Draft revision to the 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"~~, based on the CDM-PDD "Methane capture and combustion of swine manure treatment for Peralillo" whose baseline study, monitoring and verification plan and project design document were prepared by Agricola Super Limitada. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0022: "Methane capture and combustion of swine manure treatment for Peralillo" on <http://cdm.unfccc.int/methodologies/approved>~~;
- AM0016: "Greenhouse gas mitigation from improved Animal Waste Management Systems in confined animal feeding operations"~~, whose baseline study, monitoring and verification plan and project design document were prepared by AgCert Canada Co. on behalf of Granja Becker, L.B.Pork, Inc. and AgCert Canada Co. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0034-rev2: "Granja Becker GHG Mitigation Project" on <http://cdm.unfccc.int/methodologies/approved>~~.

~~For more information regarding the proposals and their consideration by the Executive Board please refer to:~~

- ~~Case NM0022: "Methane capture and combustion of swine manure treatment for Peralillo";~~
- ~~Case NM0034-rev2: "Granja Becker GHG Mitigation Project".~~

~~on <http://cdm.unfccc.int/goto/MPappmeth>.~~

~~The~~ This methodology also refers to the latest approved versions of the following tools:~~[1]~~

- ~~"Tool to determine project emissions from flaring gases containing Methane~~ "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";
- ~~"Tool for demonstration assessment and of additionality";~~
- "Tool to calculate the emission factor for an electricity system";
- "Assessment of the validity of the original/current baseline and to 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".

~~[1] Please refer to <http://cdm.unfccc.int/goto/MPappmeth>.~~

~~For more information on the proposals and their consideration by the Executive Board as well as on approved methodological tools please refer to: <http://cdm.unfccc.int/goto/MPappmeth>.~~

For more information regarding the proposed new methodologies and the tools as well as their consideration by the Executive Board of the clean development mechanism 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 ~~generally~~ 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.

This methodology is applicable to manure management projects under ~~with~~ 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;~~[2]~~
- The annual average temperature ~~in~~ 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)~~/process~~ in the project case results in ~~should ensure that~~ no leakage of manure waste into ground water ~~takes place~~, e.g. the lagoon should have a non-permeable layer at the lagoon bottom.

~~This baseline methodology shall be used in conjunction with the approved monitoring methodology ACM0010 (Consolidated baseline methodology for GHG emission reductions from manure management systems).~~

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.

~~The methodology determines the baseline scenario through the following steps:~~

~~Step 1: Define alternative scenarios to the proposed CDM project activity;~~

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

~~Step 2: Barriers analysis;~~

~~Step 3: Investment analysis;~~

~~Step 4: Baseline revision at renewal of crediting period.~~

~~***Step 1: Define alternative scenarios to the proposed CDM project activity***~~

~~(1) Identify realistic and credible alternative scenarios that are available either to the project participants or to other potential project developers[3] for managing the manure. These alternative scenarios should include: AA: It is not clear why do we have footnote 3 in this methodology as all alternatives are under the control of the PPs (since the farm is owned by the PP in all cases). None of the alternatives can be implemented in parallel by the PPs and therefore the combined tool is applicable…~~

- ~~The proposed project activity not being registered as a CDM project activity;~~
- ~~All other plausible and credible alternatives to the project activity scenario, including the common practices in the relevant sector.~~

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

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

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

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

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

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

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

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

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

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

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

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

~~[3] For example, a coal-fired power station or hydropower may not be an alternative for an independent power producer investing in wind energy or for a sugar factory owner investing in a co-generation, but may be an alternative for a public utility. As a result, the proposed project may be able to avoid emissions that would have occurred from the coal-fired power station that would have been built (or built earlier) by the utility in the absence of the CDM. Therefore, there may be cases where the baseline scenario includes an alternative that is not accessible to the project participant. However, there are also cases where all the alternatives are accessible to the project participant: for instance, this may be the case for projects flaring landfill gas, improving boilers, etc.~~

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

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

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

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

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

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

~~If applicable, continuation of the current situation (no project activity or other alternatives undertaken).~~

~~Eliminate alternatives that are not in compliance with all applicable legal and regulatory requirements. Apply Sub-step 1b of the latest version of the "Tool for demonstration assessment and of additionality".~~

~~For the purpose of identifying alternative scenarios that are common practice, provide an analysis of other manure management practices implemented previously or currently underway. Projects are considered similar if they are in the same country/region, are of a similar scale, and take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, access to financing, etc. Other CDM project activities are not to be included in this analysis. Provide documented evidence. On the basis of that analysis, identify and include all alternative scenarios that are common practice.~~

~~***Step 2: Barrier analysis***~~

~~Establish a complete list of barriers that would prevent alternative scenarios to occur in the absence of the CDM. Such barriers may include:~~

- ~~Investment barriers, *inter alia*:~~
    - ~~Debt funding is not available for this type of innovative activities;~~
    - ~~Neither access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented.~~
- ~~Technological barriers, *inter alia:*~~
    - ~~Skilled and/or properly trained labour to operate and maintain the technology is not available and no education/training institution in the host country provides the needed skill, leading to equipment disrepair and malfunctioning;~~
    - ~~Lack of infrastructure for implementation of the technology.~~
- ~~Barriers due to prevailing practice, *inter alia*:~~
    - ~~The alternative is the "first of its kind": No alternative of this type is currently operational in the host country or region.~~

~~Since the proposed project activity not being registered as a CDM project activity shall be one of the considered alternatives, any barrier that may prevent the project activity to occur shall be included in that list.~~

~~Provide transparent and documented evidence, and offer conservative interpretations of this documented evidence, as to how it demonstrates the existence and significance of the identified barriers.~~

Anecdotal evidence can be included, but alone is not sufficient proof of barriers. The type of evidence to be provided may include:

(a) Relevant legislation, regulatory information or industry norms;

(b) Relevant (sectoral) studies or surveys (e.g. market surveys, technology studies, etc) undertaken by universities, research institutions, industry associations, companies, bilateral/multilateral institutions, etc;

(c) Relevant statistical data from national or international statistics;

(d) Documentation of relevant market data (e.g. market prices, tariffs, rules);

(e) Written documentation from the company or institution developing or implementing the CDM project activity or the CDM project developer, such as minutes from Board meetings, correspondence, feasibility studies, financial or budgetary information, etc;

(f) Documents prepared by the project developer, contractors or project partners in the context of the proposed project activity or similar previous project implementations;

(g) Written documentation of independent expert judgments from industry, educational institutions (e.g. universities, technical schools, training centers), industry associations and others.

Assess for all barriers identified which scenario alternatives would be prohibited from being implemented by the barrier and eliminate those alternatives from further consideration.

If there is only one scenario alternative that is not prevented by any barrier, and

(i) If this alternative is not the proposed project activity not being registered as a CDM project activity, then this scenario alternative is the most plausible baseline scenario;

(ii) If this alternative is the proposed project activity not being registered as a CDM project activity, then the project activity is the most plausible baseline scenario;

If there are still several baseline scenario alternatives remaining, either go to Step 3 (investment analysis) or choose the alternative with the lowest emissions (i.e. the most conservative) as the most plausible baseline scenario.

Step 3: Investment analysis

Undertake investment analysis of all the alternatives that do not face any barriers, as identified in Step 2. For each alternative, all costs and economic benefits attributable to the waste management scenario should be illustrated in a transparent and complete manner, as shown in Table 1 below.

Table 1: Calculation of NPV and IRR

COSTS AND BENEFITS	**Year 1**	**Year 2**	**Year n**	**Year n+1**
Equipment costs (specify the equipment needed)				
Installation costs	-	-	-	-
Maintenance costs	-	-	-	-
Other costs (e.g. operation, consultancy, engineering, etc.)	-	-	-	-
Revenues from the sale of electricity or other project related products, when applicable				
SUBTOTAL	-	-	-	-
TOTAL	-	-	-	-
NPV (US$) (specify discount rate)				

~~IRR (%)~~		

~~For each alternative baseline scenario, the internal rate of return (IRR) and/or the net present value (NPV) should be calculated. The calculation of the IRR must include *inter alia* investment costs, operation and maintenance costs, as well as any other appropriate costs (engineering, consultancy, etc.). Similarly, take into consideration all revenues generated by each manure management scenario, including revenue from the sale of electricity and cost savings due to avoided electricity purchases and other sources of income related to the implementation of the project, except revenues from the sale of CERs.~~

~~The IRR for all alternative scenarios should be calculated in a conservative manner. To ensure this, assumptions and parameters for the proposed project activity, if still under consideration, should be chosen in a conservative way such that they tend to lead to a higher IRR and NPV. For all other scenarios considered, assumptions and parameters should be chosen in a way such that they tend to lead to a lower IRR and NPV. This conservative choice of parameters and assumptions should be ensured by obtaining expert opinions and should be evaluated by the DOE as part of the validation of the project activity.~~

~~If the IRR cannot be calculated due to the existence of only negative flows in the financial analysis, the comparison should be based on the NPV, stating explicitly the discount rate used.~~

~~The baseline scenario is identified as the economically most attractive course of action i.e., alternative scenario with highest IRR or NPV, where the IRR cannot be calculated~~

~~Step 4: Baseline revision at renewal of crediting period~~

~~Renewal of crediting period: The project participants, at the renewal of each credit period, will undertake the relevance of baseline scenario identified above taking into account change in the relevant national and/or sectoral regulations between two crediting periods as well as any increase in the animal stock above the pre-project animal stock. This assessment will be undertaken by the verifying DOE.~~

~~Additionality~~

~~If the baseline determination in this methodology (see section "Identification of the baseline scenario" above) demonstrates that the baseline is different from the proposed project activity not undertaken as a CDM project activity it may be concluded that the project is additional.~~

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.

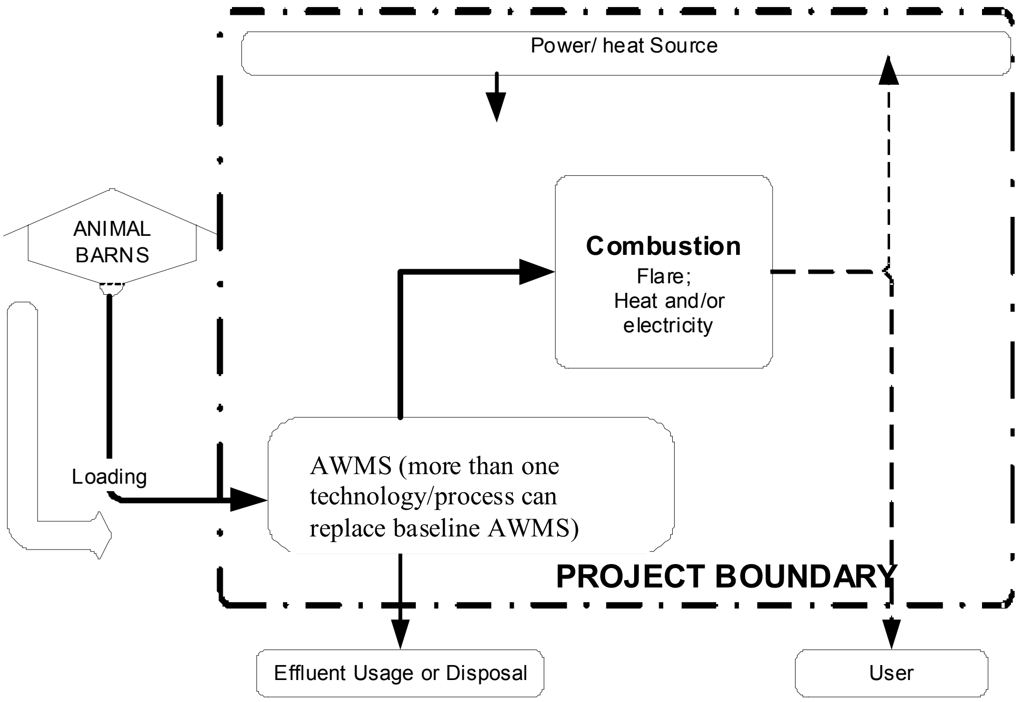

Figure 1: The Project ~~activity b~~ Boundary

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

	Source	Gas		Justification/Explanation
Baseline	~~Direct~~ Eemissions from the waste treatment processes	CH_4	Included	The major source of emissions in the baseline
		N_2O	Included	Direct and indirect N_2O emissions are accounted
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted
	Emissions from electricity consumption / generation	CO_2	Included	Electricity may be consumed from the grid or generated onsite in the baseline scenario
		CH_4	Excluded	Excluded for simplification. This is conservative
		N_2O	Excluded	Excluded for simplification. This is conservative
	Emissions from thermal energy generation	CO_2	Included	If thermal energy generation is included in the project activity
		CH_4	Excluded	Excluded for simplification. This is conservative
		N_2O	Excluded	Excluded for simplification. This is conservative
	Source	**Gas**		**Justification/Explanation**
Project Activity	Emissions from thermal energy ~~generation~~ use	CO_2	Included	May be an important emission source
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small
	Emissions from on-site electricity use	CO_2	Included	May be an important emission source. If electricity is generated from collected biogas, these emissions are not accounted for
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small
	~~Direct~~ Eemissions from the waste treatment processes	N_2O	Included	Direct and indirect N_2O emissions are accounted
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted
		CH_4	Included	The emission from anaerobic digesters and ~~uncombusted methane, physical leakage, and minor CH_4 emissions from~~ aerobic treatment

The project proponents ~~will~~ shall provide a clear diagrammatic representation in the CDM-PDD of the project scenario ~~with~~ showing all the manure waste treatments steps ~~adopted in treating the manure waste~~ as well as its final disposal ~~in the CDM-PDD. The diagrammatic representation will also indicate the fraction of volatile solids degraded within the project boundary in pre-project situation before disposal~~. This shall include the final ~~disposal~~ 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:

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

Where:

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

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

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

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

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)~~(0.00067 t/m^3 at room temperature (20 ºC) and 1 atm pressure)~~
MCF_j	=	Annual methane conversion factor (MCF) for the baseline $AWMS_j$
$B_{0,LT}$	=	Maximum methane producing potential of the volatile solid generated~~, in m^3CH_4/kg_dm,~~ 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)~~, as estimated below~~
$MS\%_{Bl,j}$	=	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) $\boldsymbol{VS_{LT,y}}$ *~~can~~ shall be determined in one of the following four ways, ~~stated~~ presented in the order of preference*

Option1:

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:

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

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) ~~(IPCC 2006 defaults available)~~
UE ~~GE_{LT}~~	=	Urinary energy (fraction of GE_{LT}) ~~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~~
ASH	=	Ash content of manure (fraction of the dry matter feed intake). ~~Use country-specific values where available~~
ED_{LT}	=	Energy density of the feed ~~(IPCC notes the energy density of feed, ED, is typically 18.45 MJ/kg DM, which is relatively constant across a wide variety of grain-based feeds.)~~ fed to livestock type LT (MJ/kg-dm). ~~The project proponent will record the composition of the feed to enable the DOE to verify the energy density of the feed~~
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:

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

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) ~~from where the data on $VS_{default}$ is sourced (IPCC 2006 or US-EPA, which ever is lower)~~

$VS_{default}$	=	Default value ~~(IPCC 2006 or US-EPA, which ever is lower)~~ 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 (IPCC 2006 guidelines, volume 4, chapter 10), multiply the value ~~with~~ by nd_y (number of days in year y).

Developed countries $VS_{LT,y}$ values ~~can~~ may be used provided the following conditions ~~can be~~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.

~~The following sources should be used to calculate baseline emissions:~~

- ~~IPCC 2006 guidelines, volume 4, chapter 10;~~
- ~~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, Chapter 8.2 (http://epa.gov/ost/guide/cafo/devdoc.html http://water.epa.gov/scitech/wastetech/guide/cafo/upload/2001_02_06_guide_cafo_DDChapters1-4.pdf).~~

~~*(B) Maximum Methane Production Potential ($B_{0,LT}$):*~~

~~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 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.);~~
- ~~The project specific animal weights are more similar to developed country IPCC default values.~~

~~*(C) Methane conversion factors (MCFs):*~~

- ~~The IPCC 2006 MCF values given in table 10.17 (chapter 10, volume 4) should be used, which is attached here as Annex 3. 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.~~

For subsequent treatment stages, the reduction of the volatile solids during a treatment stage is estimated based on referenced data for different treatment types. Emissions from the next treatment stage are then calculated following the approach outlined above, but with volatile solids adjusted for the reduction from the previous treatment stages by multiplying by (1 - R_{VS}), where R_{VS} is the relative reduction of volatile solids from the previous stage. The relative reduction (R_{VS}) of volatile solids depends on the treatment technology and should be estimated in a ***conservative manner***. Default values for different treatment technologies can be found in ~~Table 8.10 of chapter 8.2 in US-EPA (2001).[4] These values are provided in~~ appendix 1 (values for VS).

(B) Annual average number of animals of type LT (N_{LT})

Option 1:

$$N_{LT} = N_{da} \times \left(\frac{N_p}{365} \right) \tag{5.a}$$

Where:

N_{LT}	=	Annual average number of animals of type LT for the year *y* (number)
N_{da}	=	Number of days animal is alive in the farm in the year *y* (number)
N_p	=	Number of animals produced annually of type LT 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 ~~an average of the daily stock of animals in the farm without considering dead animals and discarded animals~~follows:

$$N_{LT} = \frac{\sum_{1}^{365} N_{AA}}{365} \tag{5.b}$$

Where:

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

[4] ~~<http://www.epa.gov/ost/guide/cafo/pdf/DDChapters8.pdf>.~~

313 ***(ii) Baseline N_2O emissions ($BE_{N2O,y}$)*** ~~*from manure management*~~

314 $$BE_{N2O,y} = GWP_{N2O} * CF_{N2O-N,N} * \frac{1}{1000} * (E_{N2O,D,y} + E_{N2O,ID,y}) \quad (6)$$

315 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)

316 $$E_{N2O,D,y} = \sum_{j,LT} EF_{N2O,D,j} * NEX_{LT,y} * N_{LT} * MS\%_{Bl,j} \quad (7)$$

317 Where:

$E_{N2O,D,y}$	=	Direct N_2O emission in year *y* (kg N_2O-N/yr) ~~Are the direct nitrous oxide emissions in kg of N_2O per 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) ~~(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)~~
$NEX_{LT,y}$	=	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)

318 $$E_{N2O,ID,y} = \sum_{j,LT} EF_{N2O,ID} * F_{gasMS,j,LT} * NEX_{LT,y} * N_{LT} * MS\%_{Bl,j} \quad (8)$$

319 Where:

$E_{N2O,ID,y}$	=	Indirect N_2O emission in year *y* (kg N_2O-N/year) ~~Are the indirect nitrous oxide emissions in kg of N_2O per 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) ~~emitted, 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~~
$NEX_{LT,y}$	=	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)
$F_{gasMS,j,LT}$	=	~~Percent of managed manure nitrogen for livestock category that volatilises as NH_3 and NO_X in the manure management system~~ 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)

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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 Chapter 8.2 in US-EPA (2001).[5] These values are provided~~ in appendix 1 (values for TN).

(iii) Baseline CO_2 emission from electricity and/or heat ~~within the project boundary~~ used in the baseline

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

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)

~~$$BE_{elec/heat,y} = EG_{Bl,y} \cdot CEF_{Bl,elec,y} + EG_{d,y} \cdot CEF_{grid} + HG_{BL,y} \cdot CEF_{Bl,therm,y} \quad (9)$$~~

~~Where:~~

~~$EG_{BL,y}$~~	~~=~~	~~Is the amount of electricity in the year y that would be consumed at the project site in the absence of the project activity (MWh) for operating AWMS~~
~~$CEF_{Bl,elec,y}$~~	~~=~~	~~Is the carbon emissions factor for electricity consumed at the project site in the absence of the project activity (tCO_2/MWh)~~
~~$EG_{d,y}$~~	~~=~~	~~Is the amount of electricity generated utilizing the biogas collected during project activity and exported to the grid during the year y (MWh)~~
~~CEF_{grid}~~	~~=~~	~~Is the carbon emissions factor for the grid in the project scenario (tCO_2/MWh)~~
~~$HG_{BL,y}$~~	~~=~~	~~Is the quantity of thermal energy that would be consumed in year y at the project site in the absence of the project activity (MJ) using fossil fuel for operating AWMS~~
~~$CEF_{Bl,therm}$~~	~~=~~	~~Is the CO_2 emissions intensity for thermal energy generation (tCO_2e/MJ)~~

[5] ~~<http://www.epa.gov/ost/guide/cafo/pdf/DDChapters8.pdf>~~.

~~Determination of $CEF_{Bl,elec}$:~~

~~In cases where electricity would in the absence of the project activity be generated in an on-site fossil fuel fired power plant, project participants should use for $CEF_{Bl,elec}$, the default emission factor for a diesel generator with a capacity of more than 200 kW for small-scale project activities (0.8 tCO_2/MWh, see Table I.D.1 in the simplified baseline and monitoring methodology AMS.I.D for selected small-scale CDM project activity categories).~~

~~In cases where electricity would, in the absence of the project activity, be purchased from the grid, the emission factor $CEF_{Bl,elec}$ should be calculated according to approved methodology "Tool to calculate the emission factor for an electricity system". If electricity consumption is less than small scale threshold (15 GWh/yr), use the default emission factor for a diesel generator with a capacity of more than 200 kW for small-scale project activities (0.8 tCO_2/MWh, see Table I.D.1 in the simplified baseline and monitoring methodology AMS.I.D for selected small-scale CDM project activity categories).~~

~~Determination of CEF_{grid}:~~

~~CEF_{grid} should be calculated according to "Tool to calculate the emission factor for an electricity system".~~

~~Determination of $CEF_{Bl,therm}$:~~

~~$CEF_{Bl,therm}$ is the CO_2 emissions intensity for thermal energy generation (tCO2e/MJ).~~

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 generated 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 methane in the biogas which is sent to the heat generation equipment in the project activity (boiler or air heater), as follows:

$$BE_{HG,y} = NCV_{CH4} * \sum_{k=1}^{n} \left(R_{efficiency,k,y} * F_{CH4,HG,dest,k,y} * EF_{CO2,BL,HG,k} \right) \quad \textbf{(10)}$$

Where:

$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (tCO_2/yr)
NCV_{CH4}	=	Net calorific value of methane at reference conditions (TJ/t CH_4)
$R_{efficiency,k,y}$	=	Ratio of the project and baseline efficiency of heat equipment type *k* in year *y*
$F_{CH4,HG,dest,k,y}$	=	Amount of methane in the biogas which is destroyed for heat generation by equipment type *k* in year *y* (t CH_4/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)

k	=	Heat generation equipment (boiler or air heater)
n	=	Number of different heat generation equipment used in the project activity

Determination of $R_{efficiency,k,y}$

The ratio of the project and baseline efficiency of an air heater or boiler is determined as follows:

$$R_{\text{efficiency,k,y}} = \min\left\{1;\ \frac{\eta_{\text{HG,PJ,k,y}}}{\eta_{\text{HG,BL,k}}}\right\} \quad \textbf{(11)}$$

Where:

$R_{\text{efficiency,k,y}}$	=	Ratio of the project and baseline efficiency of equipment type k in year y
$\eta_{\text{HG,BL,k}}$	=	Efficiency of the heat generation equipment type k used in the baseline
$\eta_{\text{HG,PJ,k,y}}$	=	Efficiency of the heat generation equipment type k used in the project activity in year y
k	=	Heat generation equipment type (boiler, air heater or kiln)

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".

Determination of $F_{CH4,HG,dest,k,y}$

$F_{CH4,HG,y}$ is determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". The following requirements apply:

(a) The gaseous stream the tool shall be applied to is the biogas delivery pipeline to each item of heat generation equipment k, $F_{CH4,HG,k,y}$ is then calculated as the sum of mass flows to each item of heat generation equipment k;

(b) CH_4 is the greenhouse gases for which the mass flow should be determined;

(c) The mass flow should be calculated on an hourly basis for each hour h in year y;

(d) The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool); and

(e) The mass flow for each hour in year y shall be summed to a yearly unit basis (t CH_4).

~~Baseline electricity and thermal energy consumptions should be estimated as the average of the historical 3 years consumption.~~

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:

~~$$PE_y = PE_{AD,y} + PE_{Aer,y} + PE_{N2O,y} + PE_{PL,y} + PE_{flare,y} + PE_{elec/heat} \quad \textbf{(10)}$$~~

$$PE_y = PE_{AD,y} + PE_{Aer,y} + PE_{N2O,y} + PE_{EC/FC,y} \quad \textbf{(12)}$$

Where:

$PE_{AD,y}$	=	Project emissions associated with the anaerobic digester in year *y* (tCO_2e/yr) ~~Leakage from AWMS systems that capture's methane in t CO2e/yr~~
$PE_{Aer,y}$	=	Project CH_4 ~~Methane~~ emissions from aerobic AWMS treatment ~~that aerobically treats the manure in~~ (tCO_2e/yr)
$PE_{N2O,y}$	=	Project N_2O emissions in year *y* (t CO_2/yr) ~~Nitrous oxide emission from project manure waste management system in t CO2e/yr~~
~~$PE_{PL,y}$~~	~~=~~	~~Physical leakage of emissions from biogas network to flare the captured methane or supply to the facility where it is used for heat and/or electricity generation in (t CO2e/yr)~~
~~$PE_{flare,y}$~~	~~=~~	~~Project emissions from flaring of the residual gas stream in t CO2e/yr~~
~~$PE_{elec/heat,y}$~~ $PE_{EC/FC,y}$	=	Project emissions from electricity consumption and fossil fuel combustion ~~use of heat and/or electricity in the project case in~~ (tCO_2e/yr)

(i) Project emissions associated with the anaerobic digester in year y ~~Methane emissions from AWMS where gas is captured~~ ($PE_{AD,y}$)

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

~~IPCC guidelines specify physical leakage from anaerobic digesters as being 15% of total biogas production. Where project participants use lower values for percentage of physical leakage, they should provide measurements proving that this lower value is appropriate for the project.~~

~~*Ex ante* leakage to be reported in the CDM-PDD will be estimated using equation 11.a or 11.b below, with a leakage factor of 0.15 or a lower value, if properly justified through documented evidence (which should be validated by the DOE).~~

~~If project case AWMS is anaerobic digester only, then use equation (11.a), else use equation (11.b).~~

$$PE_{AD,y} = GWP_{CH4} \cdot D_{CH4} * LF_{AD} * F_{AD} * \sum_{LT} (B_{0,LT} * N_{LT} * VS_{LT,y}) \quad \text{(11.a)}$$

$$PE_{AD,y} = GWP_{CH4} \cdot D_{CH4} * LF_{AD} * F_{AD} * \left[\prod_{n=1}^{N} (1 - R_{VS,n}) \right] * \sum_{j,LT} (B_{0,LT} * N_{LT} * VS_{LT,y} * MS\%_j) \quad \text{(11.b)}$$

~~Where:~~

~~D_{CH4}~~	~~=~~	~~CH_4 density (0.00067 t/m^3 at room temperature (20 ºC) and 1 atm pressure)~~
~~LF_{AD}~~	~~=~~	~~Methane leakage from Anaerobic digesters, default of 0.15~~
~~F_{AD}~~	~~=~~	~~Fraction of volatile solid directed to anaerobic digester~~
~~$R_{VS,n}$~~	~~=~~	~~Fraction of volatile solid treated in AWMS stage n. The project proponents shall provide the values based on proven test results. In absence of such values the conservative value of volatile solids treated in Annex 1 shall be used~~
~~LT~~	~~=~~	~~Index for livestock type~~
~~$B_{0,LT}$~~	~~=~~	~~CH_4 production capacity from manure for livestock type LT, in m^3 CH_4/kg-VS, to be chosen based on procedure provided for in the baseline methodology section~~
~~N_{LT}~~	~~=~~	~~Annual average number of animals of type LT for the year y estimated as per equation (5.a) or (5.b), expressed in numbers~~
~~$VS_{LT,y}$~~	~~=~~	~~Annual volatile solid excretion of livestock type LT on a dry-matter basis in kg/animal/year~~
~~$MS\%_j$~~	~~=~~	~~Fraction of manure handled in system j~~

~~As noted in equations (11.a) and (11.b), not all volatile solids are degraded in the anaerobic digester. If the undegraded volatile solid in the effluent from anaerobic digester is discharged outside the project boundary without further treatment, these emissions should be treated as leakage and appropriately reported and accounted.~~

(ii) Project CH_4~~Methane~~ 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.

$$PE_{Aer,y} = GWP_{CH4} * D_{CH4} * 0.001 * F_{Aer} * \left[\prod_{n=1}^{N} \left(1 - R_{VS,n}\right) \right] * \sum_{j,LT} (B_{0,LT} * N_{LT} * VS_{LT,y} * MS\%_j) + PE_{Sl,y} \quad \textbf{(13)}$$

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 being treated ~~in an aerobic lagoon~~ (fraction)
D_{CH4}	=	Density of CH_4 (t/m^3)~~(0.00067 t/m^3 at room temperature (20 ºC) and 1 atm pressure)~~.
F_{Aer}	=	Fraction of volatile solid directed to aerobic system (fraction)
LT	=	~~Index for~~ Type of livestock ~~type~~
$B_{0,LT}$	=	Maximum methane producing potential of the volatile solid generated by animal type LT (m^3CH_4/kg_dm) ~~CH_4 production capacity from manure for livestock type LT, in m^3 CH_4/kg-VS, to be chosen based on procedure provided for in the Baseline methodology section.~~
$VS_{LT,y}$	=	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).~~, expressed in numbers~~
$PE_{Sl,y}$	=	Project CH_4 emissions from sludge disposed of in storage pit prior to disposal during the year y~~, expressed in tons of~~ (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 ~~in~~ as leakage~~s~~. The emissions from sludge ponds shall be estimated as follows:

$$PE_{Sl,y} = GWP_{CH4} * D_{CH4} * MCF_{sl} * F_{Aer} * \left[\prod_{n=1}^{N} \left(1 - R_{VS,n}\right) \right] * \sum_{j,LT} (B_{0,LT} * N_{LT} * VS_{LT,y} * MS\%_j) \quad \textbf{(14)}$$

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) ~~Values for Rvs should be taken from Annex 1~~
D_{CH4}	=	Density of CH_4 (t/m^3) ~~CH_4 density (0.00067 t/m^3 at room temperature (20 ºC) and 1 atm pressure).~~
F_{Aer}	=	Fraction of volatile solid directed to aerobic system (fraction)
LT	=	Type of livestock ~~Index for livestock type~~
$B_{0,LT}$	=	Maximum methane producing potential of the volatile solid generated by animal type LT (m^3CH_4/kg_dm) ~~CH_4 production capacity from manure for livestock type LT, in m^3 CH_4/kg-VS, to be chosen based on procedure provided for in the baseline methodology section~~
$VS_{LT,y}$	=	Annual volatile solid excretion livestock type LT entering all AWMS on a dry matter weight basis in (kg-dm/animal/yr)~~Annual volatile solid excretion of livestock type LT on a dry-matter basis in kg/animal/year~~

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), expressed in numbers

$MS\%_j$ = 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) estimated as in the baseline emissions section

421 *(iii) Project N_2O emissions in year y ($PE_{N2O,y}$) N_2O emissions from manure management*

422 $$PE_{N2O,y} = GWP_{N2O} * CF_{N2O-N,N} * \frac{1}{1000} * (E_{N2O,D,y} + E_{N2O,ID,y}) \quad (15)$$

423 Where:

$PE_{N2O,y}$ = Project N_2O emissions in year *y* (t CO_2/yr) Annual project N_2O emissions in t CO2e/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) Direct N_2O emission in kg N_2O-year

$E_{N2O,ID,y}$ = Indirect N_2O emission in year *y* (kg N_2O-N/year) Indirect N_2O emission in kg N_2O-year

424 **Option 1:**

425 $$E_{N2O,D,y} = \sum_{j,LT} EF_{N2O,D,j} * NEX_{LT,y} * N_{LT} * MS\%_j \quad (16)$$

426 Where:

$E_{N2O,D,y}$ = Direct N_2O emission in year *y* (kg N_2O-N/yr) Are the direct nitrous oxide emissions in kg of N_2O per 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) Is the direct N_2O emission factor for the treatment system j of the manure management system in kg N_2O-N/kg N (estimated with site-specific, regional or national data if such data is available, otherwise use default EF3 in volume 4, chapter 10, table 10.21 in IPCC 2006 Guidelines)

$NEX_{LT,y}$ = 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)

427 $$E_{N2O,ID,y} = \sum_{j,LT} EF_{N2O,ID} * F_{gasMS,j,LT} * NEX_{LT,y} * N_{LT} * MS\%_j \quad (17)$$

428 Where:

$E_{N2O,ID,y}$ = Indirect N_2O emission in year *y* (kg N_2O-N/year) Are the indirect nitrous oxide emissions in kg of N_2O per 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) emitted 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 can be used

$NEX_{LT,y}$ = 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)
$F_{gasMS,j,LT}$	=	~~Percent of managed manure nitrogen for livestock category that volatilises as NH3 and NO_X in the manure management system~~ 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:

$$E_{N_2O,D,y} = \sum_j EF_{N_2O,D,j} * \sum_{m=1}^{12} \left(Q_{EM,m} * [N]_{EM,m}\right) \quad (18)$$

$$E_{N_2O,ID,y} = EF_{N_2O,ID} \cdot \sum_{j,LT} F_{gasMS,j,LT} \cdot \sum_{m=1}^{12} \left(Q_{EM,m} \cdot [N]_{EM,m}\right) \quad (19)$$

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 NH3-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)

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 Chapter 8.2 in US-EPA (2001).[6] These values are provided~~ in appendix 1 (values for TN).

~~*(iv) Physical leakage from distribution network of the captured methane in (PE_{PL})*~~

~~This refers to leaks in the biogas system from the biogas pipeline delivery system. The sum of the quantities of captured methane fed to the flare, to the power plant and to the boiler (measured as per the monitoring plan) must be compared annually with the total methane generated as measured by meter at the outlet of the methane generating digester. The difference between the monitored value of methane generated and that consumed in flare/electricity generation/heat shall be accounted as leakage from the pipelines.~~

~~In the case where biogas is just flared and the pipeline from collection point to flare is short (i.e., less than 1 km, and for on site delivery only), one flow meter can be used. In such cases the physical leakage may be considered as zero.~~

[6] <http://www.epa.gov/ost/guide/cafo/pdf/DDChapters8.pdf>.

~~*(v) Project emissions from flaring of the residual gas stream ($PE_{flare,y}$):*~~

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

~~Project emissions from flaring of the residual gas stream should be determined following the procedure described in the "Tool to determine project emissions from flaring gases containing Methane".~~

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

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 $PE_{AD,y}$.

~~$$PE_{elec/heat,y} = PE_{Elec,y} + \sum_j PE_{heat,j,y} \quad (21)$$~~

$$PE_{EC/FC,y} = PE_{EC,y} + \sum_j PE_{FC,j,y} \quad (20)$$

Where:

$PE_{EC,y}$ ~~$PE_{Elec,y}$~~	=	~~Are the~~ Project emissions from electricity consumption in year y ~~of electricity in the project case~~. The project emissions from electricity consumption ~~($PE_{Elec,y}$ = $PE_{EC,y}$)~~ will be calculated following the latest version of "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
$PE_{FC,j,y}$ ~~$PE_{heat,j,y}$~~	=	Project emissions from fossil fuel combustion in process j during the year y ~~Are the emissions from consumption of heat in the project case.~~ The project emissions from fossil fuel combustion ~~($PE_{heat,j,y}$ = $PE_{FC,j,y}$)~~ will be calculated following the latest version of "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". For this purpose, the processes j in the tool corresponds to all fossil fuel combustion in the AWMS (not including fossil fuels consumed for transportation of feed material and sludge or any other on-site transportation). ~~paper plant established as part of the project activity, as well as any other on-site fuel combustion for the purposes of the project activity~~

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 ~~of N_2O and CH_4~~ are only considered if they are positive.

$$LE_y = (LE_{P,N2O,y} - LE_{B,N2O,y}) + (LE_{P,CH4,y} - LE_{B,CH4,y}) + LE_{AD,y} \quad (21)$$

Where:

$LE_{P,N2O,y}$	=	~~Are the~~ Leakage N_2O emissions released during project activity from land application of the treated manure in year y (tCO_2e/yr)
$LE_{B,N2O,y}$	=	~~Are the~~ Leakage N_2O emissions released during baseline scenario from land application of the treated manure in year y (tCO_2e/yr)
$PE_{FC,j,y}$	=	~~Are the~~ Leakage CH_4 emissions released during project activity from land application of the treated manure in year y (tCO_2e/yr)

$LE_{B,CH4,y}$	=	~~Are the~~ 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

~~The baseline case N_2O emissions are estimated using the following equations:~~

$$LE_{B,N2O,y} = GWP_{N2O} * CF_{N2O-N,N} \cdot \frac{1}{1000} * (LE_{N2O,land,y} + LE_{N2O,runoff,y} + LE_{N2O,vol,y}) \quad (22)$$

$$LE_{N2O,land,y} = EF_1 * \prod_{n=1}^{N}(1 - R_{N,n}) * \sum_{LT} NEX_{LT,y} * N_{LT} \quad (23)$$

$$LE_{N2O,runoff,y} = EF_5 * F_{leach} * \prod_{n=1}^{N}(1 - R_{N,n}) * \sum_{LT} NEX_{LT,y} * N_{LT} \quad (24)$$

$$LE_{N2O,vol,y} = EF_4 * \prod_{n=1}^{N}(1 - R_{N,n}) * F_{gasm} * \sum_{LT} NEX_{LT,y} * N_{LT} \quad (25)$$

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 ~~Direct nitrous oxide emission~~ from application of manure waste in year *y* (Kg N_2O-N/year)
$LE_{N2O,runoff,y}$	=	Leakage N_2O emissions ~~Nitrous oxide emission~~ 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) ~~Fraction of animal manure N that volatizes as NH_3 and NO_X in kg NH_3-N and NO_X-N per kg of N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3, chapter 11, volume 4 of IPCC 2006 guidelines can be used~~
N_{LT}	=	Annual average number of animals of type LT estimated as per equation (5.a) or (5.b) (number)
NEX_{LT}	=	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 ~~direct emission of~~ N_2O emissions from ~~soils in~~ N inputs (Kg N_2O-N/kg N input) ~~, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.1, chapter 11, volume 4 of IPCC 2006 guidelines can be used~~
EF_5	=	Emission factor for ~~indirect emission of~~ N_2O emissions from N leaching and runoff in (Kg N_2O-N/kg N leached and runoff)~~, 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~~
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)]~~, 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~~

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) ~~should be 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~~
$R_{N,n}$	=	Nitrogen reduction factor (fraction) ~~Fraction of NEX in manure waste that is reduced in the Baseline AWMS. The relative reduction of nitrogen depends on the treatment technology and should be estimated in a conservative manner. Default values for different treatment technologies can be found in Annex 1~~

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

~~The project case N_2O emissions are estimated using the following equations:~~

$$LE_{P,N2O} = GWP_{N2O} \cdot CF_{N2O-N,N} \cdot \frac{1}{1000} * (LE_{N2O,land,y} + LE_{N2O,runoff,y} + LE_{N2O,vol,y}) \quad \textbf{(26)}$$

$$LE_{N2O,land,y} = EF_1 * \prod_{n=1}^{N} (1 - R_{N,n}) * \sum_{LT} NEX_{LT,y} \cdot N_{LT} \quad \textbf{(27)}$$

$$LE_{N2O,runoff} = EF_5 * F_{leach} * \prod_{n=1}^{N} (1 - R_{N,n}) * \sum_{LT} NEX_{LT,y} \cdot N_{LT} \quad \textbf{(28)}$$

$$LE_{N2O,vol} = EF_4 * \prod_{n=1}^{N} (1 - R_{N,n}) * F_{gasm} * \sum_{LT} NEX_{LT,y} \cdot N_{LT} \quad \textbf{(29)}$$

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 ~~Direct nitrous oxide emission~~ from application of manure waste in year *y* (Kg N_2O-N/year)
$LE_{N2O,runoff,y}$	=	Leakage N_2O emissions ~~Nitrous oxide emission~~ 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) ~~Fraction of animal manure N that volatizes as NH_3 and NO_X in kg NH_3-N and NO_X-N per kg of N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3, chapter 11, volume 4 of IPCC 2006 guidelines can be used~~
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 ~~direct emission of~~ N_2O emissions from ~~soils in~~ N inputs (Kg N_2O-N/kg N input) ~~, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.1, chapter 11, volume 4 of IPCC 2006 guidelines can be used~~

EF_5	=	Emission factor for ~~indirect emission of~~ N_2O emissions from N leaching and runoff in (Kg N_2O-N/kg N leached and runoff)~~, 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~~
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)]~~, 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~~
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) ~~should be 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~~
$R_{N,n}$	=	Nitrogen reduction factor (fraction) ~~Fraction of NEX in manure waste that is reduced in the Baseline AWMS. The relative reduction of nitrogen depends on the treatment technology and should be estimated in a conservative manner. Default values for different treatment technologies can be found in Annex 1~~

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, $\prod_{n=1}^{N}\left(1-R_{N,n}\right)*\sum_{LT} NEX_{LT,y}\cdot N_{LT}$ in equations (28), (29) and (30) above should be substituted by Q_{DM}*N_{DM}.

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

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

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

$$LE_{P,CH4,y} = GWP_{CH4} * D_{CH4} * MCF_d * \left[\prod_{n=1}^{N}\left(1-R_{VS,n}\right)\right] * \sum_{j,LT}\left(B_{0,LT} * N_{LT} * VS_{LT,y} * MS\%_j\right) \quad \textbf{(31)}$$

Where:

$LE_{B,CH4,y}$	=	Leakage CH_4 emissions released during baseline scenario from land application of the treated manure in year *y* ~~Methane leakage emissions in the baseline~~ (tCO_2e/yr)
$LE_{P,CH4,y}$	=	Leakage CH_4 emissions released during project activity from land application of the treated manure in year *y* ~~Methane leakage emissions in the project case~~ (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. ~~Values for R_{vs} should be taken from annex 1~~
GWP_{CH4}	=	Global Warming Potential (GWP) of CH_4 (tCO_2e/tCH_4)
D_{CH4}	=	Density of CH_4 (t/m^3) ~~(0.00067 t/m^3 at room temperature (20 ºC) and 1 atm pressure)~~

$B_{0,LT}$	=	Maximum methane producing potential of the volatile solid generated~~, in~~ by animal type LT (m^3CH_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 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:

$$ER_y = BE_y - PE_y - LE_y \quad \textbf{(32)}$$

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" ~~this is calculated as product of biogas flow at the digester outlet and methane fraction in the biogas~~), 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" ~~$PE_{AD,y}$ – $PE_{PL,y}$~~) and if found lower, then ($BE_{CH4,y}$ - $PE_{AD,y}$ ~~$PE_{AD,y}$ – $PE_{PL,y}$~~) (which is a component of BE_y -PE_y)in equation (33) is replaced by $Q_{CH4,y}$ ~~.actual methane captured~~.

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".

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.

~~**ID Number:**~~	~~1~~
Data/Parameter:	$R_{VS,n}$
Data unit:	Fraction
Description:	~~VS degradation factor~~ Fraction of volatile solid degraded in AWMS treatment method *n* of the N treatment steps prior to waste being treated ~~in an aerobic lagoon~~
Source of data:	Refer to appendix 1 (values for VS)
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Any comment:	~~Estimated from Table provided in Annex 1.~~ The **most conservative** value for the given technology must be used

~~**ID Number:**~~	~~2~~
Data/Parameter:	$EF_{N2O,D,j}$~~, $EF_{N2O,ID,j}$~~
Data unit:	kg N_2O-N/ kg N ~~and kg N_2O-N/ kg NH3-N and NO_X-N~~
Description:	~~N_2O emission factors (direct and indirect emissions) used in equation 14 and 15~~ Direct N_2O emission factor for the treatment system j of the manure management system
Source of data:	~~IPCC 2006 Guidelines~~ 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):	~~Archive electronically during project plus 5 years~~
Any comment:	~~IPCC 2006 default values may be used, if country specific or region specific data are not available~~

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:	---

~~**ID Number:**~~	~~3~~
Data/Parameter:	~~F_{gasm}~~ $F_{gasMS,j,LT}$
Data unit:	Fraction
Description:	~~Fraction of N lost due to volatilization~~ 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):	~~Archive electronically during project plus 5 years~~
Any comment:	IPCC 2006 default values can be used

Data/Parameter:	Fgasm
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:	IPCC 2006 default values can be used

525

ID Number:	4
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 NH3-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. IPCC 2006 Guidelines
Measurement procedures (if any):	Archive electronically during project plus 5 years
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

526

ID Number:	5
Data/Parameter:	F_{leach}
Data unit:	Fraction
Description:	Fraction of N leached 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. IPCC 2006 default values can be used.
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	

527

ID Number:	6
Parameter:	$CEF_{Bl, therm,y}$
Data unit:	tCO_2/MJ
Description:	Emission factor of baseline heat use
Source of data:	Refer to baseline methodology
Measurement procedures (if any):	Archive electronically during project plus 5 years
Any comment:	Calculated as per procedure described in the baseline methodology

528

ID Number:	7
Parameter:	$EG_{Bl,y}$
Data unit:	MWh
Description:	Electricity consumption by Baseline AWMS
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically for the duration of project plus 5 years
Any comment:	Estimation is based on three years data prior to start of the project. Electricity meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company. Uncertainty of the meters to be obtained from the manufacturers. This uncertainty to be included in a conservative manner while calculating CERs and procedure for doing so should be described in the CDM-PDD

529

~~**ID Number:**~~	~~8~~
~~**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):~~	~~Archive electronic for the duration of project plus 5 yrs~~
~~Any comment:~~	~~---~~

~~**ID Number:**~~	~~9~~
~~**Parameter:**~~	~~$HG_{BL,y}$~~
~~Data unit:~~	~~MJ~~
~~Description:~~	~~Heat used by baseline AWMS~~
~~Source of data:~~	~~Project proponents~~
~~Measurement procedures (if any):~~	~~Archive electronic for the duration of project plus 5 yrs~~
~~Any comment:~~	~~At start of project. Fuel purchase records to be cross checked with estimates. Estimation is based on three years data prior to start of the project~~

~~**ID Number:**~~	~~10~~
Data/Parameter:	$MS\%_{Bl,j}$
Data unit:	Fraction
Description:	Fraction of manure handled in system j in the baseline
Source of data:	Project proponents
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Any comment:	---

~~**ID Number:**~~	~~11~~
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:	---

~~**ID Number:**~~	~~12~~
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:	---

536

~~**ID Number:**~~	~~13~~
Data/Parameter:	D_{CH4}
Data unit:	t/m^3
Description:	Density of CH_4
Source of data:	Technical literature
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Any comment:	0.00067 t/m^3 at room temperature 20^{o}C and 1 atm pressure

537

~~**ID Number:**~~	~~14~~
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):	~~Archive electronically during project plus 5 years~~
Any comment:	---

538

~~**ID Number:**~~	~~15~~
~~**Parameter:**~~	~~$CF_{N2O-N,N}$~~
~~Data unit:~~	~~---~~
~~Description:~~	~~Conversion factor = 44/28~~
~~Source of data:~~	~~Technical literature~~
~~Measurement procedures (if any):~~	~~Archive electronically during project plus 5 years~~
~~Any comment:~~	~~---~~

539

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):	~~Archive electronically during project plus 5 years~~
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 ^{o}C and above 5 ^{o}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 ^{o}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

540

541

Data/Parameter:	$W_{default}$
Data unit:	kg
Description:	Default average animal weight of a defined population
Source of data:	IPCC 2006 or US-EPA, which ever is lower.
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Any comment:	---

542

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, which ever is lower
Measurement procedures (if any):	
Any comment:	---

543

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

544

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

545

Data/Parameter:	R_N
Data unit:	Fraction
Description:	Nitrogen ~~degradation~~ reduction factor
Source of data:	Refer to appendix 1
Measurement procedures (if any):	
Any comment:	Estimated from Table provided in appendix 1 (value for TN). The most conservative value for the given technology must be used

III. 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).

~~*Baseline emissions:*~~

- ~~Diagrammatic representation of animal waste management system existing on the project site prior to project implementation;~~
- ~~Parameters MCF, B_o, and R_{VS} for estimating methane emissions from AWMS in the baseline;~~
- ~~EF_{N2O} and R_N for estimating nitrogen emission from AWMS in the baseline;~~
- ~~Ambient temperature at the AWMS site;~~
- ~~Amount of electricity used for the operation of the AWMS in the baseline;~~
- ~~Amount of fossil fuel used for the operation of the AWMS in the baseline;~~
- ~~Biogas based electricity exported to the grid, needs to be monitored only if emissions reduction for electricity generation from biogas are claimed;~~
- ~~Data and parameters for estimating heat and electricity emission factors.~~

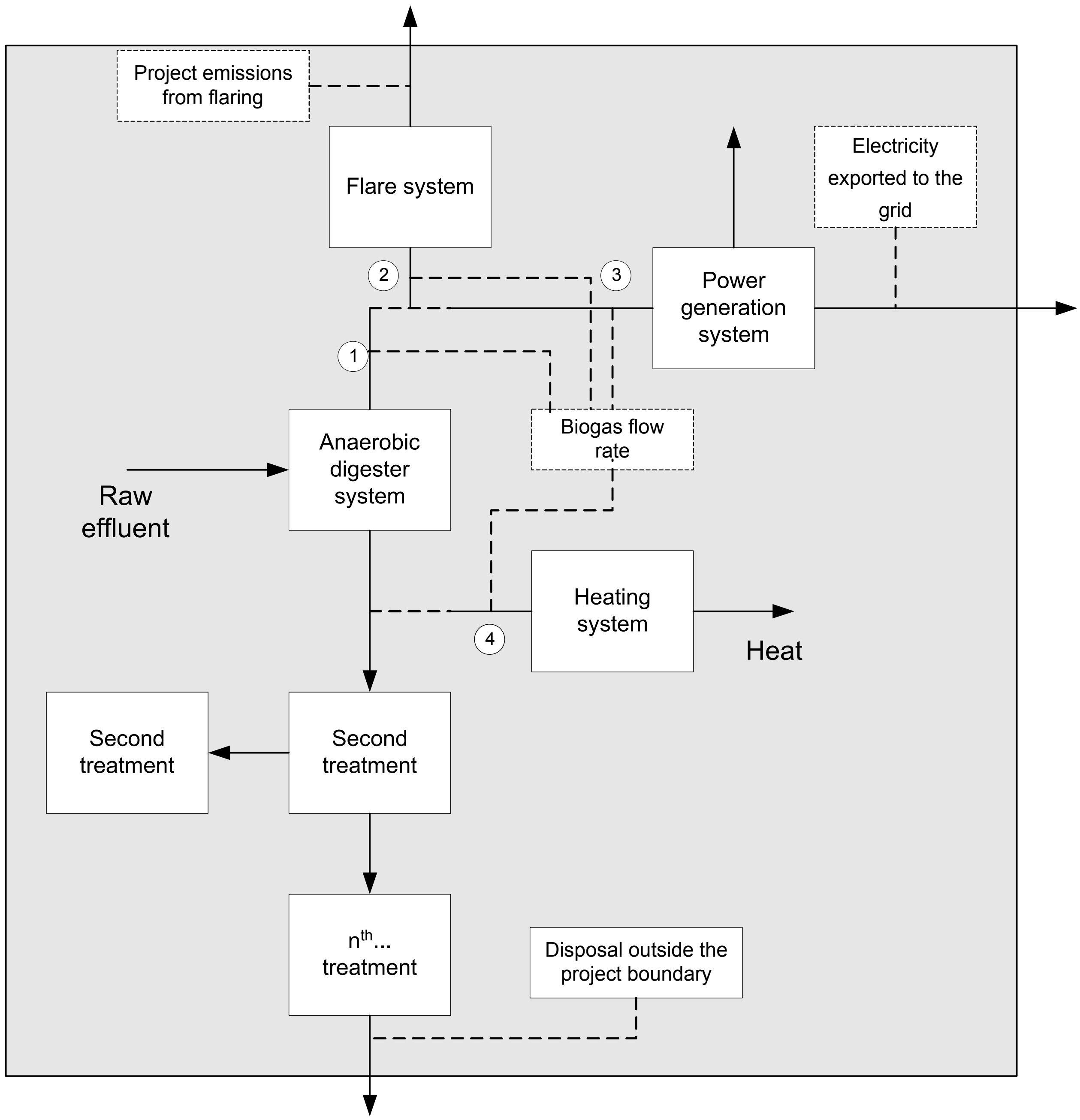
~~*Project emissions:*~~

- ~~The livestock populations by different livestock types. This includes the number of heads of each population and the average animal weight in each population,~~
- ~~Parameters MCF, Bo, and RVS for estimating methane emissions from AWMSs in the project case;~~
- ~~EFN2O and RN for estimating nitrogen emission from AWMS in the baseline;~~
- ~~The default volatile solid excretion values or other parameters required for estimating the volatile solids. If dietary intake method is used, the feed intake of animals and its energy will be monitored;~~
- ~~Leakage from anaerobic digester, if used. The default value is 15%, but in case project participants use a lower value, the appropriate measurement to support the lower value shall be monitored and reported;~~
- ~~The default nitrogen excretion per animal or parameters required to estimate nitrogen excretion. If N intake method is used the amount of dry matter intake by livestock shall be monitored;~~
- ~~Amount of electricity used in the project case. If electricity consumption is measured in the project, then project proponents may use the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption";~~
- ~~Fuel consumption for generation of heat used in the project case. Calculated following the latest version of "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion";~~

- ~~Flow of biogas to the flare, heat generation, and electricity generation. In the case where biogas is just flared, one flow meter can be used provided that the meter used is calibrated periodically by an officially accredited entity;~~
- ~~Concentration of methane in biogas at outlet of anaerobic digester, this shall be measured on wet basis;~~
- ~~The parameters used for determining the project emissions from flaring of the residual gas stream in year y ($PE_{flare,y}$) should be monitored as per the "Tool to determine project emissions from flaring gases containing Methane";~~
- ~~Biogas leakage in project: through leaks in the pipeline during transportation of biogas.~~

~~*Leakage:*~~

- ~~Nitrogen concentration and COD in waste water/sludge disposed outside the project boundary.~~



595
596 **Figure 2: Flow diagram and biogas flow measurement points of project activity**

597 **Data and parameters monitored**

~~**Data / Parameter:**~~	~~MCF~~
~~Data unit:~~	~~Fraction~~
~~Description:~~	~~Methane correction factor~~
~~Source of data:~~	~~IPCC 2006 Guidelines~~
~~Measurement procedures (if any):~~	~~Archive electronically during project plus 5 years~~
~~Monitoring frequency:~~	~~Annually~~
~~QA/QC procedures:~~	~~---~~
~~Any comment:~~	~~The factor MCF is taken from IPCC 2006 guidelines. If annual average temperature is lower than 10 °C and higher than 5 °C, Annual MCF should be estimated using linear interpolation assuming MCF=0 at annual average temperature of 5 °C~~

598

Data/Parameter:	MCF_{sl}
Data unit:	Fraction
Description:	Methane ~~correction~~ 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) ~~IPCC 2006 Guidelines~~
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	~~The factor MCF is taken from IPCC 2006 guidelines. If annual average temperature is lower than 10 °C and higher than 5 °C, Annual MCF should be estimated using linear interpolation assuming MCF=0 at annual average temperature of 5 °C~~ • 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

599

Data/Parameter:	$B_{0,LT}$
Data unit:	~~Fraction~~ m^3CH_4/kg_dm
Description:	Maximum methane ~~production~~ 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):	~~Archive electronically during project plus 5 years~~
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	The value is taken from published sources. The parameter value should be updatesd on latest available public data source

600

~~**Data / Parameter:**~~	~~$VS_{LT,y}$~~
~~Data unit:~~	~~kg dry matter/animal/year~~
~~Description:~~	~~Volatile solid excretion per animal per day~~
~~Source of data:~~	~~Project proponents~~
~~Measurement procedures (if any):~~	~~Archive electronically during project plus 5 years~~
~~Monitoring frequency:~~	~~Annually, estimated or based on published information such as IPCC~~
~~QA/QC procedures:~~	~~---~~
~~Any comment:~~	~~If it is required to use developed country VS values, the following should be monitored: - Genetic source of the production operations livestock originate from an Annex I Party; - The formulated feed rations (FFR). If equation 4 is used to estimate the value, $VS_{default}$ (kg-dm/animal/day, Default average animal weight of a defined population in kg from where the data on $VS_{default}$ is sourced (IPCC 2006 or US-EPA, which ever is lower) shall be recorded and archived . Further, when using equation 4, please refer to the guidance below for estimating W_{site}.~~

601

~~**Data / Parameter:**~~	~~$CEF_{BI,elec,y}$~~
~~Data unit:~~	~~tCO_2/MWh~~
~~Description:~~	~~Emission factor of baseline electricity use~~
~~Source of data:~~	~~Refer to baseline methodology~~
~~Measurement procedures (if any):~~	~~Archive electronically during project plus 5 years~~
~~Monitoring frequency:~~	~~At start of project~~
~~QA/QC procedures:~~	~~---~~
~~Any comment:~~	~~Calculated as per procedure described in the baseline methodology~~

~~**Data / Parameter:**~~	~~CEF_{grid}~~
~~Data unit:~~	~~tCO_2/MWh~~
~~Description:~~	~~Emission factor of exported electricity~~
~~Source of data:~~	~~Refer to baseline methodology~~
~~Measurement procedures (if any):~~	~~Archive electronically during project plus 5 years~~
~~Monitoring frequency:~~	~~Annually~~
~~QA/QC procedures:~~	~~---~~
~~Any comment:~~	~~Calculated as per procedure described in the baseline methodology~~

~~**Data / Parameter:**~~	~~LF_{AD}~~
~~Data unit:~~	~~Fraction~~
~~Description:~~	~~Fraction of methane leakage from anaerobic digester~~
~~Source of data:~~	~~IPCC 2006 Guidelines~~
~~Measurement procedures (if any):~~	~~Archive electronically during project plus 5 years~~
~~Monitoring frequency:~~	~~Annually~~
~~QA/QC procedures:~~	~~---~~
~~Any comment:~~	~~IPCC default of 0.15 or less if documented evidence can be provided (to be checked by DOE)~~

~~**Data / Parameter:**~~	~~$R_{N,n}$~~
~~Data unit:~~	~~Fraction~~
~~Description:~~	~~Nitrogen degradation factor~~
~~Source of data:~~	~~Refer to Annex 1~~
~~Measurement procedures (if any):~~	~~Archive electronically during project plus 5 years~~
~~Monitoring frequency:~~	~~Annually~~
~~QA/QC procedures:~~	~~---~~
~~Any comment:~~	~~Estimated from Table provided in Annex 1. The most conservative value for the given technology must be used.~~

Data/Parameter:	Type
Data unit:	---
Description:	Type of barn and AWMS
Source of data:	Project proponents
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
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):	~~Archive electronically during project plus 5 years~~
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):	~~Archive electronically during project plus 5 years~~
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:	°C
Description:	Annual Average ambient temperature at Project site
Source of data:	Project proponents
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
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 ~~exported to grid~~generated using biogas in year y
Source of data:	Project proponents
Measurement procedures (if any):	Archive electronically during project plus 5 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:**~~	~~Regulations~~
~~Data unit:~~	~~---~~
~~Description:~~	~~Existence and enforcement of relevant regulation~~
~~Source of data:~~	~~Project proponents~~
~~Measurement procedures (if any):~~	~~---~~
~~Monitoring frequency:~~	~~At start of crediting period~~
~~QA/QC procedures:~~	~~Quality control for the existence and enforcement of relevant regulations and incentives is beyond the bounds of the project activity. Instead, the DOE will verify the evidence collected~~
~~Any comment:~~	~~---~~

614

Data/Parameter:	N_{da}
Data unit:	Number
Description:	Number of days animal is alive in the farm in the year *y*
Source of data:	Project proponents
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Monitoring frequency:	Monthly
QA/QC procedures:	---
Any comment:	The PDD should describe the system on monitoring the number ~~of livestock population.~~ 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}

615

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

616

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):	~~Archive electronically during project plus 5 years~~
Monitoring frequency:	Monthly
QA/QC procedures:	---

617

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 3 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 3 weight categories as described above

618

~~**Data / Parameter:**~~	~~F_{AD}~~
~~Data unit:~~	~~Fraction~~
~~Description:~~	~~Fraction of volatile solids directed to anaerobic digesters~~
~~Source of data:~~	~~Project proponents~~
~~Measurement procedures (if any):~~	~~Archive electronically during project plus 5 years~~
~~Monitoring frequency:~~	~~Annually~~
~~QA/QC procedures:~~	~~---~~
~~Any comment:~~	~~---~~

619

Data/Parameter:	F_{Aer}
Data unit:	Fraction
Description:	Fraction of volatile solids directed to aerobic treatment
Source of data:	~~Project proponents~~
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	---

620

Data/Parameter:	V_f
Data unit:	m^3
Description:	Biogas flow
Source of data:	Project proponents
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Monitoring frequency:	Continuously by flow meter and reported cumulatively on weekly basis

621

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 4 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

622

~~**Data / Parameter:**~~	~~C_{CH4}~~
~~Data unit:~~	~~Fraction~~
~~Description:~~	~~Methane fraction of biogas~~
~~Source of data:~~	~~Project proponents~~
~~Measurement procedures (if any):~~	~~Archive electronically during project plus 5 years. Shall be measured on wet basis~~
~~Monitoring frequency:~~	~~To be decided by PPs~~
~~QA/QC procedures:~~	~~The project proponents shall define the variability of the concentration. They shall also define the error in estimate for different level of measurement frequency. The level of accuracy will be deducted from average concentration of measurement~~
~~Any comment:~~	~~The project proponents shall define the variability of the concentration. They shall also define the error in estimate for different level of measurement frequency. The level of accuracy will be deducted from average concentration of measurement~~

623

~~**Data / Parameter:**~~	~~$PE_{flare,y}$~~
~~Data unit:~~	~~tCO_{2e}~~
~~Description:~~	~~Project emissions from flaring of the residual gas stream in year *y*~~
~~Source of data:~~	~~---~~
~~Measurement procedures (if any):~~	~~The parameters used for determining the project emissions from flaring of the residual gas stream in year y ($PE_{flare,y}$) should be monitored as per the "Tool to determine project emissions from flaring gases containing Methane"~~
~~Monitoring frequency:~~	~~---~~
~~QA/QC procedures:~~	~~The parameters used for determining the project emissions from flaring of the residual gas stream in year *y* ($PE_{flare,y}$) should use the QA/QC procedures as per the "Tool to determine project emissions from flaring gases containing Methane"~~
~~Any comment:~~	~~---~~

624

~~**Data / parameter:**~~	~~$PE_{Elec,y}$~~
~~Data unit:~~	~~tCO_2~~
~~Description:~~	~~Emissions from consumption of electricity in the project case in year y.~~
~~Source of data:~~	~~Calculated as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". When using the tool $PE_{Elec,y} = PE_{EC,y}$.~~
~~Measurement procedures (if any):~~	~~As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"~~
~~Monitoring frequency:~~	~~As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"~~

~~QA/QC procedures:~~	~~As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"~~
~~Any comment:~~	~~---~~

~~**Data / parameter:**~~	~~$PE_{HEAT,j,y}$~~
~~Data unit:~~	~~tCO_{2e}~~
~~Description:~~	~~Project emissions from fossil fuel combustion in process *j* during the year *y*~~
~~Source of data:~~	~~Calculated as per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". When using the tool $PE_{heat,j,y} = PE_{FC,j,y}$.~~
~~Measurement procedures (if any):~~	~~As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"~~
~~Monitoring frequency:~~	~~As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"~~
~~QA/QC procedures:~~	~~As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"~~
~~Any comment:~~	~~---~~

~~**Data / Parameter:**~~	~~$CP_{i,y}$~~
~~Data unit:~~	~~MW~~
~~Description:~~	~~Rated capacity of electrical equipment i used for project activity in year *y*~~
~~Source of data:~~	~~Equipment at site~~
~~Measurement procedures (if any):~~	~~---~~
~~Monitoring frequency:~~	~~Annually~~
~~QA/QC procedures:~~	~~---~~
~~Any comment:~~	~~This parameter is used in case the electricity consumption is not measured~~

Data/Parameter:	N_{DM}
Data unit:	kg N20-N/KG effluent
Description:	N concentration in disposed manure
Source of data:	Project proponents
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Monitoring frequency:	Every batch disposed
QA/QC procedures:	---
Any comment:	---

Data/Parameter:	Q_{DM}
Data unit:	kg
Description:	Mass of manure disposed outside project boundary
Source of data:	Project proponents
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Monitoring frequency:	Every batch disposed
QA/QC procedures:	---
Any comment:	---

630

Data/Parameter:	$MS\%_j$
Data unit:	Fraction
Description:	Fraction of manure handled in system j in the project activity
Source of data:	Project proponents
Measurement procedures (if any):	~~Archive electronically during project plus 5 yrs~~
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	---

631

Data/Parameter:	$NEX_{LT,y}$
Data unit:	kg N/animal/year
Description:	Annual average nitrogen excretion per head of a defined livestock population ~~in kg N/animal/year~~ estimated as described in appendix 2
Source of data:	Refer to appendix 2
Measurement procedures (if any):	~~Archive electronically during project plus 5 yrs~~
Monitoring frequency:	Annually
QA/QC procedures:	---
Any comment:	When using equation 2 in appendix 2, please refer to above guidance for estimating W_{site}

632

Data/Parameter:	GE_{LT}
Data unit:	MJ/animal/day
Description:	Daily average gross energy intake ~~in MJ/day~~
Source of data:	Project proponents
Measurement procedures (if any):	~~Archive electronically during project plus 5 yrs~~
Monitoring frequency:	Daily
QA/QC procedures:	---
Any comment:	---

633

Data/Parameter:	DE_{LT}
Data unit:	%
Description:	Digestible energy of the feed in percent ~~(IPCC 2006 defaults available)~~
Source of data:	---
Measurement procedures (if any):	~~Archive electronically during project plus 5 yrs~~
Monitoring frequency:	---
QA/QC procedures:	---
Any comment:	IPCC 2006: Typically 45-55% for low quality forages

634

Data/Parameter:	UE
Data unit:	Fraction of GE_{LT}
Description:	Urinary energy ~~expressed as fraction of GE_{LT}~~
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):	~~Archive electronically during project plus 5 yrs~~

Monitoring frequency:	---
QA/QC procedures:	---
Any comment:	---

635

Data / Parameter:	ASH
Data unit:	Fraction of the dry matter feed intake
Description:	Ash content of the manure ~~calculated as a fraction of the dry matter feed intake~~
Source of data:	Use country-specific values where available
Measurement procedures (if any):	~~Archive electronically during project plus 5 years~~
Monitoring frequency:	---
QA/QC procedures:	---
Any comment:	---

636

Data/Parameter:	ED_{LT}
Data unit:	MJ/kg
Description:	Energy density of the feed ~~in MJ/kg~~ fed to livestock type LT
Source of data:	Measured or IPCC default
Measurement procedures (if any):	~~Archive electronically during project plus 5 years.~~ The project proponent will record the composition of the feed to enable the DOE to verify the energy density of the feed
Monitoring frequency:	---
QA/QC procedures:	---
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

637

Data/Parameter:	N_{AA}
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):	~~Archive electronically during project plus 5 yrs~~
Monitoring frequency:	Daily
QA/QC procedures:	~~Project participant should provide a for the measurement in the PDD~~
Any comment:	The PDD should describe the system ~~on~~ for monitoring stock of animals

638

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:	---

639

640

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):	
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)

641

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)

642 **IV. REFERENCES AND ANY OTHER INFORMATION**

643 Not applicable.

Appendix ~~Annex~~ 1: Anaerobic Unit Process Performance

Table 8-10. Anaerobic Unit Process Performance

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

Source: Moser and Martin, 1999

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

Option 1:

$$NEX_{LT,y} = N_{intake} * (1 - N_{retention}) * nd_y \quad \textbf{(1)}$$

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. ~~(Default values are reported in Table 10.20 in IPCC 2006 guidelines, volume 4, chapter 10)~~ (kg N retained/animal/yr)
nd_y	=	Number of days treatment plant was operational in year *y*

N_{intake} may be calculated using:

$$N_{intake} = \left(\frac{GE}{18.45}\right) * \left(\frac{CP/100}{6.25}\right) \quad \textbf{(1.a)}$$

Where:

CP	=	Crude protein percent (percent)
GE	=	Gross energy intake of the animal~~, in enteric model, based on digestible energy, milk production, pregnancy, current weight, mature weight, rate of weight gain, and IPCC constants,~~ (MJ/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:

$$NEX_{LT,y} = \frac{W_{site}}{W_{default}} \cdot NEX_{IPCC\ default} \quad \textbf{(2)}$$

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)
$NEX_{IPCCdefault}$	=	Default value ~~(IPCC 2006 or US-EPA)~~ for the nitrogen excretion per head of a defined livestock population (kg N/animal/year)

Appendix ~~Annex~~ 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.

666

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).

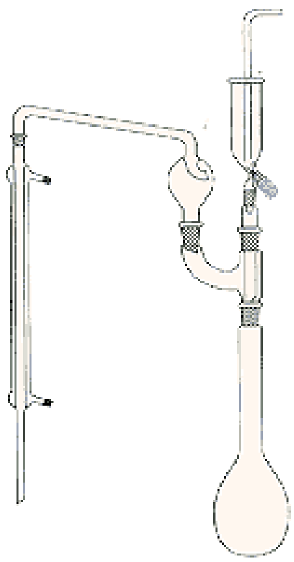
The use of oxidizing can cause loss of nitrogen (Peters & Van Slyke, 1932). There the use of such agents is not recommended for the purposes of the project activities employing this methodology.

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

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

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

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



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 v degrees of freedom for a range of one-sided confidence intervals

v	75%	80%	85%	90%	95%	97.5%	99%	99.5%	99.75%	99.9%	99.95%
1	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	127.3	318.3	636.6
2	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	14.09	22.33	31.60
3	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	7.453	10.21	12.92
4	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767

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

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
06.0.0	EB 67, Annex # 11 May 2012	• Adds reference to methodological tools; • Improves the clarity of the language and provides an additional option to estimate project N_2O emissions.
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.