Approved consolidated baseline methodology ACM0010

"Consolidated baseline methodology for GHG emission reductions from manure management systems"

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".

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 CO_2 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";
- "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".

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 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 methodology is also applicable to Greenfield 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.

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

II. BASELINE METHODOLOGY PROCEDURE

Identification of the baseline scenario and demonstration of additionality

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 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), including the flare or energy and/or heat generation equipment and the power/heat source.

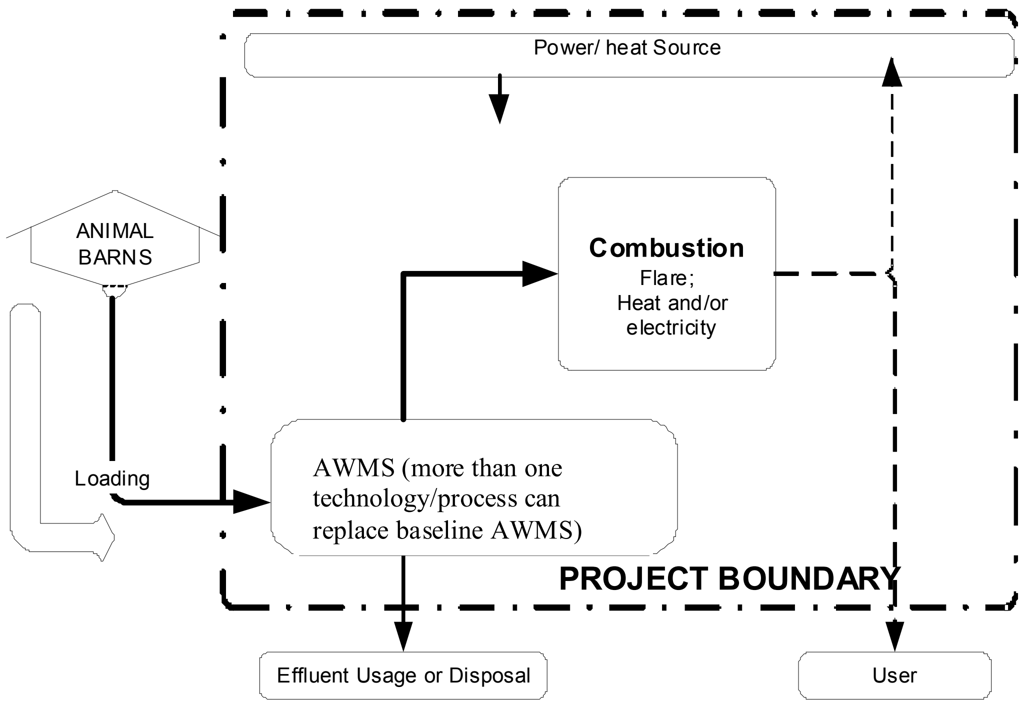


Figure 1: The project boundary

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

Source		Gas	Included?	Justification/Explanation
Baseline	Emissions from the waste treatment processes	CH_4	Yes	The major source of emissions in the baseline
		N_2O	Yes	Direct and indirect N_2O emissions are accounted
		CO_2	No	CO_2 emissions from the decomposition of organic waste are not accounted
	Emissions from electricity consumption/generation	CO_2	Yes	Electricity may be consumed from the grid or generated onsite in the baseline scenario
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
	Emissions from thermal energy generation	CO_2	Yes	If thermal energy generation is included in the project activity
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
Project Activity	Emissions from thermal energy use	CO_2	Yes	May be an important emission source
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small
	Emissions from on-site electricity use	CO_2	Yes	May be an important emission source. If electricity is generated from collected biogas, these emissions are not accounted for
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small
	Emissions from the waste treatment processes	N_2O	Yes	Direct and indirect N_2O emissions are accounted
		CO_2	No	CO_2 emissions from the decomposition of organic waste are not accounted
		CH_4	Yes	The emission from anaerobic digesters and aerobic treatment

The project proponents shall provide a clear diagrammatic representation in the CDM-PDD of the project scenario showing all the manure waste treatment~~s~~ 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 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:

$$BE_y = BE_{CH4,y} + BE_{N2O,y} + BE_{elec/heat,y} \qquad \textbf{(1)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2/yr)
$BE_{CH4,y}$	=	Baseline CH_4 emissions in year *y* (tCO_2/yr)
$BE_{N2O,y}$	=	Baseline N_2O emissions in year *y* (tCO_2/yr)
$BE_{elec/heat,y}$	=	Baseline CO_2 emissions from electricity and/or heat used in the baseline (tCO_2/yr)

(i) Baseline CH_4 emissions ($BE_{CH4,y}$)

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

$$BE_{CH4,y} = GWP_{CH4} \times D_{CH4} \times \sum_{j,LT} \left(MCF_j \times B_{0,LT} \times N_{LT} \times VS_{LT,y} \times MS\%_{Bl,j} \right) \qquad \textbf{(2)}$$

Where:

$BE_{CH4,y}$	=	Baseline CH_4 emissions (tCO_2/yr)
GWP_{CH4}	=	Global Warming Potential (GWP) of CH_4 (tCO_2e/tCH_4)
D_{CH4}	=	Density of CH_4 (t/m^3)
MCF_j	=	Annual methane conversion factor (MCF) for the baseline $AWMS_j$
$B_{0,LT}$	=	Maximum methane producing potential of the volatile solid generated by animal type LT (m^3CH_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)
$MS\%_{Bl,j}$	=	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) **$VS_{LT,y}$** 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 $VS_{LT,y}$ based on dietary intake of livestock:

$$VS_{LT,y} = \left[GE_{LT} \times \left(1 - \frac{DE_{LT}}{100} \right) + \left(UE \times GE_{LT} \right) \right] \times \left[\left(\frac{1 - ASH}{ED_{LT}} \right) \right] \times nd_y \quad \textbf{(3)}$$

Where:

$VS_{LT,y}$	=	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 $VS_{default}$ to adjust for a site-specific average animal weight as shown in equation below:

$$VS_{LT,y} = \left(\frac{W_{site}}{W_{default}} \right) \times VS_{default} \times nd_y \quad \textbf{(4)}$$

Where:

$VS_{LT,y}$	=	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)
$W_{default\ t}$	=	Default average animal weight of a defined population (kg)
$VS_{default}$	=	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 $VS_{LT,y}$ (IPCC 2006 guidelines, volume 4, chapter 10), multiply the value by nd_y (number of days in year y).

Developed countries $VS_{LT,y}$ 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:

$$N_{LT} = N_{da,LT} \times \left(\frac{N_{p,LT}}{365} \right) \quad \textbf{(5.a)}$$

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:

$$N_{LT} = \frac{\sum_{1}^{365} N_{AA,LT}}{365} \quad \textbf{(5.b)}$$

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 N_2O emissions ($BE_{N2O,y}$)

$$BE_{N2O,y} = GWP_{N2O} \times CF_{N2O-N,N} \times \frac{1}{1000} \times (E_{N2O,D,y} + E_{N2O,ID,y}) \quad \textbf{(6)}$$

Where:

$BE_{N2O,y}$	=	Annual baseline N_2O emissions in (tCO_2e/yr)
GWP_{N2O}	=	Global Warming Potential (GWP) for N_2O (tCO_2e/tN_2O)
$CF_{N2O-N,N}$	=	Conversion factor N_2O-N to N_2O (44/28)
$E_{N2O,D,y}$	=	Direct N_2O emission in year *y* (kg N_2O-N/year)
$E_{N2O,ID,y}$	=	Indirect N_2O emission in year *y* (kg N_2O-N/year)

$$E_{N2O,D,y} = \sum_{j,LT} EF_{N2O,D,j} \times NEX_{LT,y} \times N_{LT} \times MS\%_{Bl,j} \qquad \textbf{(7)}$$

Where:

$E_{N2O,D,y}$	=	Direct N_2O emission in year *y* (kg N_2O-N/yr)
$EF_{N2O,D,j}$	=	Direct N_2O emission factor for the treatment system *j* of the manure management system (kg N_2O-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
$MS\%_{Bl,j}$	=	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)

$$E_{N2O,ID,y} = \sum_{j,LT} EF_{N2O,ID} \times F_{gasMS,j,LT} \times NEX_{LT,y} \times N_{LT} \times MS\%_{Bl,j} \qquad \textbf{(8)}$$

Where:

$E_{N2O,ID,y}$	=	Indirect N_2O emission in year *y* (kg N_2O-N/year)
$EF_{N2O,ID}$	=	Indirect N_2O emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces (kg N_2O-N/kg NH3-N and NO_X-N)
$NEX_{LT,y}$	=	Annual average nitrogen excretion per head of a defined livestock population (kg N/animal/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 NH_3 and 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

$$BE_{elec/heat,y} = BE_{EC,y} + BE_{HG,y} \qquad \textbf{(9)}$$

Where:

$BE_{elec/heat,y}$	=	Baseline CO_2 emissions from electricity and/or heat used in the baseline (tCO_2/yr)
$BE_{EC,y}$	=	Baseline emissions associated with electricity generation in year *y* (tCO_2/yr)
$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (tCO_2/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:

$$BE_{HG,y} = \sum_{k=1}^{n} \frac{HG_{PJ,k,y} \times EF_{CO2,BL,HG,k}}{\eta_{HG,BL,k}} \qquad \textbf{(10)}$$

Where:

$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (tCO_2/yr)
$HG_{PJ,k,y}$	=	Net quantity of heat generated with biogas by equipment type k in the project in year *y* (TJ/yr)
$EF_{CO2,BL,HG,k}$	=	CO_2 emission factor of the fossil fuel type used for heat generation by equipment type *k* in the baseline (t CO_2/TJ)
$\eta_{HG,BL,k}$	=	Efficiency of the heat generation equipment type *k* used in the baseline
k	=	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 ($\eta_{HG,BL,k}$) project participants shall apply the "Tool to determine the baseline efficiency of thermal or electric energy generation systems".

Project emissions

The project activity might include one or more AWMS to treat the manure. For example, the manure might be first treated in an anaerobic digester and then treated waste might be further processed using an aerobic pond. Each AWMS is referred to as a treatment stage.

Project emissions are estimated as follows:

$$PE_y = PE_{AD,y} + PE_{Aer,y} + PE_{N2O,y} + PE_{EC/FC,y} \tag{11}$$

Where:

PE_y	=	Project emissions in year *y*
$PE_{AD,y}$	=	Project emissions associated with the anaerobic digester in year *y* (tCO_2e/yr)
$PE_{Aer,y}$	=	Project CH_4 emissions from aerobic AWMS treatment (tCO_2e/yr)
$PE_{N2O,y}$	=	Project N_2O emissions in year *y* (t CO_2/yr)
$PE_{EC/FC,y}$	=	Project emissions from electricity consumption and fossil fuel combustion (tCO_2e/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.

$$PE_{Aer,y} = GWP_{CH4} \times D_{CH4} \times 0.001 \times F_{Aer} \times \left[\prod_{n=1}^{N}\left(1 - R_{VS,n}\right)\right] \times \sum_{j,LT}(B_{0,LT} \times N_{LT} \times VS_{LT,y} \times MS\%_j) + PE_{Sl,y} \tag{12}$$

Where:

GWP_{CH4}	=	Global Warming Potential (GWP) of CH_4 (tCO_2e/tCH_4)
$R_{VS,n}$	=	Fraction of volatile solid degraded in AWMS treatment method *n* of the *N* treatment steps prior to waste being treated (fraction)
D_{CH4}	=	Density of CH_4 (t/m^3).
F_{Aer}	=	Fraction of volatile solid directed to aerobic system (fraction)
LT	=	Type of livestock
$B_{0,LT}$	=	Maximum methane producing potential of the volatile solid generated by animal type LT (m^3CH_4/kg dm)
$VS_{LT,y}$	=	Annual volatile solid excretion livestock type LT entering all AWMS on a dry matter weight basis in (kg -dm/animal/yr)
N_{LT}	=	Annual average number of animals of type LT for the year *y* (number) as estimated in equation (5.a) or (5.b).
$PE_{Sl,y}$	=	Project CH_4 emissions from sludge disposed of in storage pit prior to disposal during the year *y* (tCO_2e/yr)
$MS\%_j$	=	Fraction of manure handled in system *j* 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:

$$PE_{Sl,y} = GWP_{CH4} \times D_{CH4} \times MCF_{sl} \times F_{Aer} \times \left[\prod_{n=1}^{N}\left(1 - R_{VS,n}\right)\right] \times \sum_{j,LT}(B_{0,LT} \times N_{LT} \times VS_{LT,y} \times MS\%_j) \quad \textbf{(13)}$$

Where:

GWP_{CH4}	=	Global Warming Potential (GWP) of CH_4 (tCO_2e/tCH_4)
$R_{VS,n}$	=	Fraction of volatile solid degraded in AWMS treatment method *n* of the *N* treatment steps prior to waste (sludge) 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
$B_{0,LT}$	=	Maximum methane producing potential of the volatile solid generated by animal type LT (m^3CH_4/kg dm)
$VS_{LT,y}$	=	Annual volatile solid excretion livestock type LT entering all AWMS on a dry matter weight basis in (kg -dm/animal/yr)
N_{LT}	=	Annual average number of animals of type LT for the year *y* (number) as estimated as per equation (5.a) or (5.b)
$MS\%_j$	=	Fraction of manure handled in system *j* in the project activity (fraction)
MCF_{sl}	=	Methane conversion factor (MCF) for the sludge stored in sludge pits (fraction)

(iii) Project N_2O emissions in year y ($PE_{N2O,y}$)

$$PE_{N2O,y} = GWP_{N2O} \times CF_{N2O-N,N} \times \frac{1}{1000} \times (E_{N2O,D,y} + E_{N2O,ID,y}) \quad \textbf{(14)}$$

Where:

$PE_{N2O,y}$	=	Project N_2O emissions in year *y* (tCO_2/yr)
GWP_{N2O}	=	Global Warming Potential (GWP) for N_2O (tCO_2e/tN_2O)
$CF_{N2O-N,N}$	=	Conversion factor N_2O-N to N_2O (44/28)
$E_{N2O,D,y}$	=	Direct N_2O emission in year *y* (kg N_2O-N/year)
$E_{N2O,ID,y}$	=	Indirect N_2O emission in year *y* (kg N_2O-N/year)

Option 1:

$$E_{N2O,D,y} = \sum_{j,LT} EF_{N2O,D,j} \times NEX_{LT,y} \times N_{LT} \times MS\%_j \quad \textbf{(15)}$$

Where:

$E_{N2O,D,y}$	=	Direct N_2O emission in year *y* (kg N_2O-N/yr)
$EF_{N2O,D,j}$	=	Direct N_2O emission factor for the treatment system *j* of the manure management system (kg N_2O-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)

$$E_{N2O,ID,y} = \sum_{j,LT} EF_{N2O,ID} \times F_{gasMS,j,LT} \times NEX_{LT,y} \times N_{LT} \times MS\%_j \quad \textbf{(16)}$$

Where:

$E_{N2O,ID,y}$	=	Indirect N_2O emission in year *y* (kg N_2O-N/year)
$EF_{N2O,ID}$	=	Indirect N_2O emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces(kg N_2O-N/kg NH_3-N and NO_X-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)
$F_{gasMS,j,LT}$	=	Default values for nitrogen loss due to volatilisation of NH_3 and 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:

$$E_{N_2O,D,y} = \sum_{j} EF_{N_2O,D,j} \times \sum_{m=1}^{12} \left(Q_{EM,m} \times [N]_{EM,m} \right) \quad \textbf{(17)}$$

$$E_{N_2O,ID,y} = EF_{N_2O,ID} \times \sum_{j,LT} F_{gasMS,j,LT} \times \sum_{m=1}^{12} \left(Q_{EM,m} \times [N]_{EM,m} \right) \quad \textbf{(18)}$$

Where:

$E_{N_2O,D,y}$	=	Direct N_2O emission in year *y* (kg N_2O-N/year)
$E_{N_2O,ID,y}$	=	Indirect N_2O emission in year *y* (kg N_2O-N/year)
$EF_{N2O,D,j}$	=	Direct N_2O emission factor for the treatment system *j* of the manure management system (kg N_2O-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)
$EF_{N_2O,ID}$	=	Indirect N_2O emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces(kg N_2O-N/kg NH_3-N and NO_X-N)
$F_{gasMS,j,LT}$	=	Default values for nitrogen loss due to volatilisation of NH_3 and NO_X from manure management (fraction)

Option 2 is the preferred option for estimating N_2O 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).

(v) Project emissions from use of heat and/or electricity-($PE_{elec/heat}$)

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 $PE_{AD,y}$.

$$PE_{EC/FC,y} = PE_{EC,y} + \sum_j PE_{FC,j,y} \quad \textbf{(19)}$$

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: $EC_{PJ,y} = \sum_i CP_{i,y} * 8760$, 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)

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.

$$LE_y = (LE_{PJ,N2O,y} - LE_{BL,N2O,y}) + (LE_{PJ,CH4,y} - LE_{BL,CH4,y}) + LE_{AD,y} \quad \textbf{(20)}$$

Where:

$LE_{PJ,N2O,y}$	=	Leakage N_2O emissions released during project activity from land application of the treated manure in year *y* (tCO_2e/yr)
$LE_{BL,N2O,y}$	=	Leakage N_2O emissions released during baseline scenario from land application of the treated manure in year *y* (tCO_2e/yr)
$LE_{PJ,CH4,y}$	=	Leakage CH_4 emissions released during project activity from land application of the treated manure in year *y* (tCO_2e/yr)
$LE_{BL,CH4,y}$	=	Leakage CH_4 emissions released during baseline scenario from land application of the treated manure in year *y* (tCO_2e/yr)
$LE_{AD,y}$	=	Leakage emissions associated with the anaerobic digester in year *y* (tCO_2e)

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

$$LE_{BL,N2O,y} = GWP_{N2O} \times CF_{N2O-N,N} \times \frac{1}{1000} \times (LE_{N2O,land,y} + LE_{N2O,runoff,y} + LE_{N2O,vol,y}) \quad \textbf{(21)}$$

$$LE_{N2O,land,y} = EF_1 \times \prod_{n=1}^{N} (1 - R_{N,n}) \times \sum_{LT} NEX_{LT,y} \times N_{LT} \quad \textbf{(22)}$$

$$LE_{N2O,runoff,y} = EF_5 \times F_{leach} \times \prod_{n=1}^{N}(1-R_{N,n}) \times \sum_{LT} NEX_{LT,y} \times N_{LT} \quad \textbf{(23)}$$

$$LE_{N2O,vol,y} = EF_4 \times \prod_{n=1}^{N}(1-R_{N,n}) \times F_{gasm} \times \sum_{LT} NEX_{LT,y} \times N_{LT} \quad \textbf{(24)}$$

Where:

GWP_{N2O}	=	Global Warming Potential (GWP) for N_2O (tCO_2e/tN_2O)
$CF_{N2O-N,N}$	=	Conversion factor N_2O-N to N_2O (44/28)
$LE_{N2O,land,y}$	=	Leakage N_2O emissions from application of manure waste in year *y* (kg N_2O-N/year)
$LE_{N2O,runoff,y}$	=	Leakage N_2O emissions due to leaching and run-off in year *y* (kg N_2O-N/year)
$LE_{N2O,vol,y}$	=	Leakage N_2O emissions due to volatilisation in year *y* (kg N_2O-N/year)
F_{gasm}	=	Fraction of N lost due to volatilization (fraction)
N_{LT}	=	Annual average number of animals of type LT estimated as per equation (5.a) or (5.b) (number)
$NEX_{LT,y}$	=	Annual average nitrogen excretion per head of a defined livestock population (kg N/animal/year) estimated as described in appendix 2
EF_1	=	Emission factor for N_2O emissions from N inputs (kg N_2O-N/kg N input)
EF_5	=	Emission factor for N_2O emissions from N leaching and runoff in (kg N_2O-N/kg N leached and runoff)
EF_4	=	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N- N_2O/(kg NH_3-N + NO_X-N volatilized)]
F_{leach}	=	Fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff (fraction)
$R_{N,n}$	=	Nitrogen reduction factor (fraction)

(ii) Estimation of leakage N_2O emissions released during project activity from land application of the treated manure in year y

$$LE_{PJ,N2O} = GWP_{N2O} \times CF_{N2O-N,N} \times \frac{1}{1000} \times (LE_{N2O,land,y} + LE_{N2O,runoff,y} + LE_{N2O,vol,y}) \quad \textbf{(25)}$$

$$LE_{N2O,land,y} = EF_1 \times \prod_{n=1}^{N}(1-R_{N,n}) \times \sum_{LT} NEX_{LT,y} \times N_{LT} \quad \textbf{(26)}$$

$$LE_{N2O,runoff,y} = EF_5 \times F_{leach} \times \prod_{n=1}^{N}(1-R_{N,n}) \times \sum_{LT} NEX_{LT,y} \times N_{LT} \quad \textbf{(27)}$$

$$LE_{N2O,vol} = EF_4 \times \prod_{n=1}^{N}(1-R_{N,n}) \times F_{gasm} \times \sum_{LT} NEX_{LT,y} \times N_{LT} \quad \textbf{(28)}$$

Where:

GWP_{N2O}	=	Global Warming Potential (GWP) for N_2O (tCO_2e/tN_2O)
$CF_{N2O-N,N}$	=	Conversion factor N_2O-N to N_2O (44/28)

$LE_{N2O,land,y}$	=	Leakage N_2O emissions from application of manure waste in year *y* (kg N_2O-N/year)
$LE_{N2O,runoff,y}$	=	Leakage N_2O emissions due to leaching and run-off in year *y* (kg N_2O-N/year)
$LE_{N2O,vol}$	=	Leakage N_2O emissions due to volatilisation in year *y* (kg N_2O-N/year)
F_{gasm}	=	Fraction of *N* lost due to volatilization (fraction)
N_{LT}	=	Annual average number of animals of type LT estimated as per equation (5.a) or (5.b) (number)
$NEX_{LT,y}$	=	Annual average nitrogen excretion per head of a defined livestock population in year *y* (kg N/animal/year) estimated as described in appendix 2
EF_1	=	Emission factor for N_2O emissions from N inputs (kg N_2O-N/kg N input)
EF_5	=	Emission factor for N_2O emissions from *N* leaching and runoff in (kg N_2O-N/kg N leached and runoff)
EF_4	=	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N- N_2O/(kg NH3-N + NO_X-N volatilized)]
F_{leach}	=	Fraction of all *N* added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff (fraction)
$R_{N,n}$	=	Nitrogen reduction factor (fraction)

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

(iii) Estimation of leakage CH_4 emissions from land application of the treated manure

The calculation of methane emissions from land application of manure in the baseline and project cases are estimated from equations 29 and 30 below:

$$LE_{BL,CH4,y} = GWP_{CH4}\times D_{CH4}\times MCF_d\times\left[\prod_{n=1}^{N}\left(1-R_{VS,n}\right)\right]\times\sum_{j,LT}(B_{0,LT}\times N_{LT}\times VS_{LT,y}\times MS\%_j) \quad \textbf{(29)}$$

$$LE_{PJ,CH4,y} = GWP_{CH4}\times D_{CH4}\times MCF_d\times\left[\prod_{n=1}^{N}\left(1-R_{VS,n}\right)\right]\times\sum_{j,LT}(B_{0,LT}\times N_{LT}\times VS_{LT,y}\times MS\%_j) \quad \textbf{(30)}$$

Where:

$LE_{BL,CH4,y}$	=	Leakage CH_4 emissions released during baseline scenario from land application of the treated manure in year *y* (tCO_2e/yr)
$LE_{PJ,CH4,y}$	=	Leakage CH_4 emissions released during project activity from land application of the treated manure in year *y* (tCO_2e/yr)
$R_{VS,n}$	=	Fraction of volatile solid degraded in AWMS treatment method *n* of the *N* treatment steps prior to sludge being treated
GWP_{CH4}	=	Global Warming Potential (GWP) of CH_4 (tCO_2e/tCH_4)

D_{CH4}	=	Density of 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_{LT}	=	Annual average number of animals of type *LT* estimated as per equation (5.a) or (5.b), expressed (number)
$VS_{LT,y}$	=	Annual volatile solid excretions for livestock *LT* entering all AWMS on a dry matter weight basis (kg -dm/animal/yr)
$MS\%_j$	=	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) 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".

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:

$$ER_y = BE_y - PE_y - LE_y \quad (31)$$

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 ($BE_{CH4,y}$ - $PE_{AD,y}$ in the tool "Project and leakage emissions from anaerobic digesters") and if found lower, then ($BE_{CH4,y}$ - $PE_{AD,y}$) (which is a component of BE_y -PE_y) in equation (32) is replaced by $Q_{CH4,y}$.

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.

Data / Parameter:	$R_{VS,n}$
Data unit:	Fraction
Description:	Fraction of volatile solid degraded in AWMS treatment method *n* of the *N* treatment steps prior to waste being treated
Source of data:	Refer to appendix 1 (values for VS)
Measurement procedures (if any):	
Any comment:	The **most conservative** value for the given technology must be used

Data / Parameter:	$EF_{N2O, D,j}$
Data unit:	kg N_2O-N/kg N
Description:	Direct N_2O emission factor for the treatment system *j* of the manure management system
Source of data:	Estimated with site-specific, regional or national data if such data is available, otherwise use default EF_3 from table 10.21, chapter 10, volume 4, in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Measurement procedures (if any):	
Any comment:	

Data / Parameter:	$EF_{N2O,ID}$
Data unit:	kg N_2O-N/kg NH3-N and NO_X-N
Description:	Indirect N_2O emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces
Source of data:	Estimated with site-specific, regional or national data if such data is available. Otherwise, default values for EF_4 from table 11.3, chapter 11, volume 4 of IPCC 2006 Guidelines for National Greenhouse Gas Inventories can be used
Measurement procedures (if any):	
Any comment:	---

Data / Parameter:	$F_{gasMS,j,LT}$
Data unit:	Fraction
Description:	Default values for nitrogen loss due to volatilisation of NH_3 and NO_X from manure management
Source of data:	IPCC 2006 Guidelines. Volume 4, Chapter 10 - Table 10.22
Measurement procedures (if any):	
Any comment:	

Data / Parameter:	F_{gasm}
Data unit:	Fraction
Description:	Fraction of N lost due to volatilization
Source of data:	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
Measurement procedures (if any):	
Any comment:	

Data / Parameter:	EF_1, EF_4, EF_5
Data unit:	kg N_2O-N/kg N for EF_1, EF_5 and [kg N_2O-N/ (kg NH_3-N and NO_X-N) for EF_4
Description:	Emission factor for N_2O emissions from N inputs; from N leaching and runoff; from atmospheric deposition of N on soils and water surfaces
Source of data:	Estimated with site-specific, regional or national data if such data is available.
Measurement procedures (if any):	
Any comment:	IPCC 2006 Guidelines default values may be used, if country specific or region specific data are not available. EF_1 from table 11.1, chapter 11, volume 4. EF_4 and EF_5 from table 11.3, chapter 11, volume 4

Data / Parameter:	F_{leach}
Data unit:	Fraction
Description:	Fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff
Source of data:	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
Measurement procedures (if any):	
Any comment:	

Data / Parameter:	$MS\%_{Bl,j}$
Data unit:	Fraction
Description:	Fraction of manure handled in system *j* in the baseline
Source of data:	Project proponents
Measurement procedures (if any):	
Any comment:	---

Data / Parameter:	GWP_{CH4}
Data unit:	tCO_2e/tCH_4
Description:	Global warming potential of CH_4
Source of data:	IPCC
Measurement procedures (if any):	21 for the first commitment period. Shall be updated according to any future COP/MOP decisions
Any comment:	---

Data / Parameter:	GWP_{N2O}
Data unit:	tCO_2e/tN_2O
Description:	Global warming potential for N_2O
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:	---

Data / Parameter:	D_{CH4}
Data unit:	t/m^3
Description:	Density of CH_4
Source of data:	Technical literature
Measurement procedures (if any):	
Any comment:	0.00067 t/m^3 at room temperature 20°C and 1 atm pressure

Data / Parameter:	MCF_d
Data unit:	---
Description:	Methane conversion factor for leakage calculation assumed to be equal 1
Source of data:	
Measurement procedures (if any):	
Any comment:	---

Data / Parameter:	MCF_j
Data unit:	---
Description:	Methane conversion factor for the baseline $AWMS_j$
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

Data / Parameter:	$W_{default}$
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):	
Any comment:	---

Data / Parameter:	$VS_{default}$
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:	$N_{retention}$
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:	$NEX_{IPCCdefault}$
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:	$EF_{CO2,BL,HG,k}$
Data unit:	t CO_2/TJ
Description:	CO_2 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.

Diagrammatic representation of animal waste management system existing on the project site prior to project implementation should be presented (an example is shown in Figure 2).

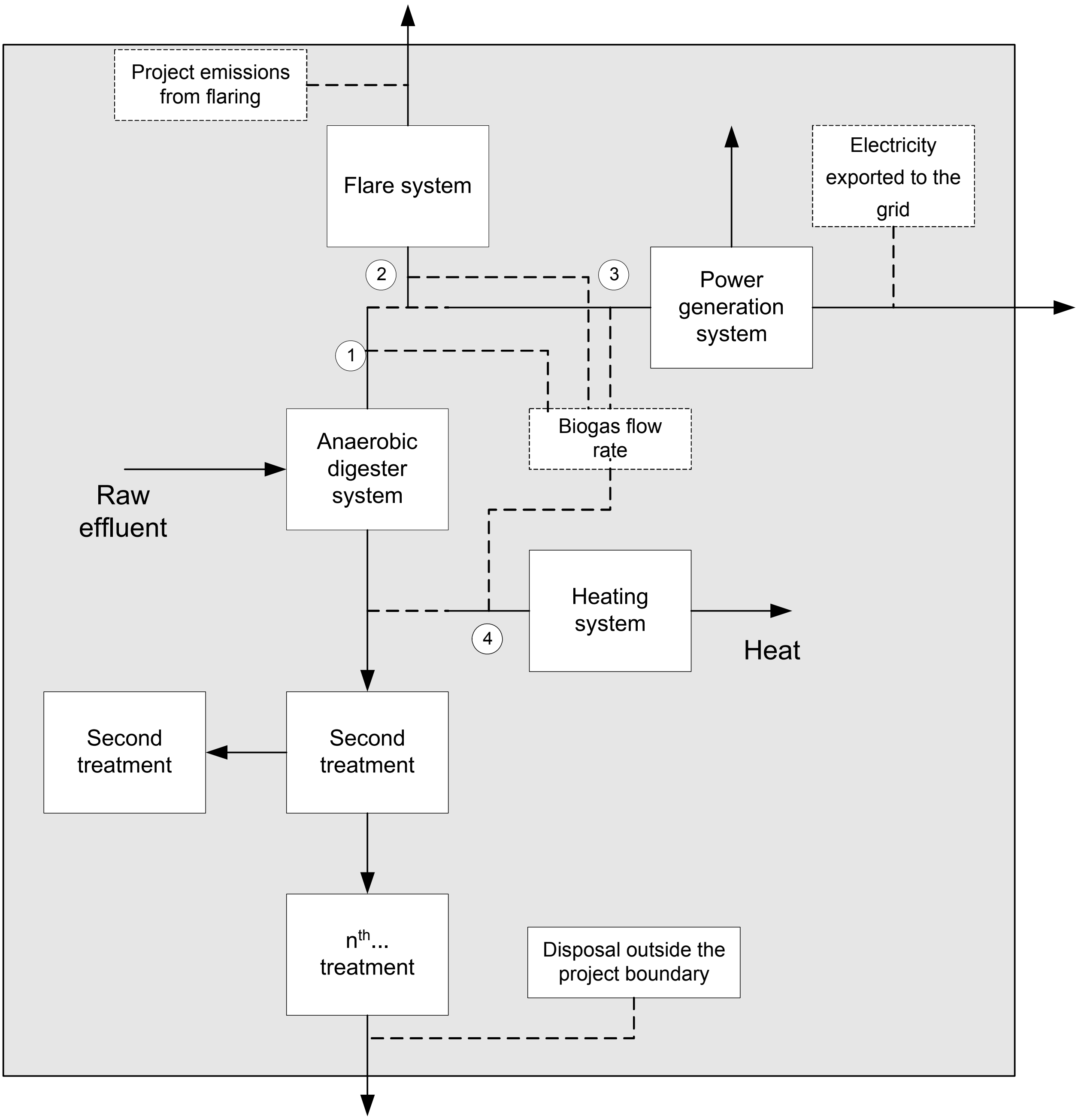


Figure 2: Flow diagram and biogas flow measurement points of project activity

Data and parameters monitored

Data / Parameter:	MCF_{sl}
Data unit:	Fraction
Description:	Methane conversion factor (MCF) for the sludge stored in sludge pits
Source of data:	IPCC 2006 table 10.17, chapter 10, volume 4 (see appendix 3)
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	---
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

Data / Parameter:	$B_{0,LT}$
Data unit:	m^3CH_4/kg dm
Description:	Maximum methane producing potential of the volatile solid generated by animal type *LT*
Source of data:	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 B0,LT as per: • ISO 11734:1995; • ASTM E2170-01 (2008);and • ASTM D 5210-92

Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	The value is taken from published sources. The parameter value should be updated on latest available public data source

Data / Parameter:	Type
Data unit:	---
Description:	Type of barn and AWMS
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	
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 $NEX_{LT,y}$ 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

Data / Parameter:	T
Data unit:	^{o}C
Description:	Annual Average ambient temperature at project site
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Monthly
QA/QC procedures:	---
Any comment:	Used to select the annual MCF from IPCC 2006 guidelines

Data / Parameter:	$EG_{d,y}$
Data unit:	MWh
Description:	Electricity generated using biogas in year *y*
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus five years
Monitoring frequency:	Annual
QA/QC procedures:	Electricity meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company. Uncertainty of the meters to be obtained from the manufacturers. This uncertainty to be included in a conservative manner while calculating CERs and procedure for doing so should be described in the CDM-PDD
Any comment:	---

Data / Parameter:	$N_{da,LT}$
Data unit:	Number
Description:	Number of days animal of type *LT* is alive in the farm in the year *y*
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Monthly
QA/QC procedures:	---
Any comment:	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}

Data / Parameter:	$N_{p,LT}$
Data unit:	Number
Description:	Number of animals of type *LT* produced annually for the year *y*
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Monthly
QA/QC procedures:	---
Any comment:	The PDD should describe the system on monitoring the number of livestock produced. 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}

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):	
Monitoring frequency:	Monthly
QA/QC procedures:	---
Any comment:	This parameter is used in equation 4 for estimating $VS_{LT,y}$ 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:	---

Data / Parameter:	V_f
Data unit:	m^3
Description:	Biogas flow
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Continuously by flow meter and reported cumulatively on weekly basis
QA/QC procedures:	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
Any comment:	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

Data / Parameter:	N_{DM}
Data unit:	kg N/KG effluent
Description:	N concentration in disposed manure
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Every batch disposed
QA/QC procedures:	---
Any comment:	---

Data / Parameter:	Q_{DM}
Data unit:	kg
Description:	Mass of manure disposed outside project boundary
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Every batch disposed
QA/QC procedures:	---
Any comment:	---

Data / Parameter:	$MS\%_j$
Data unit:	Fraction
Description:	Fraction of manure handled in system j in the project activity
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	---

Data / Parameter:	$NEX_{LT,y}$
Data unit:	kg N/animal/year
Description:	Annual average nitrogen excretion per head of a defined livestock population estimated as described in appendix 2
Source of data:	Refer to appendix 2
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	When using equation 2 in appendix 2, please refer to above guidance for estimating W_{site}

Data / Parameter:	GE_{LT}
Data unit:	MJ/animal/day
Description:	Daily average gross energy intake
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Daily
QA/QC procedures:	---
Any comment:	---

Data / Parameter:	DE_{LT}
Data unit:	%
Description:	Digestible energy of the feed in percent
Source of data:	---
Measurement procedures (if any):	
Monitoring frequency:	---
QA/QC procedures:	---
Any comment:	IPCC 2006: Typically 45-55% for low quality forages

Data / Parameter:	UE
Data unit:	Fraction of GE_{LT}
Description:	Urinary energy
Source of data:	Typically $0.04GE_{LT}$ 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
Measurement procedures (if any):	
Monitoring frequency:	---
QA/QC procedures:	---
Any comment:	---

Data / Parameter:	ASH
Data unit:	Fraction of the dry matter feed intake
Description:	Ash content of the manure
Source of data:	Use country-specific values where available
Measurement procedures (if any):	
Monitoring frequency:	---
QA/QC procedures:	---
Any comment:	---

Data / Parameter:	ED_{LT}
Data unit:	MJ/kg
Description:	Energy density of the feed fed to livestock type *LT*
Source of data:	Measured in laboratory based on local or international standards or IPCC default (18.45MJ/kg -dm)
Measurement procedures (if any):	The project proponent will record the composition of the feed to enable the DOE to verify the energy density of the feed
Monitoring frequency:	---
QA/QC procedures:	---
Any comment:	IPCC notes the energy density of feed, ED, is typically 18.45 MJ/kg -dm, which is relatively constant across a wide variety of grain-based feeds

Data / Parameter:	$N_{AA,LT}$
Data unit:	---
Description:	Daily stock of animals in the farm, discounting dead and discarded animals
Source of data:	Daily counting of alive animals in the farm, discounting dead animals and animals discarded from the productive process from the daily stock
Measurement procedures (if any):	
Monitoring frequency:	Daily
QA/QC procedures:	
Any comment:	The PDD should describe the system for monitoring stock of animals

Data / Parameter:	nd_y
Data unit:	Number
Description:	Number of days treatment plant was operational in year *y*
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Daily
QA/QC procedures:	---
Any comment:	---

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

Data / Parameter:	$[N]_{EM,m}$
Data unit:	kg N/m^3
Description:	Monthly total nitrogen concentration in the effluent mix entering the central treatment plant
Source of data:	Project proponents
Measurement procedures (if any):	
Monitoring frequency:	Weekly aggregated for monthly average
QA/QC procedures:	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
Any comment:	The effluent mix shall be collected after the effluent admittance point or after the equalization tanks (if existent)

Data / Parameter:	$HG_{PJ,k,y}$
Data unit:	TJ/yr
Description:	Net quantity of heat with biogas by equipment type *k* in the project t in year *y*
Source of data:	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)
Measurement procedures (if any):	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*
Monitoring frequency:	Monitored daily
QA/QC procedures:	-
Any comment:	

IV. REFERENCES AND ANY OTHER INFORMATION

Not applicable.

Appendix 1
Anaerobic Unit Process Performance

Table 8-10. Anaerobic Unit Process Performance

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

Source: Moser and Martin, 1999

Source: US-EPA 2001: Development Document for the Proposed Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations

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

Option 1:

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

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

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:

$$NEX_{LT,y} = \frac{W_{site}}{W_{default}} \times NEX_{IPCC\,default} \tag{2}$$

Where:

$NEX_{LT,y\,y}$	=	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)

Appendix 3
Table 10.17 of IPCC 2006

TABLE 10.17
MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS

System[a]		MCFs by Average Annual Temperature (°C)																			Source and Comments
		Cool					Temperate											Warm			
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28	
Pasture/Range/Paddock		1.0%					1.5%											2.0%			Judgement of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Daily Spread		0.1%					0.5%											1.0%			Hashimoto and Steed (1993).
Solid Storage		2.0%					4.0%											5.0%			Judgement of IPCC Expert Group in combination with Amon, et. al (2001), which shows emissions of approximately 2% in winter and 4% in summer. Warm climate is based on judgement of IPCC Expert Group and Amon, et. al (1998).
Dry Lot		1.0%					1.5%											2.0%			Judgement of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Liquid/Slurry	With natural crust cover	10%	11%	13%	14%	15%	17%	18%	20%	22%	24%	26%	29%	31%	34%	37%	41%	44%	48%	50%	Judgement of IPCC Expert Group in combination with Mangino et. al (2001) and Sommer (2000). The estimated reduction due to the crust cover (40%) is an annual average value based on a limited data set and can be highly variable dependent on temperature, rainfall, and composition. When slurry tanks are used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.
	Without natural crust cover	17%	19%	20%	22%	25%	27%	29%	32%	35%	39%	42%	46%	50%	55%	60%	65%	71%	78%	80%	Judgement of IPCC Expert Group in combination with Mangino et. al (2001). When slurry tanks are used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.

TABLE 10.17 (CONTINUED)
MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS

System[a]		MCFs by Average Annual Temperature (°C)																			Source and Comments
		Cool					Temperate											Warm			
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28	
Uncovered Anaerobic Lagoon		66%	68%	70%	71%	73%	74%	75%	76%	77%	77%	78%	78%	78%	79%	79%	79%	79%	80%	80%	Judgement of IPCC Expert Group in combination with Mangino et. al (2001). Uncovered lagoon MCFs vary based on several factors, including temperature, retention time, and loss of volatile solids from the system (through removal of lagoon effluent and/or solids).
Pit Storage below animal confinements	< 1 month	3%					3%											30%			Judgement of IPCC Expert Group in combination with Moller, et. al (2004) and Zeeman (1994). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions. When pits used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.
	> 1 month	17%	19%	20%	22%	25%	27%	29%	32%	35%	39%	42%	46%	50%	55%	60%	65%	71%	78%	80%	Judgement of IPCC Expert Group in combination with Mangino et. al (2001). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions. When pits used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.

Appendix 4
Determination of Total Nitrogen in animal waste

Definitions

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

Principles and guidelines for total nitrogen determination

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

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

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

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

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

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

The more commonly utilized open-tube digestion requires a temperature close to 400°C for adequate decomposition of nitrogenous compounds to ammonia. The evidence for this is clear (Bradstreet, 1965; Fleck & Munro, 1965 APUD Fleck, 1969), as is the evidence that the only satisfactory means of attaining this temperature is to add the appropriate amounts of 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 400ºC lead to loss of nitrogen (as well as loss of acid which leads to the solid cold digest).

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

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

For manual determination 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 gof potassium sulfate and 40 mL of concentrated sulfuric acid;

4 –Gently heat the digestion tube, keeping it slightly tilted. Frothing may occur. If needed frothing may be controlled through the use of anti-frothing agents;

5 –Once frothing ceases, boil reagents during 2 hours;

6 – After cooling add 200 mL of water and 25 mL of sodium thiosulphate solution (0.5 M). Perform this step under agitation;

7 – Add a few glass beads to the mixture;

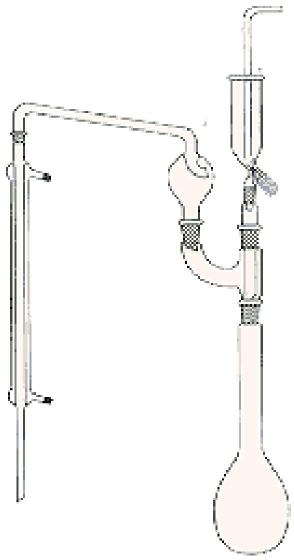
8 –Carefully introduce in the digestion tube a sodium hydroxide solution (11 M). Before mixing the reagents, connect the digestion tube to a distillation apparatus (see figure below). Keep the outlet of the condenser immersed into a known volume of 0.1 M HCl solution. Be certain that the contents of the digestion tube are well mixed;

9 –Boil until the 150 mL of the distilled liquid has been collected in the receptor tube;

10 – Add indicator Methyl Red to the receptor tube. Titrate with 0.1 M NaCl (*b* mL). Titrate a blank using the same volume of 0.1 M HCl (*c* mL).

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

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



Assembly of the Kjeldahl apparatus.

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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 4ºC;

4 - It should be checked that the suspended matter does not adhere to the walls, prior to the analysis procedure;

5 – If results must be expressed in a dry matter basis, dry matter content shall be determined after oven-drying at 103°C for 24 hours or until constant weight is obtained;

6 - Uncertainty range shall not exceed 20% under a 90% confidence interval, which is calculated as depicted in the formula below:

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

Where:

$\bar{x}$	Sample average;
t	t student value for n– – 1 (v) degrees of freedom (see table 3);
s	Sample standard deviation;
n	Number of samples.

Table 3: Values for t-distributions with ν degrees of freedom for a range of one-sided confidence intervals

ν	75%	80%	85%	90%	95%	97.5%	99%	99.5%	99.75%	99.9%	99.95%
1	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	127.3	318.3	636.6
2	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	14.09	22.33	31.60
3	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	7.453	10.21	12.92
4	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883

Table 3: Values for t-distributions with v degrees of freedom for a range of one-sided confidence intervals

20	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
50	0.679	0.849	1.047	1.299	1.676	2.009	2.403	2.678	2.937	3.261	3.496
60	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
80	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	2.887	3.195	3.416
100	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	2.871	3.174	3.390
120	0.677	0.845	1.041	1.289	1.658	1.980	2.358	2.617	2.860	3.160	3.373
∞	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

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History of the document

Version	Date	Nature of revision(s)
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 N_2O 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}); • Reformat of 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 CO_2 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.
Decision Class: Regulatory **Document Type**: Standard **Business Function**: Methodology		