}_2\text{O},\text{D},j} \times \sum_{m=1}^{12} (Q_{EM,m} \times [N]_{EM,m}) \]  

(18)

\[ E_{\text{N}_2\text{O},\text{ID},y} = EF_{\text{N}_2\text{O},\text{ID},j} \times \sum_{j,LT} F_{\text{gasMS},j,LT} \times \sum_{m=1}^{12} (Q_{EM,m} \times [N]_{EM,m}) \]  

(19)

Where:

- \( E_{\text{N}_2\text{O},\text{D},y} \) = Direct \( \text{N}_2\text{O} \) emission in year \( y \) (kg \( \text{N}_2\text{O}-\text{N/year} \))
- \( E_{\text{N}_2\text{O},\text{ID},y} \) = Indirect \( \text{N}_2\text{O} \) emission in year \( y \) (kg \( \text{N}_2\text{O}-\text{N/year} \))
- \( EF_{\text{N}_2\text{O},\text{D},j} \) = Direct \( \text{N}_2\text{O} \) emission factor for the treatment system \( j \) of the manure management system (kg \( \text{N}_2\text{O}-\text{N/kg N} \))
- \( Q_{EM,m} \) = Monthly volume of the effluent mix entering the manure management system (m\(^3\)/month)
- \([N]_{EM,m} \) = Monthly total nitrogen concentration in the effluent mix entering the manure management system (kg N/m\(^3\))
- \( EF_{\text{N}_2\text{O},\text{ID}} \) = Indirect \( \text{N}_2\text{O} \) emission factor for \( \text{N}_2\text{O} \) emissions from atmospheric deposition of nitrogen on soils and water surfaces (kg \( \text{N}_2\text{O}-\text{N/kg NH}_3\text{-N and NO}_X\text{-N} \))
- \( F_{\text{gasMS},j,LT} \) = Default values for nitrogen loss due to volatilisation of \( \text{NH}_3 \) and \( \text{NO}_X \) from manure management (fraction)

Option 2 is the preferred option for estimating \( \text{N}_2\text{O} \) emissions since it is based on actual measurements. Project proponents should indicate in the PDD which option will be used and should continue with the selected option throughout the crediting period.

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-R\(_N\)), where R\(_N\) is the relative reduction of nitrogen from the previous stage. The relative reduction (R\(_N\)) 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 appendix 1 (values for TN). The default factor for composting technology shall be referred from literature.
If the project involves the co-composting of various substrate for example, digestate and animal manure, the project emission will be the sum of emissions from both component as estimated above iv.a and iv.b.

(v) Project emissions from use of heat and/or electricity-(PE\text{electric/heat})

These emissions should only be considered for consumption of electricity or heat that is not related to the anaerobic digester, as those emissions will be considered while estimating $PE_{AD,y}$.

$$PE_{ECFC,y} = PE_{EC,y} + \sum_j PE_{FC,j,y}$$

Where:

- $PE_{EC,y}$ = Project emissions from electricity consumption in year $y$. The project emissions from electricity consumption will be calculated following the latest version of “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”. In case, the electricity consumption is not measured then the electricity consumption shall be estimated as follows:

$$EC_{pl,y} = \sum CP_{i,y} \times 8760$$

where $CP_{i,y}$ is the rated capacity (in MW) of electrical equipment $i$ used for the project activity.

- $PE_{FC,j,y}$ = Project emissions from fossil fuel combustion in process $j$ during the year $y$. The project emissions from fossil fuel combustion 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 AWMS (not including fossil fuels consumed for transportation of feed material and sludge or any other on-site transportation).

(vi) Project emissions from manure transportation (PE\text{Transport})

The project emissions from manure transportation from collection points to the central treatment plant shall be calculated according to the Methodological tool “Project and leakage emissions from transportation of freight”.

(vii) Project emissions from manure storage (PE\text{Storage,$y$})

In the cases tank trucks are used to collect residues, there may be the need to temporarily store them in storage tanks in between collection procedures interval. This methodology only covers those situations in which residues are stored in outdoor open storage tanks. If project participants wish to use a different storage technology they are encouraged to proposed amendments to this methodology. Methane project emissions may occur during residues storage and shall be calculated as follows:

$$PE_{storage,y} = GWP_{CH_4} \times D_{CH_4,n} \times \sum_l \left( \frac{365}{AI_l} \sum_{N_{LT}} (N_{LT} \times VS_{LT,d} \times MS\%_l \times (1 - e^{-k(\frac{AI_l - d)}{T}}) \times MCFl \times B_{0,LT}) \right)$$

Where:

- $PE_{storage,y}$ = Annual project emission in manure storage tanks in tCO$_2$/yr
- $GWP_{CH_4}$ = Global warming potential of methane
- $D_{CH_4,n}$ = Density of methane ($6.7 \times 10^{-4}$ 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/animal LT/day)
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Leakage

Leakage covers the emissions from land application of treated manure as well as the emissions related to anaerobic digestion in a digester, occurring 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 are only considered if they are positive.

\[ LE_y = (LE_{Pj,N2O,y} - LE_{BL,N2O,y}) + (LE_{Pj,CH4,y} - LE_{BL,CH4,y}) + LE_{comp,y} + LE_{AD,y} + LE_{Trans,y} \]  \hspace{1cm} (22)

Where:

- \( LE_{Pj,N2O,y} \) = Leakage \( N_2O \) emissions released during project activity from land application of the treated manure in year \( y \) (tCO2e/yr)
- \( LE_{BL,N2O,y} \) = Leakage \( N_2O \) emissions released during baseline scenario from land application of the treated manure in year \( y \) (tCO2e/yr)
- \( LE_{Pj,CH4,y} \) = Leakage \( CH_4 \) emissions released during project activity from land application of the treated manure in year \( y \) (tCO2e/yr)
- \( LE_{BL,CH4,y} \) = Leakage \( CH_4 \) emissions released during baseline scenario from land application of the treated manure in year \( y \) (tCO2e/yr)
- \( LE_{comp,y} \) = Leakage emissions associated with the storage and disposal of compost in year \( y \) (tCO2e)
- \( LE_{AD,y} \) = Leakage emissions associated with the anaerobic digester in year \( y \) (tCO2e)
- \( LE_{Trans,y} \) = Emissions from incremental distance travelled for waste/final compost/residue transportation in tCO2e/yr

(i) Estimation of leakage \( N_2O \) emissions released during baseline scenario from land application of the treated manure in year \( y \)

\[ LE_{BL,N2O,y} = GWP_{N2O} \times CF_{N2O-N,N} \times \frac{1}{1000} \times (LE_{N2O,land,y} + LE_{N2O,runoff,y} + LE_{N2O,vol,y}) \]  \hspace{1cm} (23)

\[ LE_{N2O,land,y} = EF_1 \times \prod_{n=1}^{N} \left( 1 - R_{N,n} \right) \times \sum_{LT} \text{NEX}_{LT,y} \times N_{LT} \]  \hspace{1cm} (24)

\[ LE_{N2O,runoff,y} = EF_5 \times \frac{F_{leach}}{F_{gasm}} \times \prod_{n=1}^{N} \left( 1 - R_{N,n} \right) \times \sum_{LT} \text{NEX}_{LT,y} \times N_{LT} \]  \hspace{1cm} (25)

\[ LE_{N2O,vol,y} = EF_4 \times \prod_{n=1}^{N} \left( 1 - R_{N,n} \right) \times F_{gasm} \times \sum_{LT} \text{NEX}_{LT,y} \times N_{LT} \]  \hspace{1cm} (26)

Where:

- \( GWP_{N2O} \) = Global Warming Potential (GWP) for \( N_2O \) (tCO2e/tN2O)
- \( CF_{N2O-N,N} \) = Conversion factor \( N_2O-N \) to \( N_2O \) (44/28)
\[ LE_{\text{N}_2\text{O,land,year}} = \text{Leakage N}_2\text{O emissions from application of manure waste in year } y \]  
\[ \text{(kg N}_2\text{O-N/year)} \]

\[ LE_{\text{N}_2\text{O,runoff,year}} = \text{Leakage N}_2\text{O emissions due to leaching and run-off in year } y \]  
\[ \text{(kg N}_2\text{O-N/year)} \]

\[ LE_{\text{N}_2\text{O,vol,year}} = \text{Leakage N}_2\text{O emissions due to volatilisation in year } y \]  
\[ \text{(kg N}_2\text{O-N/year)} \]

\[ F_{\text{gasm}} = \text{Fraction of } N \text{ lost due to volatilization (fraction)} \]

\[ N_{\text{LT}} = \text{Annual average number of animals of type LT estimated as per equation (5.a) or (5.b) (number)} \]

\[ NEX_{\text{LT,year}} = \text{Annual average nitrogen excretion per head of a defined livestock population} \]  
\[ \text{(kg N/animal/year) estimated as described in appendix 2} \]

\[ EF_1 = \text{Emission factor for N}_2\text{O emissions from N inputs (kg N}_2\text{O-N/kg N input)} \]

\[ EF_5 = \text{Emission factor for N}_2\text{O emissions from N leaching and runoff in} \]  
\[ \text{(kg N}_2\text{O-N/kg N leached and runoff)} \]

\[ EF_4 = \text{Emission factor for N}_2\text{O emissions from atmospheric deposition of N on soils and water surfaces, [kg N- N}_2\text{O/(kg NH}_3\text{-N + NO}_x\text{-N volatilized)]} \]

\[ F_{\text{leach}} = \text{Fraction of all N added to/mineralised in managed soils in regions where} \]  
\[ \text{leaching/runoff occurs that is lost through leaching and runoff (fraction)} \]

\[ R_{\text{N,land}} = \text{Nitrogen reduction factor (fraction)} \]

(ii) Estimation of leakage N\textsubscript{2}O emissions released during project activity from land application of the treated manure in year \( y \)

\[ LE_{\text{PJ,N}_2\text{O}} = GWP_{\text{N}_2\text{O}} \times CF_{\text{N}_2\text{O}-\text{N,N}} \times \frac{1}{1000} \times (LE_{\text{N}_2\text{O,land,year}} + LE_{\text{N}_2\text{O,runoff,year}} + LE_{\text{N}_2\text{O,vol,year}}) \]  
\[ (27) \]

\[ LE_{\text{N}_2\text{O,land,year}} = EF_1 \times \prod_{n=1}^{N} (1 - R_{\text{N,land}}) \times \sum_{LT} NEX_{\text{LT,year}} \times N_{\text{LT}} \]  
\[ (28) \]

\[ LE_{\text{N}_2\text{O,runoff,year}} = EF_5 \times F_{\text{leach}} \times \prod_{n=1}^{N} (1 - R_{\text{N,runoff}}) \times \sum_{LT} NEX_{\text{LT,year}} \times N_{\text{LT}} \]  
\[ (29) \]

\[ LE_{\text{N}_2\text{O,vol,year}} = EF_4 \times \prod_{n=1}^{N} (1 - R_{\text{N,vol}}) \times F_{\text{gasm}} \times \sum_{LT} NEX_{\text{LT,year}} \times N_{\text{LT}} \]  
\[ (30) \]

Where:

\[ GWP_{\text{N}_2\text{O}} = \text{Global Warming Potential (GWP) for N}_2\text{O (tCO}_2\text{e/tN}_2\text{O)}} \]

\[ CF_{\text{N}_2\text{O}-\text{N,N}} = \text{Conversion factor N}_2\text{O-N to N}_2\text{O (44/28)} \]

\[ LE_{\text{N}_2\text{O,land,year}} = \text{Leakage N}_2\text{O emissions from application of manure waste in year } y \]  
\[ \text{(kg N}_2\text{O-N/year)} \]

\[ LE_{\text{N}_2\text{O,runoff,year}} = \text{Leakage N}_2\text{O emissions due to leaching and run-off in year } y \]  
\[ \text{(kg N}_2\text{O-N/year)} \]

\[ LE_{\text{N}_2\text{O,vol,year}} = \text{Leakage N}_2\text{O emissions due to volatilisation in year } y \]  
\[ \text{(kg N}_2\text{O-N/year)} \]

\[ F_{\text{gasm}} = \text{Fraction of } N \text{ lost due to volatilization (fraction)} \]

\[ N_{\text{LT}} = \text{Annual average number of animals of type LT estimated as per equation (5.a) or (5.b) (number)} \]

\[ NEX_{\text{LT,year}} = \text{Annual average nitrogen excretion per head of a defined livestock population in year } y \]  
\[ \text{(kg N/animal/year) estimated as described in appendix 2} \]

\[ EF_1 = \text{Emission factor for N}_2\text{O emissions from N inputs (kg N}_2\text{O-N/kg N input)} \]

\[ EF_5 = \text{Emission factor for N}_2\text{O emissions from N leaching and runoff in} \]  
\[ \text{(kg N}_2\text{O-N/kg N leached and runoff)} \]

\[ EF_4 = \text{Emission factor for N}_2\text{O emissions from atmospheric deposition of N on soils and water surfaces, [kg N- N}_2\text{O/(kg NH}_3\text{-N + NO}_x\text{-N volatilized)]} \]

\[ R_{\text{N,land}} = \text{Nitrogen reduction factor (fraction)} \]
\( EF_4 \) = Emission factor for \( \text{N}_2\text{O} \) emissions from atmospheric deposition of \( \text{N} \) on soils and water surfaces, [kg \( \text{N} \cdot \text{N}_2\text{O}/(\text{kg NH}_3\cdot\text{N} + \text{NO}_X\cdot\text{N} \) volatilized] \\
\( F_{\text{leach}} \) = Fraction of all \( \text{N} \) added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff (fraction) \\
\( R_{\text{N,n}} \) = Nitrogen reduction factor (fraction) \\

It is possible to measure the quantity of manure applied to land in kg manure/yr \( (Q_{\text{DM}}) \) and the nitrogen concentration in kg N/kg manure \( (N_{\text{DM}}) \) in the manure to estimate the total quantity of nitrogen applied to land. In this case, \( \prod_{n=1}^{Y} (1 - R_{\text{N,n}}) \times \sum_{j=1}^{L} \text{NEX}_{\text{LT},y} \times N_{\text{LT}} \) in equations (28), (29) and (30) above should be substituted by \( Q_{\text{DM}} \times N_{\text{DM}} \).

(iii) Estimation of leakage \( \text{CH}_4 \) emissions from land application of the treated manure

The calculation of methane emissions from land application in the baseline and project cases are estimated from equations 31 and 32 below:

\[
LE_{BL,\text{CH}_4,y} = GWP_{\text{CH}_4} \times D_{\text{CH}_4} \times MCF_{d} \times \left[ \prod_{n=1}^{Y} (1 - R_{\text{Y,S,n}}) \right] \times \sum_{j=1}^{L} (B_{0,LT} \times N_{\text{LT}} \times VS_{\text{LT},y} \times MS\%_{j})
\]

\[
LE_{PJ,\text{CH}_4,y} = GWP_{\text{CH}_4} \times D_{\text{CH}_4} \times MCF_{d} \times \left[ \prod_{n=1}^{Y} (1 - R_{\text{Y,S,n}}) \right] \times \sum_{j=1}^{L} (B_{0,LT} \times N_{\text{LT}} \times VS_{\text{LT},y} \times MS\%_{j})
\]

Where:

\( LE_{BL,\text{CH}_4,y} \) = Leakage \( \text{CH}_4 \) emissions released during baseline scenario from land application of the treated manure in year \( y \) (tCO\( _2 \)e/yr) \\
\( LE_{PJ,\text{CH}_4,y} \) = Leakage \( \text{CH}_4 \) emissions released during project activity from land application of the treated manure in year \( y \) (tCO\( _2 \)e/yr) \\
\( R_{\text{Y,S,n}} \) = Fraction of volatile solid degraded in AWMS treatment method \( n \) of the \( N \) treatment steps prior to sludge being treated \\
\( GWP_{\text{CH}_4} \) = Global Warming Potential (GWP) of \( \text{CH}_4 \) (tCO\( _2 \)e/t\( \text{CH}_4 \)) \\
\( D_{\text{CH}_4} \) = Density of \( \text{CH}_4 \) (t/m\(^3\)) \\
\( B_{0,LT} \) = Maximum methane producing potential of the volatile solid generated by animal type \( LT \) (m\(^3\)CH\( _4 \)/kg dm) \\
\( N_{\text{LT}} \) = Annual average number of animals of type \( LT \) estimated as per equation (5.a) or (5.b), expressed (number) \\
\( VS_{\text{LT},y} \) = Annual volatile solid excretions for livestock \( LT \) entering all AWMS on a dry matter weight basis (kg -dm/animal/yr) \\
\( MS\%_{j} \) = Fraction of manure handled in system \( j \) in the project activity (fraction) \\
\( MCF_{d} \) = Methane conversion factor (MCF) assumed to be equal to 1

(iv) Leakage emissions from compost disposal or storage \( (LE_{\text{COMP},y}) \)

Leakage emissions associated with composting \( (LE_{\text{COMP},y}) \) are calculated according to the methodological tool “Project and leakage emissions from composting”.

For solid digestate and compost please refer “Tool to estimate the emissions from solid waste disposal sites”.
For liquid digestate refer the Tool on “Project and leakage emissions from anaerobic digesters”.

(v) Estimation of leakage emissions associated with the anaerobic digester

\( LE_{AD,y} \) is determined using the methodological tool “Project and leakage emissions from anaerobic digesters”.

(vi) Estimation of leakage emission associated with the incremental distance travelled for waste/final compost/residue transportation

\( LE_{Trans,y} \) shall be determined according to the Methodological tool “Project and leakage emissions from transportation of freight.

Emission reduction

The emission reduction \( ER_y \) by the project activity during a given year \( y \) is the difference between the baseline emissions \( (BE_y) \) and the sum of project emissions \( (PE_y) \) and leakage, as follows:

\[
ER_y = BE_y - PE_y - LE_y
\]  

(33)

Further, in estimating emissions reduction for claiming certified emissions reductions, if the calculated CH\(_4\) baseline emissions from anaerobic lagoons are higher than the measured CH\(_4\) generated in the anaerobic digester in the project situation \( (Q_{CH4,y} \) in the tool “Project and leakage emissions from anaerobic digesters”), then the latter shall be used to calculate the emissions reduction for claiming certified emissions reductions. Therefore, the actual methane captured from an anaerobic digester shall be compared to the \( (BE_{CH4,y} - PE_{AD,y}) \) (which is a component of \( BE_y - PE_y \)) in equation (32) is replaced by \( Q_{CH4,y} \).

Further, in case co-digestion of manure and biomass/other organic matter are applied, the emission reductions achieved by the project activity from the anaerobic digester due to the collection and destruction of biogas shall be determined ex post through direct measurement of the amount of biogas fuelled, flared or gainfully used. The emission reductions achieved by the project is limited to the ex post calculated baseline emissions minus project and leakage emissions using the actual monitoring data for the project activity. The emission reductions achieved in any year are the lowest value of the following:

\[
ER_{y,ex\ post} = \min \left[ (BE_{y,ex\ post} - PE_{y,ex\ post} - LE_{y,ex\ post}), (MD_y - PE_{y,ex\ post} - LE_{y,ex\ post}) \right]
\]  

(34)

Where

- \( ER_{y,ex\ post} \) = Emission reductions achieved by the project activity based on monitored values in year \( y \) (tCO\(_2\)/a)
- \( BE_{y,ex\ post} \) = Baseline emissions calculated using equations provided by ACM0010 and ACM0022 with ex post monitored values in year \( y \) (tCO\(_2\)/a)
- \( PE_{y,ex\ post} \) = Project emissions calculated using equations provided with ex post monitored values in year \( y \) (tCO\(_2\)/a)
- \( LE_{y,ex\ post} \) = Leakage emissions calculated with ex post monitored values in year \( y \) (tCO\(_2\)/a)
- \( MD_y \) = Methane captured and destroyed or used gainfully by the project activity in year \( y \) (tCO\(_2\)/a)
Changes required for methodology implementation in 2nd and 3rd crediting periods

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”.

Project activity under a programme of activities

In addition to the requirements set out in the latest approved version of the “Standard for demonstration of additionality, development of eligibility criteria and application of multiple methodologies for programme of activities”, the following shall be applied for the use of this methodology in a project activity under a programme of activities (PoAs).

The PoA may consist of one or several types of CPAs. CPAs are regarded to be of the same type if they are similar with regard to the demonstration of additionality, emission reduction calculations and monitoring. The Coordination/managing Entity (CME) shall describe in the CDM-PoA-DD for each type of CPAs separately:

(a) Eligibility criteria for CPA inclusion used for each type of CPAs;
   (i) In case of different setups of animal waste management systems in one CPA, the eligibility criteria shall be defined for each setup of animal waste management system separately;
   (ii) Emission reduction calculations for each type of CPAs;
   (iii) Monitoring provisions for each type of CPAs.

The CME shall describe transparently and justify in the CDM-PoA-DD which CPAs are regarded to be of the same type. CPAs are not regarded to be of the same type if one of the following conditions is different:

(a) The baseline scenario with regard to any of the following aspects:
   (i) The manure management system used in the baseline;
   (ii) The alternative scenarios for the use of gas generated from an anaerobic digester (biogas);

(b) The project activity with regard to the animal waste management systems used and the use of the gas generated from an anaerobic digester (biogas): flaring, electricity generation or heat generation;

(c) The legal and regulatory framework;

(d) Type of animal manure.

For example, one type of CPAs may be characterized by the following combinations. The baseline scenario is the use of an uncovered anaerobic lagoon for manure treatment. Under the project activity, an anaerobic digester is used. The biogas from the digester is used to produce heat.

When defining eligibility criteria for CPA inclusion for a distinct type of CPAs, the CME shall consider relevant technical and economic parameters, such as:

(a) Ranges of design specifications of baseline and project manure management systems (e.g. a range of average depths and surface areas of lagoons, electricity consumption, residence time of the organic matter and effluent adjustment factor);

(b) Local conditions (temperature);
(c) Ranges of capacity of biogas production;

(d) Ranges of costs (capital investment in Greenfield manure management system, operating and maintenance costs, etc.);

(e) Ranges of revenues (income from electricity or heat production, subsidies/fiscal incentives, ODA).

The eligibility criteria related to the costs and revenues parameters shall be updated every two years in order to correctly reflect the technical and market circumstances of a CPA implementation.

In case the PoA contains several types of CPAs, the actual CPA-DD shall contain the description of each type of actual CPAs, be validated by a DOE and submitted for the registration to the Board.

Data and parameters not monitored

All data collected as part of not monitored parameters or monitoring should be archived electronically and be kept at least for two years after the end of the last crediting period.

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{VS,n}$</td>
<td>Fraction of volatile solid degraded in AWMS treatment method $n$ of the $N$</td>
</tr>
<tr>
<td></td>
<td>treatment steps prior to waste being treated</td>
</tr>
<tr>
<td>Source of data</td>
<td>Refer to appendix 1 (values for VS)</td>
</tr>
<tr>
<td>Any comment</td>
<td>The most conservative value for the given technology must be used</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$EF_{N2O,D,j}$</td>
<td>Direct $N_2O$ emission factor for the treatment system $j$ of the manure</td>
</tr>
<tr>
<td></td>
<td>management system</td>
</tr>
<tr>
<td>Source of data</td>
<td>Estimated with site-specific, regional or national data if such data is</td>
</tr>
<tr>
<td></td>
<td>available, otherwise use default $EF_3$ from table 10.21, chapter 10,</td>
</tr>
<tr>
<td></td>
<td>volume 4, in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories</td>
</tr>
<tr>
<td>Any comment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$EF_{N2O,ID}$</td>
<td>Indirect $N_2O$ emission factor for $N_2O$ emissions from atmospheric</td>
</tr>
<tr>
<td></td>
<td>deposition of nitrogen on soils and water surfaces</td>
</tr>
<tr>
<td>Source of data</td>
<td>Estimated with site-specific, regional or national data if such data is</td>
</tr>
<tr>
<td></td>
<td>available. Otherwise, default values for $EF_4$ from table 11.3, chapter 11,</td>
</tr>
<tr>
<td></td>
<td>volume 4 of IPCC 2006 Guidelines for National Greenhouse Gas Inventories can</td>
</tr>
<tr>
<td></td>
<td>be used</td>
</tr>
<tr>
<td>Any comment</td>
<td></td>
</tr>
<tr>
<td>Data / Parameter:</td>
<td>$F_{\text{gasMS,j,LT}}$</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Data unit:</td>
<td>Fraction</td>
</tr>
<tr>
<td>Description:</td>
<td>Default values for nitrogen loss due to volatilisation of NH$_3$ and NO$_X$ from manure management.</td>
</tr>
<tr>
<td>Source of data:</td>
<td>IPCC 2006 Guidelines. Volume 4, Chapter 10 - Table 10.22</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Any comment:</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$F_{\text{gasm}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Fraction</td>
</tr>
<tr>
<td>Description:</td>
<td>Fraction of N lost due to volatilization.</td>
</tr>
<tr>
<td>Source of data:</td>
<td>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 IPCC 2006 guidelines can be used.</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Any comment:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$\text{EF}_1$, $\text{EF}_4$, $\text{EF}_5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>kg N$_2$O-N/kg N for $\text{EF}_1$, $\text{EF}_4$ and [kg N$_2$O-N/ (kg NH$_3$-N and NO$_X$-N)] for $\text{EF}_5$</td>
</tr>
<tr>
<td>Description:</td>
<td>Emission factor for N$_2$O emissions from N inputs; from N leaching and runoff; from atmospheric deposition of N on soils and water surfaces</td>
</tr>
<tr>
<td>Source of data:</td>
<td>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 IPCC 2006 guidelines can be used.</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td>IPCC 2006 Guidelines default values may be used, if country specific or region specific data are not available. $\text{EF}_1$ from table 11.1, chapter 11, volume 4. $\text{EF}_4$ and $\text{EF}_5$ from table 11.3, chapter 11, volume 4</td>
</tr>
<tr>
<td>Any comment:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$F_{\text{leach}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Fraction</td>
</tr>
<tr>
<td>Description:</td>
<td>Fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff.</td>
</tr>
<tr>
<td>Source of data:</td>
<td>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 IPCC 2006 guidelines can be used</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Any comment:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$\text{MS%Bl,j}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Fraction</td>
</tr>
<tr>
<td>Description:</td>
<td>Fraction of manure handled in system $j$ in the baseline</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td>---</td>
</tr>
<tr>
<td>Any comment:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$\text{GWP}_{\text{CH4}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>tCO$_2$e/tCH$_4$</td>
</tr>
<tr>
<td>Description:</td>
<td>Global warming potential of CH$_4$</td>
</tr>
</tbody>
</table>
### GWP\textsubscript{N2O}

**Data / Parameter:** GWP\textsubscript{N2O}

**Data unit:** t\textsubscript{CO2e}/t\textsubscript{N2O}

**Description:** Global warming potential for N\textsubscript{2}O

**Source of data:** IPCC

**Measurement procedures (if any):** 310 for the first commitment period. Shall be updated according to any future COP/MOP decisions

**Any comment:** ---

### D\textsubscript{CH4}

**Data / Parameter:** D\textsubscript{CH4}

**Data unit:** t/m\textsuperscript{3}

**Description:** Density of CH\textsubscript{4}

**Source of data:** Technical literature

**Measurement procedures (if any):** ---

**Any comment:** 0.00067 t/m\textsuperscript{3} at room temperature 20\textdegree C and 1 atm pressure

### MCF\textsubscript{d}

**Data / Parameter:** MCF\textsubscript{d}

**Data unit:** ---

**Description:** Methane conversion factor for leakage calculation assumed to be equal 1

**Source of data:** ---

**Measurement procedures (if any):** ---

**Any comment:** ---

### MCF\textsubscript{i}

**Data / Parameter:** MCF\textsubscript{i}

**Data unit:** ---

**Description:** Methane conversion factor for the baseline AWMS\textsubscript{i}

**Source of data:** IPCC 2006 table 10.17, chapter 10, volume 4 (see appendix 3)

**Measurement procedures (if any):** ---

**Any comment:**
- MCF values depend on the annual average temperature where the anaerobic manure treatment facility in the baseline existed. For average annual temperatures below 10 °C and above 5 °C, a linear interpolation should be used to estimate the MCF value at the specific temperature assuming an MCF value of 0 at an annual average of 5 °C. Future revisions to the IPCC Guidelines for National Greenhouse Gas Inventories should be taken into account;
- 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% uncertainty in the MCF values as reported by IPCC 2006

### W\textsubscript{default}

**Data / Parameter:** W\textsubscript{default}

**Data unit:** Kg

**Description:** Default average animal weight of a defined population

**Source of data:** IPCC 2006 or US-EPA, whichever is lower

**Measurement procedures (if any):** ---
### Data / Parameter: $\hat{V}_{\text{VS}}^{\text{default}}$
- **Data unit:** kg -dm/animal/day
- **Description:** Default value for the volatile solid excretion per day on a dry-matter basis for a defined livestock population
- **Source of data:** IPCC 2006 or US-EPA, whichever is lower
- **Measurement procedures (if any):** ---
- **Any comment:** ---

### Data / Parameter: $N_{\text{retention}}$
- **Data unit:** kg N retained/animal/yr
- **Description:** Portion of that N intake that is retained in the animal
- **Source of data:** Default values are reported in Table 10.20 in IPCC 2006 guidelines, volume 4, chapter 10 (Table 10.2)
- **Measurement procedures (if any):** ---
- **Any comment:** This parameter is used to estimate $NEX_{LT,y}$ in appendix 2

### Data / Parameter: $NEX_{\text{IPCC default}}$
- **Data unit:** kg N/animal/year
- **Description:** Default value for the nitrogen excretion per head of a defined livestock population
- **Source of data:** IPCC 2006 or US-EPA
- **Measurement procedures (if any):** ---
- **Any comment:** This parameter is used to estimate $NEX_{LT,y}$ in appendix 2

### Data / Parameter: $E_{\text{FCO2,BL,HG,k}}$
- **Data unit:** t CO2/TJ
- **Description:** CO2 emission factor of the fossil fuel type used for heat generation by equipment type k in the absence of the project activity
- **Source of data:** Actual measured or local data is to be used. If local data is not available, regional data should be used and, in its absence, IPCC default values can be used from the latest version of IPCC Guidelines for National Greenhouse Gas Inventories
- **Measurement procedures (if any):** ---
- **Any comment:** If the measurement results differ significantly from previous measurements or other relevant data sources, conduct additional measurements. Double-checked against IPCC defaults (for consistency) if data is local or regional

### Data / Parameter: $R_{N,n}$
- **Data unit:** Fraction
- **Description:** Nitrogen reduction factor
- **Source of data:** Refer to appendix 1
- **Measurement procedures (if any):** ---
- **Any comment:** Estimated from the table provided in appendix 1 (value for TN). The most conservative value for the given technology must be used
II. MONITORING METHODOLOGY

In this methodology, monitoring comprises several activities.

The monitoring plan should include on-site inspections for each individual farm included in the project boundary where the project activity is implemented for each verification period.

The precise location of manure collection points shall be identified in the CDM-PDD (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. DOEs must perform site visits on the central treatment plant during project verification. All documentation, which shall be checked by the DOE, referring to every farm, must be available during the verification (sales records, feed formulation, etc.). However, DOEs are not required to perform site visits in all farms included in the project boundary. Instead the DOEs and project participants may proceed as described in the following section.
Prior to the 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. The DOEs shall perform site inspections on the sites that are individually responsible for an amount of baseline emissions equal or higher than 900 tCO2e (“upper rank”). This guarantees that the most preponderant baseline GHG sources are properly verified. For the remaining sites (“lower rank”), DOEs shall perform site inspections on a number \( n \) of randomly selected sites, being \( n \) determined as:

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

(35)

Where:
- \( n \) = Number of “lower rank” sites to be visited by DOE
- \( N \) = Total number of “lower rank” sites
- \( E \) = Tolerable sampling error (10%)

Then, a CH\(_4\) emission reduction deviation factor \( DF_{site} \) shall be calculated for each “lower rank” site.

\[
DF_{site} = \frac{BE^{obs}_{site}}{BE^{claimed}_{site}}
\]

(36)

Where:
- \( DF_{site} \) = Deviation factor for the “lower rank” sites visited by the DOE (dimensionless)
- \( BE^{obs}_{site} \) = Baseline emissions verified by DOE after site inspection (tCO\(_2\)e)
- \( BE^{claimed}_{site} \) = Baseline emissions claimed by project proponents for a given “lower rank” site (tCO\(_2\)e)

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

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

\[
\overline{DF} = \frac{\sum_{site} (DF_{site} \cdot BE^{obs}_{site})}{\sum_{site} BE^{obs}_{site}}
\]

(37)

Where:
- \( \overline{DF} \) = Average deviation factor for the “lower rank” sites visited by the DOE (dimensionless);
- \( DF_{site} \) = Deviation factor for the “lower rank” sites visited by the DOE (dimensionless);
- \( BE^{obs}_{site} \) = Baseline emissions verified by DOE after “lower rank” sites inspection (tCO\(_2\)e)

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

\[
BE^{corrected}_{LR, total} = \overline{DF} \cdot \sum_{site} BE^{claimed}_{site}
\]

(38)
Where:

\( \text{BE}_{\text{LR, total}}^{\text{corrected}} \) = Total corrected baseline emissions from the “lower rank” sites (tCO₂e)

\( \text{DF} \) = Deviation factor for the “lower rank” sites visited by the DOE (dimensionless)

\( \text{BE}_{\text{site}}^{\text{claimed}} \) = Baseline emissions claimed by project proponents for a given “lower rank” site (tCO₂e)

Then, total baseline emissions shall be calculated as follows:

\[
\text{BE}_{\text{total}} = \text{BE}_{\text{LR, total}}^{\text{corrected}} + \text{BE}_{\text{UR, total}}
\] (39)

Where:

\( \text{BE}_{\text{total}} \) = Total baseline emissions (tCO₂e)

\( \text{BE}_{\text{LR, total}}^{\text{corrected}} \) = Total corrected baseline emissions from “lower rank” sites (tCO₂e)

\( \text{BE}_{\text{UR, total}} \) = Total baseline emissions from “upper rank” sites (tCO₂e) (no correction values shall be applied – absolute verified values must be used)

Diagrammatic representation of animal waste management system existing on the project site should be presented (an example is shown in Figure 2).
Figure 2: Flow diagram and biogas flow measurement points of project activity
Data and parameters monitored
<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>MCF&lt;sub&gt;d&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Fraction</td>
</tr>
<tr>
<td>Description:</td>
<td>Methane conversion factor (MCF) for the sludge stored in sludge pits</td>
</tr>
<tr>
<td>Source of data:</td>
<td>IPCC 2006 table 10.17, chapter 10, volume 4 (see appendix 3)</td>
</tr>
<tr>
<td>Measurement</td>
<td>---</td>
</tr>
<tr>
<td>procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
<td>Annually</td>
</tr>
<tr>
<td>frequency:</td>
<td></td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>---</td>
</tr>
</tbody>
</table>
| Any comment:     | • For average annual temperatures below 10 °C and above 5 °C, a linear interpolation should be used to estimate the MCF value at the specific temperature assuming an MCF value of 0 at an annual average of 5 °C. Future revisions to the IPCC Guidelines for National Greenhouse Gas Inventories should be taken into account;  
• 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% uncertainty in the MCF values as reported by IPCC 2006 |

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>MCF&lt;sub&gt;1&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Fraction</td>
</tr>
<tr>
<td>Description:</td>
<td>Annual methane conversion factor for the project manure storage tank</td>
</tr>
<tr>
<td>Source of data:</td>
<td>IPCC 2006 Guidelines - Table 10.17, Chapter 10, Volume 4</td>
</tr>
<tr>
<td>Measurement</td>
<td>Archive electronically during project plus 5 years</td>
</tr>
<tr>
<td>procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
<td>Annually</td>
</tr>
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<td>frequency:</td>
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<td>QA/QC procedures:</td>
<td>---</td>
</tr>
<tr>
<td>Any comment:</td>
<td>---</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>B&lt;sub&gt;0,LT&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>m³CH₄/kg dm</td>
</tr>
<tr>
<td>Description:</td>
<td>Maximum methane producing potential of the volatile solid generated by animal type LT</td>
</tr>
</tbody>
</table>
This value varies by species and diet. Where default values are used, they should be taken from tables 10A-4 through 10A-9 (IPCC 2006 Guidelines for National Greenhouse Gas Inventories volume 4, chapter 10) specific to the country where the project is implemented.

Developed countries $B_{0,LT}$ values can be used provided the following conditions are satisfied:

- The genetic source of the production operations livestock originate from an Annex I Party;
- The farm use formulated feed ratios (FFR) which are optimized for the various animal(s), stage of growth, category, weight gain/productivity and/or genetics;
- The use of FFR can be validated (through on-farm record keeping, feed supplier, etc.);
- The project specific animal weights are more similar to developed country IPCC default values.

Directly measure $B_{0,LT}$ as per:

- ISO 11734:1995;
- ASTM E2170-01 (2008); and
- ASTM D 5210-92

**Data / Parameter:** | Type
---|---
**Data unit:** | ---
**Description:** | Type of barn and AWMS
**Source of data:** | Project proponents
**Measurement procedures (if any):** | ---
**Monitoring frequency:** | Annually
**QA/QC procedures:** | ---
**Any comment:** | Barn and AWMS layout and configuration

**Data / Parameter:** | CP
---|---
**Data unit:** | %
**Description:** | Crude protein percent
**Source of data:** | Project proponents
**Measurement procedures (if any):** | ---
**Monitoring frequency:** | Annually
**QA/QC procedures:** | ---
**Any comment:** | This parameter is used to estimate $\text{NEX}_{LT,y}$ in appendix 2

**Data / Parameter:** | GE
---|---
**Data unit:** | MJ/animal/day
**Description:** | Gross energy intake of the animal
Source of data: Project proponents. 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

Measurement procedures (if any): 
Monitoring frequency: Annually
QA/QC procedures: ---
Any comment: This parameter is used to estimate $NEX_{LT,y}$ in appendix 2

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
<th>Source of data</th>
<th>Measurement procedures (if any)</th>
<th>Monitoring frequency</th>
<th>QA/QC procedures</th>
<th>Any comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T$</td>
<td>Annual Average ambient temperature at project site</td>
<td>Project proponents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$EG_{d,y}$</td>
<td>Electricity generated using biogas in year $y$</td>
<td>Project proponents</td>
<td>Archive electronically during project plus five years</td>
<td>Annual</td>
<td>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 CERs and procedure for doing so should be described in the CDM-PDD</td>
<td>---</td>
</tr>
<tr>
<td>$N_{da,LT}$</td>
<td>Number of days animal of type $LT$ is alive in the farm in the year $y$</td>
<td>Project proponents</td>
<td></td>
<td>Monthly</td>
<td>---</td>
<td>The PDD should describe the system on monitoring the number of days the animal is alive in the farm. The consistency between the value and indirect information (records of sales, records of food purchases) should be assessed. This parameter is used in option 1 to calculate $N_{LT}$</td>
</tr>
<tr>
<td>$N_{p,LT}$</td>
<td>Number of animals of type $LT$ produced annually for the year $y$</td>
<td>Project proponents</td>
<td></td>
<td>---</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data unit:
- $T$: °C
- $EG_{d,y}$: MWh
- $N_{da,LT}$: Number
- $N_{p,LT}$: Number
### Data / Parameter: $W_{site}$
- **Data unit:** Kg
- **Description:** Average animal weight of a defined livestock population at the project site
- **Source of data:** Project proponents
- **Measurement procedures (if any):** Monthly
- **QA/QC procedures:** ---
- **Any comment:** This parameter is used in equation 4 for estimating $V_{S_{LT,y}}$ using option 3, and in equation 2 (appendix 2) for estimating $NEX_{LT,y}$ when using 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: $F_{Aer}$
- **Data unit:** Fraction
- **Description:** Fraction of volatile solids directed to aerobic treatment
- **Source of data:**
- **Measurement procedures (if any):**
- **Monitoring frequency:** Annually
- **QA/QC procedures:** ---
- **Any comment:** ---
<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_f$</td>
<td>Biogas flow</td>
</tr>
<tr>
<td>$m^3$</td>
<td></td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td>Continuously by flow meter and reported cumulatively on weekly basis</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>Flow meters will undergo maintenance/calibration subject to appropriate industry standards. The frequency of calibration and control procedures would be different for each application. This maintenance/calibration practice should be clearly stated in the CDM-PDD</td>
</tr>
<tr>
<td>Any comment:</td>
<td>The biogas flow will be measured at four points, as shown in the figure. But if the project participants can demonstrate that leakage in distribution pipeline is zero, it need be measured at any three points. The biogas flow to electricity or heat equipment in a moment can be considered destroyed, by monitoring that the equipment was working at this time</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_{DM}$</td>
<td>N concentration in disposed manure</td>
</tr>
<tr>
<td>$kg \ N/KG \ effluent$</td>
<td></td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>Every batch disposed</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>---</td>
</tr>
<tr>
<td>Any comment:</td>
<td>---</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{DM}$</td>
<td>Mass of manure disposed outside project boundary</td>
</tr>
<tr>
<td>$Kg$</td>
<td></td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>Every batch disposed</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>---</td>
</tr>
<tr>
<td>Any comment:</td>
<td>---</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$MS_{%j}$</td>
<td>Fraction of manure handled in system j in the project activity</td>
</tr>
<tr>
<td>Fraction</td>
<td></td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>Annually</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>---</td>
</tr>
<tr>
<td>Any comment:</td>
<td>---</td>
</tr>
<tr>
<td>Data / Parameter:</td>
<td>NEXLT,y</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Data unit:</td>
<td>kg N/animal/year</td>
</tr>
<tr>
<td>Description:</td>
<td>Annual average nitrogen excretion per head of a defined livestock population estimated as described in appendix 2</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Refer to appendix 2</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>Annually</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>---</td>
</tr>
<tr>
<td>Any comment:</td>
<td>When using equation 2 in appendix 2, please refer to above guidance for estimating W\text{site}</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>GELT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>MJ/animal/day</td>
</tr>
<tr>
<td>Description:</td>
<td>Daily average gross energy intake</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>Daily</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>---</td>
</tr>
<tr>
<td>Any comment:</td>
<td>---</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>DE\text{LT}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>%</td>
</tr>
<tr>
<td>Description:</td>
<td>Digestible energy of the feed in percent</td>
</tr>
<tr>
<td>Source of data:</td>
<td>---</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>---</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>---</td>
</tr>
<tr>
<td>Any comment:</td>
<td>IPCC 2006: Typically 45-55% for low quality forages</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>UE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Fraction of GE\text{LT}</td>
</tr>
<tr>
<td>Description:</td>
<td>Urinary energy</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Typically 0.04GE\text{LT} 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</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>---</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>---</td>
</tr>
<tr>
<td>Any comment:</td>
<td>---</td>
</tr>
<tr>
<td>Data / Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>ASH</strong></td>
<td>Ash content of the manure</td>
</tr>
<tr>
<td>Data unit</td>
<td>Fraction of the dry matter feed intake</td>
</tr>
<tr>
<td>Source of data</td>
<td>Use country-specific values where available</td>
</tr>
<tr>
<td>Monitoring frequency</td>
<td>---</td>
</tr>
<tr>
<td>QA/QC procedures</td>
<td>---</td>
</tr>
<tr>
<td>Any comment</td>
<td>---</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ED_{LT}</strong></td>
<td>Energy density of the feed fed to livestock type LT</td>
</tr>
<tr>
<td>Data unit</td>
<td>MJ/kg</td>
</tr>
<tr>
<td>Source of data</td>
<td>Measured in laboratory based on local or international standards or IPCC default (18.45MJ/kg -dm)</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td>The project proponent will record the composition of the feed to enable the DOE to verify the energy density of the feed</td>
</tr>
<tr>
<td>Monitoring frequency</td>
<td>---</td>
</tr>
<tr>
<td>QA/QC procedures</td>
<td>---</td>
</tr>
<tr>
<td>Any comment</td>
<td>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</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N_{A,L,T}</strong></td>
<td>Daily stock of animals in the farm, discounting dead and discarded animals</td>
</tr>
<tr>
<td>Data unit</td>
<td>---</td>
</tr>
<tr>
<td>Source of data</td>
<td>Daily counting of alive animals in the farm, discounting dead animals and animals discarded from the productive process from the daily stock</td>
</tr>
<tr>
<td>Monitoring frequency</td>
<td>Daily</td>
</tr>
<tr>
<td>QA/QC procedures</td>
<td>---</td>
</tr>
<tr>
<td>Any comment</td>
<td>The PDD should describe the system for monitoring stock of animals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>nd_{y}</strong></td>
<td>Number of days treatment plant was operational in year y</td>
</tr>
<tr>
<td>Data unit</td>
<td>Number</td>
</tr>
<tr>
<td>Source of data</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Monitoring frequency</td>
<td>Daily</td>
</tr>
<tr>
<td>QA/QC procedures</td>
<td>---</td>
</tr>
<tr>
<td>Any comment</td>
<td>---</td>
</tr>
<tr>
<td>Data / Parameter:</td>
<td>$Q_{EM,m}$</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Data unit:</td>
<td>m$^3$/month</td>
</tr>
<tr>
<td>Description:</td>
<td>Monthly volume of the effluent mix entering the central treatment plant</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td>Using flow meters</td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>This parameter shall be continuously monitored</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>Flow meters will undergo maintenance/calibration subject to appropriate industry standards. This maintenance/calibration practice should be clearly stated in the CDM-PDD</td>
</tr>
<tr>
<td>Any comment:</td>
<td>This parameter shall be monitored by continuous flow meters installed after the effluent admittance point or after the equalization tanks (if existent)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$[N]_{EM,m}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>kg N/m$^3$</td>
</tr>
<tr>
<td>Description:</td>
<td>Monthly total nitrogen concentration in the effluent mix entering the central treatment plant</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>Weekly aggregated for monthly average</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>Sample collection procedures shall be performed as described in appendix 5. Total nitrogen determination should be performed according to the guidance provided in appendix 4</td>
</tr>
<tr>
<td>Any comment:</td>
<td>The effluent mix shall be collected after the effluent admittance point or after the equalization tanks (if existent)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>HG_{P1,k,y}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>TJ/yr</td>
</tr>
<tr>
<td>Description:</td>
<td>Net quantity of heat with biogas by equipment type $k$ in the project $t$ in year $y$</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Measured from the heat received by the heated process; else Calculated on the basis of measurement of the volume of biogas captured and used for heat generation by each heat generation equipment type $k$ multiplied by the methane content of the gas, net calorific value of methane, and the efficiency of heat generation equipment type $k$ during the project (i.e. with biogas)</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td>Amount of methane in the biogas is determined using the “Tool to determine the mass flow of a greenhouse gas in gaseous stream”. For the gaseous stream the tool shall be applied to is the biogas delivery pipeline to each item of heat generation equipment $k$</td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>Monitored daily</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>-</td>
</tr>
<tr>
<td>Any comment:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>-</td>
</tr>
<tr>
<td>Description:</td>
<td>Total Numbers of farms</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>Annually</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td></td>
</tr>
<tr>
<td>Any comment:</td>
<td></td>
</tr>
</tbody>
</table>

**Data / parameter:** $A_{l}$  
**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:       | $MS_{l}$  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Fraction</td>
</tr>
<tr>
<td>Description:</td>
<td>Fraction of volatile solids (%) handled by storage tank $l$.</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Project proponents</td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td>Archive electronically during project plus 5 years</td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>Monthly averaged for annual value</td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>--</td>
</tr>
<tr>
<td>Any comment:</td>
<td>--</td>
</tr>
</tbody>
</table>

**Data / Parameter:** $RATE_{\text{compliance,t,y}}$  
**Data unit:** Fraction  
**Description:** Rate of compliance with a regulatory requirement to implement the alternative waste treatment $t$ implemented in the project activity.  
**Source of data:** Studies and official reports, such as annual reports provided by municipal bodies  
**Measurement procedures (if any):** Fraction is calculated as the number of instances of compliance divided by the number of instances of compliance plus non-compliance  
**Monitoring frequency:** Annually  
**QA/QC procedures:** --  
**Any comment:** Applicable to calculating baseline emissions and confirming applicability of the methodology

**Data / Parameter:** $p_{n,j,y}$  
**Data unit:** Weight fraction  
**Description:** Fraction of waste type $j$ in the sample $n$ collected during the year $y$.  

40/54
Source of data: Sample measurements by project participants
Measurement procedures (if any): -
Monitoring frequency: A minimum of three samples shall be undertaken every three months with the mean value valid for year $y$
QA/QC procedures: -
Any comment: -

Data / Parameter: $z_y$
Data unit: -
Description: Number of samples collected during the year $y$
Source of data: Project participants
Measurement procedures (if any): -
Monitoring frequency: Continuously, aggregated annually
QA/QC procedures: -
Any comment: -

IV. REFERENCES AND ANY OTHER INFORMATION

Not applicable.
## Appendix 1

### Anaerobic Unit Process Performance

<table>
<thead>
<tr>
<th>Anaerobic Treatment</th>
<th>HRT</th>
<th>COD</th>
<th>TS</th>
<th>VS</th>
<th>TN</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>days</td>
<td>Percent Reduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pull plug pits</td>
<td>4.30</td>
<td>—</td>
<td>0.30</td>
<td>0.30</td>
<td>0.20</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>Underfloor pit storage</td>
<td>30-180</td>
<td>—</td>
<td>30-40</td>
<td>20-30</td>
<td>5-20</td>
<td>5-15</td>
<td>5-15</td>
</tr>
<tr>
<td>Open top tank</td>
<td>30-180</td>
<td>—</td>
<td>—</td>
<td>25-30</td>
<td>10-20</td>
<td>10-20</td>
<td></td>
</tr>
<tr>
<td>Open pond</td>
<td>30-180</td>
<td>—</td>
<td>—</td>
<td>70-80</td>
<td>50-65</td>
<td>40-50</td>
<td></td>
</tr>
<tr>
<td>Heated digester effluent prior to storage</td>
<td>12-20</td>
<td>35-70</td>
<td>25-50</td>
<td>40-70</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Covered first cell of two cell lagoon</td>
<td>30-90</td>
<td>70-90</td>
<td>75-95</td>
<td>80-90</td>
<td>25-35</td>
<td>50-80</td>
<td>30-50</td>
</tr>
<tr>
<td>One-cell lagoon</td>
<td>&gt;365</td>
<td>70-90</td>
<td>75-95</td>
<td>75-85</td>
<td>60-80</td>
<td>50-70</td>
<td>30-50</td>
</tr>
<tr>
<td>Two-cell lagoon</td>
<td>210+</td>
<td>90-95</td>
<td>80-95</td>
<td>90-98</td>
<td>50-80</td>
<td>85-90</td>
<td>30-50</td>
</tr>
</tbody>
</table>

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

### Source

Appendix 2
Procedure for estimating $NEX_{LT,y}$

Option 1:

$$NEX_{LT,y} = N_{intake} \times (1 - N_{retention}) \times nd_y$$  \hspace{1cm} (1)

Where:

- $N_{intake}$ = Daily $N$ intake per animal (kg $N$/animal/yr)
- $N_{retention}$ = Portion of that $N$ intake that is retained in the animal (kg $N$ retained/animal/yr)
- $nd_y$ = Number of days treatment plant was operational in year $y$

$N_{intake}$ may be calculated using:

$$N_{intake} = \left( \frac{GE}{18.45} \right) \times \left( \frac{CP/100}{6.25} \right)$$  \hspace{1cm} (1.a)

Where:

- CP = Crude protein percent (percent)
- GE = Gross energy intake of the animal (MJ/animal/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 $N$)$^{-1}$

Option 2:

In the absence of availability of project specific information on protein intake, which should be justified in the CDM-PDD, national or regional data should be used for the nitrogen excretion $NEX_{LT,y}$, if available. In the absence of such data, default values from table 10.19 of the IPCC 2006, volume 4, chapter 10) may be used and should be corrected for the animal weight at the project site in the following way:

$$NEX_{LT,y} = \frac{W_{site}}{W_{default}} \times NEX_{IPCC\,default}$$  \hspace{1cm} (2)

Where:

- $NEX_{LT,y}$ = Annual average nitrogen excretion per head of a defined livestock population (kg $N$/animal/yr)
- $W_{site}$ = Average animal weight of a defined livestock population at the project site (kg)
- $W_{default}$ = Default average animal weight of a defined population (kg)
- $NEX_{IPCC\,default}$ = Default value for the nitrogen excretion per head of a defined livestock population (kg $N$/animal/year)
### Table 10.17 of IPCC 2006

#### MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS

<table>
<thead>
<tr>
<th>System</th>
<th>MCFs by Average Annual Temperature (°C)</th>
<th>Source and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cool</td>
<td>Temperate</td>
</tr>
<tr>
<td></td>
<td>≤ 10</td>
<td>11</td>
</tr>
<tr>
<td>Pasture/Range/Paddock</td>
<td>1.0%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Daily Spread</td>
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<td>0.5%</td>
</tr>
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<td>Solid Storage</td>
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<td>4.0%</td>
</tr>
<tr>
<td>Dry Lot</td>
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**Liquid/Shurry**

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<th>11%</th>
<th>13%</th>
<th>14%</th>
<th>15%</th>
<th>17%</th>
<th>18%</th>
<th>20%</th>
<th>22%</th>
<th>24%</th>
<th>26%</th>
<th>29%</th>
<th>33%</th>
<th>34%</th>
<th>39%</th>
<th>41%</th>
<th>44%</th>
<th>48%</th>
<th>50%</th>
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<tbody>
<tr>
<td>Without natural crust cover</td>
<td>17%</td>
<td>19%</td>
<td>20%</td>
<td>22%</td>
<td>25%</td>
<td>27%</td>
<td>29%</td>
<td>32%</td>
<td>35%</td>
<td>39%</td>
<td>42%</td>
<td>46%</td>
<td>50%</td>
<td>55%</td>
<td>60%</td>
<td>65%</td>
<td>71%</td>
<td>78%</td>
<td>80%</td>
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</tbody>
</table>

Judgement of IPCC Expert Group in combination with Mangino et al. (2001) and Sommer (2001). The estimated reduction due to the crust cover (40%) is an annual average value based on a limited data set and can be highly variable dependent on temperature, rainfall, and composition. When slurry tanks are used as fed-batch storage digesters, MCF should be calculated according to Formula 1.
<table>
<thead>
<tr>
<th>System*</th>
<th>MCFs by Average Annual Temperature (°C)</th>
<th>Source and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cool</td>
<td>Temperate</td>
</tr>
<tr>
<td></td>
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<td>11</td>
</tr>
<tr>
<td>Uncovered Aerobic Lagoon</td>
<td>60%</td>
<td>68%</td>
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<tr>
<td>Pit Storage below animal confinement</td>
<td>&lt; 1 month</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>&gt; 1 month</td>
<td>17%</td>
</tr>
<tr>
<td>System</td>
<td>MCFs by average annual temperature (°C)</td>
<td>Source and comments</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
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<tr>
<td></td>
<td>Cool 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25</td>
<td>Warm 26 27 &gt; 28</td>
</tr>
<tr>
<td>Anerobic digester</td>
<td>0-100%</td>
<td>0-100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Should be subdivided in different categories, considering amount of recovery of the biogas, flaring of the biogas and storage after digestion. Calculation with formula 1.</td>
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<tr>
<td>Burned for fuel</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Cattle and swine deep bedding</td>
<td>&lt; 1 month 3%</td>
<td>3%</td>
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<tr>
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<td>&gt; 1 month 17% 20% 22% 25% 27% 29% 32% 35% 39% 42% 44% 49% 50% 55% 60% 65% 75% 78% 80%</td>
<td>71% 78% 80%</td>
</tr>
<tr>
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<td>0.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Judgement of IPCC Expert Group and Amann et al. (1998). MCFs are less than half of solid storage. Not temperature dependent.</td>
</tr>
<tr>
<td>Composting - Static pile</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Judgement of IPCC Expert Group and Amann et al. (1998). MCFs are less than half of solid storage. Not temperature dependent.</td>
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<tr>
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</tr>
<tr>
<td>Composting - Pressure window</td>
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<td>1.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Judgement of IPCC Expert Group and Amann et al. (1998). MCFs are slightly less than solid storage. Less temperature dependent.</td>
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</table>
Appendix 4

Determination of Total Nitrogen in animal waste

Definitions

- Ammoniacal nitrogen (total ammonia): Both NH₃ and NH₄ 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 NH₃ 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 NH₃ 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 450°C 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 K₂SO₄. 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 400°C 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, 1965). 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 project proponents 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 g of 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/m³) is given as follows:

$$[N] = \frac{(c - b) \times 0.1 \times 14}{a} \times 10^3$$
Assembly of the Kjeldahl apparatus.

References


Appendix 5
Guidance on sample extraction and statistical procedures

For the purposes of the essays described in Appendix 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 4°C;

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:

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

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

<table>
<thead>
<tr>
<th>v</th>
<th>75%</th>
<th>80%</th>
<th>85%</th>
<th>90%</th>
<th>95%</th>
<th>97.5%</th>
<th>99%</th>
<th>99.5%</th>
<th>99.75%</th>
<th>99.9%</th>
<th>99.95%</th>
<th>99.99%</th>
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<tbody>
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<td>1</td>
<td>1.000</td>
<td>1.376</td>
<td>1.963</td>
<td>3.078</td>
<td>6.314</td>
<td>12.71</td>
<td>31.82</td>
<td>63.66</td>
<td>127.3</td>
<td>318.3</td>
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Table 3: Values for t-distributions with \( \nu \) degrees of freedom for a range of one-sided confidence intervals

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Appendix 6
Typical boundary layouts of what is included in the project boundary

Composting/anaerobic digestion – (Animal waste management – Individual Farm)
Composting and or anaerobic digestion – (Animal waste management – Central treatment plant)
### History of the document

<table>
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<th>Version</th>
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| 07.0.0  | 13 September 2012 | EB 69, Annex 18  
The revision:  
• Expands the applicability of the methodology to include Greenfield facilities;  
• Simplifies the procedures to estimate baseline emissions associated with heat generation. |
| 06.0.0  | 20 July 2012 | EB 68, Annex 13  
The revision:  
• Adds a reference to methodological tools;  
• Improves the clarity of the language and provides an additional option to estimate project N2O emissions;  
• Introduces provisions for the use of this methodology in a project activity under a PoA. |
| 05      | EB 42, Annex 8  
26 September 2008 |  
• Addition of sampling procedures to estimate the animal weight;  
• Equation 1 in Annex 2 was amended to keep unit consistency with equation 1a. |
| 04.1    | EB 39, Paragraph 22  
16 May 2008 | “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” replaces the withdrawn “Tool to calculate project emissions from electricity consumption”. |
| 04      | EB 39, Annex 5  
16 May 2008 |  
• Inclusion of new formula to determine the annual average number of animals \( N_{LT} \);  
• Reformatted the graphic in the monitoring section showing the points where the gas has to be measured. |
| 03      | EB 35, Annex 9  
19 October 2007 | Incorporation to the methodology of the following tools:  
• Tool to calculate project or leakage CO2 emissions from fossil fuel combustion;  
• Tool to calculate project emissions from electricity consumption.  
Addition of the formula to determine the annual average number of animals \( N_{LT} \). |
| 02      | EB 28, Annex 12  
15 December 2006 |  
• Inclusion of the “Tool to determine project emissions from flaring gases containing methane1”;  
• Replace of emissions Project emissions from flaring of the residual gas stream. |
| 01      | EB 26, Annex 11  
29 September 2006 | Initial adoption. |