**Approved baseline and monitoring methodology AM0073**

**"GHG emission reductions through multi-site manure collection and treatment in a central plant"**

# I. SOURCE, DEFINITIONS AND APPLICABILITY

## Sources

This baseline and monitoring methodology is based on the following proposed new methodology:

- NM0239 "Environmental passive mitigation through the management of the swine manure by a Regional Sanitation Plant in the Santa Catarina State, Brazil" prepared by Brescel Energia Ltda and MundusCarbo - Environmental Solutions and Carbon Projects Ltd.;

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

- Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion;
- Tool to calculate baseline, project and/or leakage emissions from electricity consumption;
- Tool to calculate the emission factor for an electricity system;
- Tool for the demonstration and assessment of additionality;
- Tool to determine project emissions from flaring gases containing methane.

For more information regarding the proposed new methodologies and the tools as well as their consideration by the Executive Board 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 applies to project activities where manure is collected by tank trucks, canalized and/or pumped from multiple livestock farms and the collected material is subsequently treated in a single **central treatment plant**. The existing anaerobic manure treatment systems, in the multiple livestock farms within the project boundary, are replaced by a central treatment plant with one or a combination of more than one animal waste management systems (AWMSs) that result in less GHG emissions. CERs may also be claimed from biogas sourced heat/electricity exportations.

The methodology is applicable under the following conditions:

- Farms where livestock populations, comprising of cattle, buffalo, swine, sheep, goats, and/or poultry, are managed under confined conditions;
- Farms where manure is not discharged into natural water resources (e.g. rivers or estuaries);
- Farms where animal residues are treated under anaerobic conditions;
- The annual average temperature in the site where the anaerobic manure treatment facility in the baseline existed is higher than 5°C;[1]

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

- In the cases where the baseline anaerobic treatment system is an open lagoon, the lagoon depth shall be greater than 1 m;[2]
- The retention time of the organic matter in the baseline anaerobic treatment systems should be at least 30 days;
- If residues are stored in between collection activities, storage tanks shall comprise outdoor open equipments;
- If the treated residue is used as fertilizer in the baseline, project proponents must ensure that this end use remains the same throughout the project activity;
- Sludge produced during the project activity shall be stabilized through thermal drying or composting, prior to its final disposition/application;
- The AWMS/process in the project case should ensure that no leakage of manure waste into ground water takes place, e.g., the lagoon should have a non-permeable layer at the lagoon bottom;
- CERs shall be claimed by the Central Treatment Plant managing person/entity, only. Other parties involved must sign a legally binding declaration that they will not claim CERs from the improved animal waste treatment practices. Such declarations shall be verified by the DOE during the validation, and these documents shall be valid throughout the whole crediting period.

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

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

## II. BASELINE METHODOLOGY PROCEDURE

### Identification of the baseline scenario

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

Project participants shall apply the following steps to identify the baseline scenario:

***Step 1: Identify plausible alternative scenarios***

(1) Identify realistic and credible alternative scenarios that are available to the owner of central treatment plant, as well as for the multiple livestock farms owners. For the purpose of identifying relevant alternative scenarios, provide an overview of *other* technologies or practices that provide outputs or services with comparable quality, properties and application areas and that have been implemented previously or are currently underway in the relevant geographical area. The relevant geographical area should be the *at least* the action radius of the regional treatment plant. These alternative scenarios should include, *inter alia*:

[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.

For the owner of central treatment plant:

- The proposed project activity not being registered as a CDM project activity;
- If applicable, continuation of the current situation (no project activity or other alternatives undertaken).

For the owner of the livestock farms:

- 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 doing so, 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 be taken into account;
- If applicable, continuation of the current situation.

(2) The alternative(s) shall be in compliance with all mandatory applicable legal and regulatory requirements (this sub-step does not consider national and local policies that do not have legally-binding status). If an alternative does not comply with all mandatory applicable legislation and regulations, then show that, based on an examination of current practice in the region in which the mandatory law or regulation applies, those applicable mandatory legal or regulatory requirements are systematically not enforced and that non-compliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration. Apply Sub-step 1b of the latest version of the "Tool for demonstration assessment and of additionality".

The identification of all reasonable potential alternative scenarios shall be made through interviews and/or surveys with each farm owner to assess the technology for manure management that would be implemented in the farm in the absence of the project activity. The objective of the interviews/surveys is to collect information to evaluate for each farm owner the likeliness of implementation of the different possible alternative scenarios. From the information collected, it should be possible to identify the barriers that may prevent the implementation of alternative technologies, and when needed to perform the correspondent economic analysis.

For the purpose of identifying alternative scenarios, 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***

This step serves to identify barriers and to assess which alternatives are prevented by these barriers. Apply the following sub-steps:

***Sub-step 2.a. Identify barriers that would prevent the implementation of alternative scenarios***

Establish a complete list of realistic and credible barriers that may prevent alternative scenarios to occur.

Such realistic and credible barriers may include:

- Investment barriers, other than insufficient financial returns as analyzed in Step 3, *inter alia*:
  - For alternatives undertaken and operated by private entities: Similar activities have only been implemented with grants or other non-commercial finance terms. Similar activities are defined as activities that rely on a broadly similar technology or practices, are of a similar scale, take place in a comparable environment with respect to regulatory framework and are undertaken in the relevant geographical area, as defined in Step 1 above;
  - No private capital is available from domestic or international capital markets due to real or perceived risks associated with investments in the country where the project activity is to be implemented, as demonstrated by the credit rating of the country or other country investment reports of reputed origin.

- Technological barriers, *inter alia*:
  - Lack of infrastructure for implementation and logistics for maintenance of the technology;
  - Risk of technological failure: the process/technology failure risk in the local circumstances is significantly greater than for other technologies that provide services or outputs comparable to those of the proposed CDM project activity, as demonstrated by relevant scientific literature or technology manufacturer information;
  - The particular technology used in the proposed project activity is not available in the relevant geographical area.

- Barriers due to prevailing practice, int*er alia*:
  - The alternative is the "first of its kind": No alternative of this type is currently operational in the host country or region.

***Sub-step 2.b. Eliminate alternative scenarios which are prevented by the identified barriers***

Identify which alternative scenarios are prevented by at least one of the barriers listed above, and eliminate those alternative scenarios from further consideration. All alternative scenarios shall be compared to the same set of barriers. The assessment of the significance of barriers should take into account the level of access to and availability of information, technologies and skilled labor in the specific context of the sites.

In applying Sub-steps 2.a and 2.b, provide transparent and documented evidence, and offer conservative interpretations of this evidence, as to how it demonstrates the existence and significance of the identified barriers and whether alternative scenarios are prevented by these barriers. The type of evidence to be provided should include at least one of the following:

- Relevant legislation, regulatory information or industry norms;
- Relevant (sectoral) studies or surveys (e.g. market surveys, technology studies, etc) undertaken by universities, research institutions, industry associations, companies, bilateral/multilateral institutions, etc;
- Relevant statistical data from national or international statistics;
- Documentation of relevant market data (e.g. market prices, tariffs, rules);

- Written documentation from the companies or institutions from which animal waste will be collected, such as minutes from Board meetings, correspondence, feasibility studies, financial or budgetary information, etc;
- Written documentation of independent expert judgments from industry, educational institutions (e.g. universities, technical schools and training centers), industry associations and others.

***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*

This Step 3 serves to determine which of the alternative scenarios in the short list remaining after Step 2 is the most economically or financially attractive. For this purpose, an investment comparison analysis is conducted for the remaining alternative scenarios after Step 2. If the investment analysis is conclusive, the economically or financially most attractive alternative scenario is considered as the baseline scenario.

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 |
|---|---|---|---|---|
| | | | | |
| | | | | |
| **Maintenance costs** | | | | |
| **Other costs**<br>(e.g. operation, consultancy, engineering, etc.) | | | | |
| **Revenues from the sale of electricity or other** | | | | |
| **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.

Include a sensitivity analysis to assess whether the conclusion regarding the financial attractiveness is robust to reasonable variations in the critical assumptions.

***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***

At the renewal of each crediting period, the relevance of baseline scenario identified above will be assessed 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.

This methodology is only applicable if the application of the procedure to identify the baseline scenario results in that **anaerobic manure treatment systems** in the farms and no implementation of the central plant are the most plausible baseline scenario.

***Guidance for the assessment of the baseline scenario for the livestock farms***

For validation, project proponents shall calculate the baseline emission from each farm separately, based on *ex ante* estimation of parameters. Then, project participants shall ordinate, in decreasing order, the sites where most of the baseline emissions would occur. DOEs shall perform **site inspections** on the sites that are individually responsible for an amount of baseline emissions equal to, or higher than, 900 tCO2e ("upper rank"). This guarantees that the most preponderant baseline GHG sources are properly validated. For the remaining sites ("lower rank"), DOEs shall perform site inspections on a number *n* of randomly selected farms, being *n* determined as:

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

Where:

| | | |
|---|---|---|
| n | = | Number of farms to be visited by DOE |
| N | = | Total number of farms |
| E | = | Tolerable sampling error (10%). |

***If when performing the site inspections on the* n *randomly selected farms, one of the farms does not have an anaerobic manure treatment system without methane recovery, then* all *the farms "lower rank"should be inspected.***

## Additionality

The additionality is determined from the perspective of the central treatment plant owner only, being the livestock farms owners excluded from this analysis. The additionality of the project activity shall be demonstrated and assessed using the latest version of the "Tool for the demonstration and assessment of additionality".

Further guidance on barrier analysis is provided for the identification of the baseline scenario in the above section. When doing the investment analysis the following potential income sources should be taken into account: revenues from electricity sales; revenues from heat exportation; revenues from fertilizer sales; revenues from the treatment service provision (e.g. USD per quantity of treated residues); etc.

## Project boundary

The **spatial extent** of the project boundary encompasses:

- The central treatment plant;
- The livestock farms;
- The site of the biogas combustion or energy generation facility (if existent);
- The manure storage tanks;
- The road itineraries and/or piping system between the manure collection points and the central treatment plant.

The greenhouse gases included in or excluded from the project boundary are shown in Table 2.

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

| | **Source** | **Gas** | | **Justification / Explanation** |
|---|---|---|---|---|
| **Baseline** | Direct emissions from the manure treatment processes | $CO_2$ | Excluded | $CO_2$ emissions from the decomposition of organic waste are not accounted |
| | | $CH_4$ | Included | The major source of emissions in the baseline |
| | | $N_2O$ | Included | May be an important emission source |
| | 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. |

| | Source | Gas | | Justification / Explanation |
|---|---|---|---|---|
| | Emissions from thermal energy generation | $CO_2$ | Included | If thermal energy generation is included in the project activity |
| | | $CH_4$ | Excluded | Excluded for simplification. This is conservative. |
| | | $N_2O$ | Excluded | Excluded for simplification. This is conservative. |
| Project Activity | Emissions from thermal energy generation | $CO_2$ | Included | May be an important emission source |
| | | $CH_4$ | Excluded | Excluded for simplification. This emission source is assumed to be very small. |
| | | $N_2O$ | Excluded | Excluded for simplification. This emission source is assumed to be very small. |
| | Emissions from on-site electricity use | $CO_2$ | Included | May be an important emission source. If electricity is generated from collected biogas, these emissions are not accounted for. |
| | | $CH_4$ | Excluded | Excluded for simplification. This emission source is assumed to be very small. |
| | | $N_2O$ | Excluded | Excluded for simplification. This emission source is assumed to be very small. |
| | Direct emissions from the manure treatment processes | $CO_2$ | Excluded | $CO_2$ emissions from the decomposition of organic waste are not accounted. |
| | | $CH_4$ | Included | The emission from uncombusted methane, physical leakage, and minor CH4 emissions from aerobic treatment. |
| | | $N_2O$ | Included | May be an important emission source. |
| | Emissions from manure transportation | $CO_2$ | Included | May be an important emission source. |
| | | $CH_4$ | Excluded | Excluded for simplification. This emission source is assumed to be very small. |
| | | $N_2O$ | Excluded | Excluded for simplification. This emission source is assumed to be very small. |
| | Emissions from sludge composting | $CO_2$ | Excluded | $CO_2$ emissions from the decomposition of organic waste are not accounted. |
| | | $CH_4$ | Included | May be an important emission source. |
| | | $N_2O$ | Included | May be an important emission source. |
| | Emissions from manure storage tanks | $CO_2$ | Excluded | $CO_2$ emissions from the decomposition of organic waste are not accounted. |
| | | $CH_4$ | Included | May be an important emission source. |
| | | $N_2O$ | Excluded | Excluded for simplification. This emission source is assumed to be very small. |

The project proponents will provide a clear diagrammatic representation of the project scenario with all the 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 of methane, if any captured, and also the auxiliary energy used to run project treatments steps.

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

**Project emissions**

The project activity might include one or a combination of technologies to treat manure. For example, the effluent mix might be first treated in an anaerobic digester/reactor and then treated waste might be further processed using an aerobic pond. Each processing step is referred to as a treatment stage.
Project emissions are estimated as follows:

$$PE_y = PE_{AD,y} + PE_{Aer,y} + PE_{Comp,y} + PE_{N_2O,y} + PE_{PL,y} + PE_{flare,y} + PE_{elec/heat,y} + PE_{CO_2,Trans,y} + PE_{storage,y} \quad \textbf{(2)}$$

Where:

| | | |
|---|---|---|
| $PE_y$ | = | Project emissions ($tCO_2e/yr$) |
| $PE_{AD,y}$ | = | Leakage from treatment stage that captures methane ($tCO_2e/yr$) |
| $PE_{Aer,y}$ | = | Methane emissions from the aerobic treatment stage ($tCO_2e/yr$) |
| $PE_{Comp,y}$ | = | Total project emissions due to composting ($tCO_2e/yr$) |
| $PE_{N2O,y}$ | = | Nitrous oxide emission from project treatment system ($tCO_2e/yr$) |
| $PE_{PL,y}$ | = | Physical leakage of emissions from biogas network to flare the captured methane or supply to the facility where it is used for heat and/or electricity generation ($tCO_2e/yr$) |
| $PE_{flare,y}$ | = | Project emissions from flaring of the residual gas stream ($tCO_2e/yr$) |
| $PE_{elec/heat}$ | = | Project emissions from use of heat and/or electricity in the project case (tCO2e/yr) |
| $PE_{CO2,Trans,y}$ | = | Project emissions from manure road transportation ($tCO_2e/yr$) |
| $PE_{storage,y}$ | = | Project emissions from manure storage ($tCO_2e/yr$) |

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

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 or other source of evidence 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 3 or 4 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).

$$PE_{AD,y} = GWP_{CH_4} \cdot \rho_{CH_4,n} \cdot \frac{LF_{AD}}{(1-LF_{AD})} \cdot 10^{-3} \cdot \sum_{h=1}^{8760} \left( FV_{RG,h} \cdot fv_{CH_4,RG,h} \right) \quad \textbf{(3)}$$

Where:

| | | |
|---|---|---|
| $PE_{AD,y}$ | = | Leakage from AWMS systems that capture's methane in $tCO_2e/yr$ |
| $GWP_{CH_4}$ | = | Global Warming Potential (GWP) of $CH_4$ |
| $\rho_{CH_4,n}$ | = | Density of methane at normal (at room temperature 20°C and 1 atm pressure) conditions ($6.7 \times 10^{-4}$ $t/m^3$ ) |

| | | |
|---|---|---|
| $FV_{RG,h}$ | = | Volumetric flow rate of the captured biogas in dry basis at normal conditions in hour *h* ($m^3/h$) |
| $fv_{CH_4,RG,h}$ | = | Volumetric fraction of methane in the captured biogas on dry basis in hour *h* (fraction) |
| $LF_{AD}$ | = | Methane leakage from anaerobic digesters/reactor, default of 0.15 |

Not all volatile solids/COD are degraded in the anaerobic digester/reactor. If the un-degraded volatile solids in the effluent from anaerobic digester are discharged outside the project boundary without further treatment, these emissions should be treated as leakage and appropriately reported and accounted.

*(ii) Methane emissions from aerobic treatment (* $PE_{Aer,y}$ *)*

IPCC guidelines specify emissions from aerobic lagoons as 0.1% of total methane generating potential of the waste processed.

$$PE_{Aer,y} = GWP_{CH_4} \cdot \rho_{CH_4,n} \cdot MCF_{Aer} \sum_{m=1}^{12} \left( Q_{EM,Aer,m} \cdot VS_{EM,Aer,m} \cdot B_{0,EM,m} \right) \tag{4}$$

Where:

| | | |
|---|---|---|
| $PE_{Aer,y}$ | = | Methane emissions from the aerobic treatment stage in $tCO_2e/yr$ |
| $GWP_{CH_4}$ | = | Global Warming Potential (GWP) of $CH_4$ |
| $\rho_{CH_4,n}$ | = | $CH_4$ density ($6.7 \times 10^{-4}$ $t/m^3$ at room temperature (20 ºC) and 1 atm pressure) |
| $Q_{EM,Aer,m}$ | = | Monthly volume of the effluent entering the aerobic treatment step ($m^3$/month) |
| $VS_{EM,Aer,m}$ | = | Average monthly volatile solids (VS) concentration of the effluent entering the aerobic treatment step (ton $VS/m^3$) |
| $B_{0,EM,m}$ | = | Average monthly $CH_4$ production capacity of effluent manure entering the aerobic treatment stage ($m^3CH_4$/ton-VS) |
| $MCF_{Aer}$ | = | Methane Conversion Factor (MCF) for aerobic system (0.1%) |

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

$$PE_{Comp,y} = PE_{Comp,CH_4,y} + PE_{Comp,N_2O,y} \cdot \tag{5}$$

$$PE_{Comp,CH_4,y} = GWP_{CH_4} \cdot \rho_{CH_4,n} \cdot MCF_{res} . \sum_{m=1}^{12} \left( Q^{in}_{Comp,m} \cdot VS_{res,m} . B_{0,res,m} \right) \tag{6}$$

Where:

| | | |
|---|---|---|
| $PE_{Comp,CH_4,y}$ | = | Methane emissions from composting in $tCO_2e/yr$ |
| $GWP_{CH_4}$ | = | Global Warming Potential (GWP) of $CH_4$ |
| $Q^{in}_{Comp,m}$ | = | Monthly quantity of residues entering the composting plant in a dry matter basis (ton/month) |
| $B_{0,res,m}$ | = | Average monthly $CH_4$ production capacity of residues entering the composting step, in $m^3$ $CH_4$/ton-VS |

| | | |
|---|---|---|
| $MCF_{res}$ | = | Methane Conversion Factor (MCF) for composting system as per IPCC 2006 Table 10.17 volume 4 chapter 10 |
| $VS_{res,m}$ | = | Average monthly volatile solids (VS) concentration of the residue entering the composting step (ton VS/ton) |
| $\rho_{CH_4,n}$ | = | Density of methane at normal (at room temperature 20°C and 1 atm pressure) conditions ($6.7x10^{-4}$ $t/m^3$) |

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

- ISO 11734:1995;[3]
- ASTM E2170-01 (2008)[4] and;
- ASTM D 5210-92.[5]

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

$$PE_{Comp,N_2O,y} = GWP_{N_2O} \cdot CF_{N_2O-N,N} \cdot \left(PE_{Comp,N_2O,D,y} + PE_{Comp,N_2O,ID,y}\right) \quad \textbf{(7)}$$

$$PE_{Comp,N_2O,D,y} = EF_{N_2O,Comp,D} \cdot 10^{-3} \cdot \sum_{m=1}^{12} \left(Q_{Comp,m}^{in} \cdot [N]_{Comp,m}^{in}\right) \quad \textbf{(8)}$$

$$PE_{Comp,N_2O,ID,y} = (EF_4 + EF_5).10^{-3} \cdot \left\{ \sum_{m=1}^{12} \left[\left(Q_{Comp,m}^{in} \cdot [N]_{Comp,m}^{in}\right) - \left(Q_{Comp,m}^{out} \cdot [N]_{Comp,m}^{out}\right)\right] - PE_{Comp,N_2O,D,y} \right\} \quad \textbf{(9)}$$

Where:

| | | |
|---|---|---|
| $PE_{Comp,N_2O,y}$ | = | Total project $N_2O$ emissions due to composting in $tCO_2e/yr$ |
| $PE_{Comp,N_2O,D,y}$ | = | Total project direct $N_2O$ emissions due to composting in tN-$N_2O$/yr |
| $PE_{Comp,N_2O,ID,y}$ | = | Total project indirect $N_2O$ emissions due to composting in tN-$N_2O$/yr |
| $GWP_{N_2O}$ | = | Global Warming Potential (GWP) for $N_2O$ |
| $CF_{N_2O-N,N}$ | = | Conversion factor $N_2O$-N to $N_2O$ (44/28) |
| $EF_{N_2O,Comp,D}$ | = | Direct $N_2O$ emission factor for composting in kg $N_2O$-N/kg N (estimated with site-specific, regional or national data if such data is available. Otherwise use default $EF_3$ in volume 4, chapter 10, table 10.21 in IPCC2006 Guidelines) |
| $EF_4$ | = | Emission factor for $N_2O$ emissions from atmospheric deposition of N on soils and water surfaces, [kg N- $N_2O$ / (kg $NH_3$.N + NOx-N volatilized)], estimated with site-specific, regional or national data if such data is available.  Otherwise, default values from table 11.3, chapter 11, volume 4 of IPCC 2006 (0.01 kg N2O-N/(kg NH3-N +NOx-N volatilised) |

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

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

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

| | | |
|---|---|---|
| $EF_5$ | = | Emission factor for indirect emission of $N_2O$ from runoff in kg $N_2O$-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3, chapter 11, volume 4 of IPCC 2006 Guidelines can be used (0.0075 kg N2O-N/(kg N leaching/runoff) |
| $Q_{Comp,m}^{in}$ | = | Monthly quantity of residues entering the composting plant in a dry matter basis (ton/month) |
| $[N]_{Comp,m}^{in}$ | = | Monthly total nitrogen concentration in the residues entering the composting plant (kg N/ton residue) |
| $Q_{Comp,m}^{out}$ | = | Monthly quantity of composted residues produced, in a dry matter basis (ton/month) |
| $[N]_{Comp,m}^{out}$ | = | Monthly total nitrogen concentration in composted residues produced (kg N/ton residue) |

*(iii) $N_2O$ emissions from the central treatment plant*

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

$$E_{N_2O,D,y} = \sum_n EF_{N_2O,D,n} \cdot \sum_{m=1}^{12}\left(Q_{EM,m} \cdot [N]_{EM,m}\right) \quad \textbf{(11)}$$

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

Where:

| | | |
|---|---|---|
| $PE_{N_2O,y}$ | = | Annual project $N_2O$ emissions in $tCO_2e$/yr |
| $GWP_{N_2O}$ | = | Global Warming Potential (GWP) for $N_2O$ |
| $CF_{N_2O-N,N}$ | = | Conversion factor $N_2O$-N to $N_2O$ (44/28) |
| $E_{N_2O,D,y}$ | = | Direct $N_2O$ emission in kg $N_2O$-N/year |
| $E_{N_2O,ID,y}$ | = | Indirect $N_2O$ emission in kg $N_2O$-N/year |
| $EF_{N_2O,D,n}$ | = | Direct $N_2O$ emission factor for the treatment stage n of the central treatment plant in kg $N_2O$-N/kg N (estimated with site-specific, regional or national data if such data is available. Otherwise use default $EF_3$ in volume 4, chapter 10, table 10.21 in IPCC 2006 guidelines) |
| $Q_{EM,m}$ | = | Monthly volume of the effluent mix entering the central plant ($m^3$/month) |
| $[N]_{EM,m}$ | = | Monthly total nitrogen concentration in the effluent mix (kg N/$m^3$) entering the treatment plant |
| $EF_{N_2O,ID}$ | = | Indirect $N_2O$ emission factor for $N_2O$ emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg $N_2O$-N/kg $NH_3$-N and NOx-N emitted, estimated with site-specific, regional or national data if such data is available. Otherwise, default values for $EF_4$ from table 11.3, chapter 11, volume 4 of IPCC 2006 guidelines can be used |
| $F_{gasm,j}$ | = | Percent of total nitrogen that volatilises as $NH_3$ and NOx in the treatment stage *j* |

For subsequent treatment stages, the 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 Annex 1. Else, $R_N$ can be calculated based on the direct monitoring of the nitrogen concentration in the effluent mix after each treatment step.

*(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.

*(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 heat use and electricity use ($PE_{elec/heat}$):*

$$PE_{elec/heat,y} = PE_{Elec,y} + \sum_{j} PE_{heat,j,y} \quad \textbf{(13)}$$

Where:

$PE_{Elec,y}$ = Are the emissions from consumption of electricity in the project case. The project emissions from electricity consumption ($PE_{Elec,y} = PE_{EC,y}$) will be calculated following the latest version of “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 project activity

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

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

*(vii) Project emissions from road transportation*

The project emissions from manure transportation from the collection points to the central treatment plant are to be calculated using distance traveled by trucks and the fuel emission factor, as follows:

$$PE_{CO_2,Trans,y} = \left\{ \sum_i \left( N_{vehicles,i,y} \cdot Dist_{i,y} \cdot FC_{i,f} \right) \cdot \left[ \sum_f NCV_f \cdot EF_{CO_2,f} \right] \right\} \quad \textbf{(14)}$$

Where:

| | | |
|---|---|---|
| $PE_{CO_2,Trans,y}$ | = | Project emissions from manure road transportation in $tCO_2e/yr$ |
| $N_{vehicles,i,y}$ | = | Number of trips of vehicles type i used for transportation, with similar loading capacity |
| $Dist_{i,y}$ | = | Average distance per trip travelled by transportation vehicles type *i* during the year *y* (km) |
| $FC_{i,f}$ | = | Specific consumption of fuel type f in volume or mass units per km for vehicle type *i* |
| $NCV_f$ | = | Net calorific value of fuel type f in TJ per volume or mass units |
| $EF_{CO_2,f}$ | = | $CO_2$ emission factor of the fossil fuel type f used in transportation vehicles, ($tCO_2e/TJ$) |

Emissions arising form the road transportation of treated manure shall be calculated as described above. Such emission shall be considered as project emissions if the final destiny and itinerary between the treatment plant are included in the project boundary. Otherwise such emission shall be considered as leakage ( $LE_{CO_2,Trans,y}$ ), which shall be calculated in the same manner as depicted above.

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

$$PE_{storage,y} = GWP_{CH_4} * \rho_{CH_4,n} * \sum_{LT,l} \left[ \frac{365}{AI_l} \sum_{d=1}^{AI} (N_{LT} * VS_{LT,d} * MS\%_l * (1 - e^{-k\ (AI_l - d)}) * MCF_l * B_{0_{LT}}) \right] \quad \textbf{(15)}$$

Where:

| | | |
|---|---|---|
| $PE_{storage,y}$ | = | Annual project emission in manure storage tanks in $tCO_{2e}/yr$ |
| $GWP_{CH4}$ | = | Global warming potential of methane |
| $\rho_{CH4,n}$ | = | Density of methane ($6.7 \times 10^{-4}$ $t/m^3$ at room temperature (20ºC and 1 atm pressure) |

| | | |
|---|---|---|
| $AI_l$ | = | Annual average interval between manure collection procedures at a given storage tank l (days) |
| $N_{LT}$ | = | Number of animals of type LT during a year y, expressed in numbers |
| $VS_{LT,d}$ | = | Amount of volatile solid production by type of animal LT in a day (kg VS/head/d) |
| $MS\%_l$ | = | Fraction of volatile solids (%) handled by storage tank *l* |
| k | = | Degradation rate constant (0.069) |
| d | = | Days for which cumulative methane emissions are calculated; d can vary from 1 to 45 and to be run from 1 up to AI (average interval between manure collection procedure) |
| $MCF_l$ | = | Annual methane conversion factor for the project manure storage tank *l* from Table 10.17, Chapter 10, Volume 4 |
| $B_{o,LT}$ | = | Maximum methane yield from manure for livestock type LT, in $m^3CH_4$/kgVS from IPCC 2006, Table 10A-4 to 10A-9, Chapter 10, Volume 4 |

**Baseline emissions**

Baseline emissions are calculated as the sum of $CH_4$ and $N_2O$ emissions that would occur in the baseline animal waste treatment system and $CO_2$ emissions arising from heat and electricity consumption. Hence:

$$BE_y = BE_{AW,y} + BE_{elec/heat,y} \tag{16}$$

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Total baseline emissions in year *y*, in $tCO_2e$/year |
| $BE_{AW,y}$ | = | Baseline emissions attributable to animal waste treatment in year *y*, in $tCO_2e$/year |
| $BE_{elec/heat,y}$ | = | Baseline $CO_2$ emissions from electricity and/or heat generated/consumed in the baseline, in $tCO_2e$/year |

## *I. Emissions from animal waste treatment*

The baseline is the AWMS identified through the baseline selection procedure.

Baseline emissions are:

$$BE_{AW,y} = BE_{AW,CH_4,y} + BE_{AW,N_2O,y} \tag{17}$$

Where:

| | | |
|---|---|---|
| $BE_{AW,Y}$ | = | Baseline emissions attributable to animal waste treatment in year *y*, in $tCO_2e$/year |
| $BE_{AW,CH_4,y}$ | = | Baseline methane emissions attributable to animal waste treatment in year *y*, in $tCO_2e$/year |
| $BE_{AW,N_2O,y}$ | = | Baseline $N_2O$ emissions attributable to animal waste treatment in year *y*, in $tCO_2e$/year |

*(i) Methane emissions from animal waste treatment*

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

$$BE_{AW,CH_{4},y} = GWP_{CH_4} * \rho_{CH_{4,n}} * \sum_{j,LT}(MCF_j * B_{0,LT} * N_{LT,y} * VS_{LT,y} * MS\%_{Bl,j} \tag{18}$$[7]

Where:

| | | |
|---|---|---|
| $BE_{AW,CH_{4,y}}$ | = | Annual baseline methane emissions in $tCO_2e/y$ |
| $GWP_{CH_4}$ | = | Global Warming Potential (GWP) of $CH_4$ |
| $\rho_{CH_4,n}$ | = | $CH_4$ density ($6.7 x 10^{-4}$ t/$m^3$ at room temperature (20ºC) and 1 atm pressure) |
| $MCF_j$ | = | Annual methane conversion factor (MCF) for the baseline AWMSj from IPCC 2006 table 10.17, chapter 10, volume 4 |
| $B_{0,LT}$ | = | Maximum methane producing potential of the volatile solid generated, in $m^3$ $CH_4$/kg_VS_dm, by animal type LT |
| $N_{LT,y}$ | = | Annual average number of animals of type LT for the year *y*, expressed in numbers |
| $VS_{LT,y}$ | = | Annual volatile solid for livestock LT entering all AWMS [on a dry matter weight basis (kg-VS-dm/animal/year)], as estimated below |
| $MS\%_{Bl,j}$ | = | Fraction of manure handled in AWMS type *j* in the baseline scenario |

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

*(A)* $VS_{LT,y}$ can be determined in one of the following ways, stated in the order of preference:

(1) Using published country specific data. If the data is expressed in kg dm per day, multiply the value with $nd_y$ (number of days the central treatment plant was operational in year *y*);

(2) Estimation of VS based on dietary intake of livestock;

$$VS_{LT,y} = \left[ GE_{LT} \cdot \left(1 - \frac{DE_{LT}}{100}\right) + \left(UE \cdot GE_{LT}\right)\right] \cdot \left[\left(\frac{1 - ASH}{ED_{LT}}\right)\right] \cdot nd_y \tag{19}$$

Where:

| | | |
|---|---|---|
| $VS_{LT,y}$ | = | Annual volatile solid excretions on a dry matter weight basis (kg-dm/animal/year) |
| $GE_{LT}$ | = | Daily average gross energy intake in MJ/day; on dry matter basis (Calculated as per Equation 10.16. Chapter 10, Volume 4 of IPCC 2006 or use default value of 18.45 MJ/kg of dry matter if field specific information is not available) |
| $DE_{LT}$ | = | Digestible energy of the feed in percent (IPCC 2006 Table 10.2, Chapter 10, Volume 4) |

[7] When the dietary intake of livestock is different from farm to farm, these emissions should be separately estimated for each farm and then summed up.

| | | |
|---|---|---|
| $UE \cdot GE_{LT}$ | = | Urinary energy expressed as fraction of GE. Typically 0.04GE can be considered urinary energy excretion by most ruminants (reduce to 0.02 for ruminants fed with 85% or more grain in the diet or for swine). Use country-specific values where available |
| $ASH$ | = | Ash content of manure calculated as a fraction of the dry matter feed intake. Use country-specific values where available |
| $ED_{LT}$ | = | Energy density of the feed in MJ/kg (IPCC notes the energy density of feed, ED, is typically 18.45 MJ/kg-dm, which is relatively constant across a wide variety of grain based feeds.) fed to livestock type LT. The project proponent will record the composition of the feed to enable the DOE to verify the energy density of the feed |
| $nd_y$ | = | Number of days the central treatment plant was operational in year $y$ |

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

$$VS_{LT,y} = \left( \frac{W_{site}}{W_{default}} \right) \cdot VS_{default} \cdot nd_y \qquad \textbf{(20)}$$

Where:

| | | |
|---|---|---|
| $VS_{LT,y}$ | = | Adjusted volatile solid excretion per year on a dry-matter basis for a defined livestock population at the project site in kg-dm/animal/yr |
| $W_{site}$ | = | Average animal weight of a defined population at the project site in kg |
| $W_{default}$ | = | Default average animal weight of a defined population in kg from where the data on $VS_{default}$ is sourced (IPCC 2006, Table 10A-4 to 10A-9, Chapter 10, Volume 4 or US-EPA, whichever is lower) |
| $VS_{default}$ | = | Default value (IPCC 2006, Table 10A-4 to 10A-9, Chapter 10, Volume 4 or US-EPA, whichever is lower) for the volatile solid excretion per day on a dry-matter basis for a defined livestock population in kg-VS-dm/animal/day |
| $nd_y$ | = | Number of days the central treatment plant was operational in year $y$ |

(4) Utilizing default values of IPCC 2006, Table 10A-4 through 10A-9, Chapter 10, Volume 4, multiply the value by $nd_y$ (number of days the central treatment plant was operational in year $y$);

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

(5) Direct Measurement of VS.

$$VS_{LT;y} = W_{manure,LT} * VS_{manure,LT} * nd_y \qquad \textbf{(21)}$$

Where:

| | | |
|---|---|---|
| $VS_{LT,y}$ | = | Annual volatile solid excretions on a dry-matter weight basis (kg-VS-dm/animal/yr) |
| $W_{manure;LT}$ | = | Average manure weight excreted by a defined population at the project site in kg/animal/day) |
| $VS_{manure;LT}$ | = | Average VS in the manure excreted by a defined population at the project site in kg-VS-dm per kg of manure; (calculated as per Annex 2) |
| $nd_y$ | = | Number of days the central treatment plant was operational in year y |

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).

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

(1) This value varies by livestock 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 farms 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.

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

- ISO 11734:1995;[8]
- ASTM E2170-01 (2008)[9] and;
- ASTM D 5210-92.[10]

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

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

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

*(C) Methane conversion factors ($MCF_j$):*

- The IPCC 2006 MCF values given in table 10.17 (chapter 10, volume 4) should be used, which is attached here as Annex 4. MCF values depend on the annual average temperature where the anaerobic manure treatment facility in the baseline existed. For average annual temperatures below 10ºC and above 5ºC, 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 5ºC. 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)[11]. These values are provided in Annex 1.

*(D) Annual Average number of animals ($N_{LT}$):*

$$N_{LT} = N_{da} * \left( \frac{N_p}{365} \right) \qquad \textbf{(22)}$$

Where:

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

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.

$$N_{LT} = \frac{\sum_{1}^{365} N_{AA}}{365} \qquad \textbf{(23)}$$

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

Where:

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

*(ii) $N_2O$ emissions from manure management*

$$BE_{AW,N_2O,y} = GWP_{N_2O} * CF_{N_2O-N,N} * 10^{-3} * \left(E_{N_2O,D,y} + E_{N_2O,ID,y}\right) \quad \textbf{(24)}$$

$$E_{N_2O,D,y} = \sum_{j,LT}\left(EF_{N_2O,D,j} * NEX_{LT,y} * N_{LT,y} * MS\%_{Bl,j}\right) \quad \textbf{(25)}$$

$$E_{N_2O,ID,y} = \sum_{j,LT}\left((EF_{4,j} + EF_{5,j}) * F_{gasm} * NEX_{LT,y} * N_{LT,y} * MS\%_{Bl,j}\right) \quad \textbf{(26)}$$

Where:

| | | |
|---|---|---|
| $BE_{AW,N_2O,y}$ | = | Annual baseline $N_2O$ emissions in $tCO_2e/yr$ |
| $GWP_{N_2O}$ | = | Global Warming Potential (GWP) for $N_2O$ |
| $CF_{N_2O-N,N}$ | = | Conversion factor $N_2O$-N to $N_2O$ (44/28) |
| $E_{N_2O,D,y}$ | = | Direct $N_2O$ emissions in kg $N_2O$-N/year |
| $E_{N_2O,ID,y}$ | = | Indirect $N_2O$ emissions in kg $N_2O$-N/year |
| $EF_{N_2O,D,j}$ | = | Direct $N_2O$ emission factor for the treatment system j of the manure management system in kg $N_2O$-N/kg N (estimated with site-specific, regional or national data if such data is available, otherwise use default $EF_3$ from table 10.21, chapter 10, volume 4, in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories) |
| $NEX_{LT,y}$ | = | Is the annual average nitrogen excretion per head of a defined livestock population in kgN/animal/year estimated as described in Annex 6 |
| $N_{LT,y}$ | = | Number of animals of type LT for the year $y$, expressed in numbers |
| $MS\%_{Bl,j}$ | = | Fraction of manure handled in system $j$, in % |
| $F_{gasm}$ | = | Percent of managed manure nitrogen for livestock category that volatilises as $NH_3$ and NOx in the manure management system |
| $EF_{4,j}$ | = | Emission factor for $N_2O$ emissions from atmospheric deposition of N on soils and water surfaces, [kg N- $N_2O$ / (kg $NH_3$-N + NOx-N volatilized)], estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3, chapter 11, volume 4 of IPCC 2006 (0.01 kg N2O-N/(kg NH3-N +NOx-N volatilised) |
| $EF_{5,j}$ | = | Emission factor for indirect emission of $N_2O$ from runoff in kg $N_2O$-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3, chapter 11, volume 4 of IPCC 2006 guidelines can be used (0.0075 kg N2O-N/(kg N leaching/runoff) |

For subsequent treatment stages, the reduction of the nitrogen during a treatment stage is estimated based on referenced data for different treatment types. Emissions from the next treatment stage are then calculated following the approach outlined above, but with nitrogen adjusted for the reduction from the previous treatment stages by multiplying by (1 - $R_N$), 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 USEPA (2001).[12] These values are provided in Annex 1.

### *II. $CO_2$ emissions from electricity and heat within the project boundary*

$$BE_{elec/heat,y} = EG_{Bl,y} * CEF_{Bl,elec,y} + EG_{d,y} * CEF_{grid} + HG_{Bl,y} * CEF_{Bl,therm,y} \quad \textbf{(27)}$$

Where:

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

Determination of $CEF_{Bl,elec}$:

- 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 the latest version of the "Tool to calculate project emissions from electricity consumption". If electricity consumption is less than small-scale threshold (60 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"*.

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

Determination of $CEF_{Bl,therm}$:

$CEF_{Bl,therm}$ is the $CO_2$ emissions intensity for thermal energy generation ($tCO_2e/MJ$).

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

**Leakage**

Leakage covers the emissions from land application of treated residues, outside the project boundary. These emissions are estimated as net of those released under project activity and those released in the baseline scenario. Net leakage of $N_2O$ and $CH_4$ are only considered if they are positive. $CO_2$ emissions due to the road transportation of sludge or treated effluent outside the project boundary are also considered as leakage. Such emissions are calculated in the same as depicted in the project emissions section.

$$LE_y = \left(LE_{P,N_2O} - LE_{B,N_2O}\right) + \left(LE_{P,CH_4} - LE_{B,CH_4}\right) + LE_{CO_2,Trans,y} \tag{28}$$

Where:

| | | |
|---|---|---|
| $LE_y$ | = | Leakage emissions for the year *y*, in $tCO_2e$/year |
| $LE_{P,N_2O}$ | = | $N_2O$ emissions released during project activity from land application of the treated residues, in $tCO_2e$/year |
| $LE_{B,N_2O}$ | = | $N_2O$ emissions released during baseline scenario from land application of the treated manure, in $tCO_2e$/year |
| $LE_{P,CH_4}$ | = | $CH_4$ emissions released during project activity from land application of the treated residues, in $tCO_2e$/year |
| $LE_{B,CH_4}$ | = | $CH_4$ emissions released during baseline scenario from land application of the treated manure, in $tCO_2e$/year |
| $LE_{CO_2,Trans,y}$ | = | Emissions from treated residues road transportation in $tCO_2e$/yr |

*(i) Estimation of $N_2O$ emissions*

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

$$LE_{B,N_2O} = GWP_{N_2O} \cdot CF_{N_2O-N,N} \cdot 10^{-3} \cdot \left(LE_{B,N_2O,land} + LE_{B,N_2O,runoff} + LE_{B,N_2O,vol}\right) \tag{29}$$

$$LE_{B,N_2O,land} = EF_1 \cdot \prod_{n=1}^{N}\left(1 - R_{N,n}\right) \cdot \sum_{j,LT}\left(N_{LT,y} \cdot NEX_{LT} \cdot MS\%_{BL,j}\right) \tag{30}$$

$$LE_{B,N_2O,runoff} = EF_5 \cdot F_{leach} \cdot \prod_{n=1}^{N}\left(1 - R_{N,n}\right) \cdot \sum_{j,LT}\left(N_{LT,y} \cdot NEX_{LT} \cdot MS\%_{BL,j}\right) \tag{31}$$

$$LE_{B,N_2O,vol} = EF_4 \cdot F_{gasm} \cdot \prod_{n=1}^{N}\left(1 - R_{N,n}\right) \cdot \sum_{j,LT}\left(N_{LT,y} \cdot NEX_{LT} \cdot MS\%_{Bl,j}\right) \tag{32}$$

Where:

| | | |
|---|---|---|
| $LE_{B,N_2O}$ | = | $N_2O$ emissions released during baseline scenario from land application of the treated manure, in $tCO_2e$/year |
| $GWP_{N_2O}$ | = | Global Warming Potential (GWP) for $N_2O$ |
| $CF_{N_2O-N,N}$ | = | Conversion factor (= 44/28) |
| $LE_{B,N_2O,land}$ | = | Baseline direct $N_2O$ emissions from application of manure waste, in kg $N_2O$-N/year |
| $LE_{B,N_2O,runoff}$ | = | Baseline $N_2O$ emissions due to leaching and run-off, in kg $N_2O$-N/year |
| $LE_{B,N_2O,vol}$ | = | Baseline $N_2O$ emissions due to nitrogen volatilization as $NH_3$ and NOx, in kg $N_2O$-N/year |
| $F_{gasm}$ | = | Fraction of total N that volatizes as $NH_3$ and NOx in kg $NH_3$-N and NOx-N per kg of N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3, chapter 11, volume 4 of IPCC 2006 guidelines can be used |
| $N_{LT,y}$ | = | Number of animals of type LT for the year *y*, expressed in numbers |
| $NEX_{LT}$ | = | Is the annual average nitrogen excretion per head of a defined livestock population in kg N/animal/year estimated as described in Annex 6 |
| $MS\%_{Bl,j}$ | = | Fraction of manure handled in system j in the baseline scenario |
| $EF_1$ | = | Emission factor for direct emission of $N_2O$ from soils in kg $N_2O$-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.1, chapter 11, volume 4 of IPCC 2006 guidelines can be used |
| $R_{N,n}$ | = | Fraction of N that is reduced in the Baseline AWMS. The relative reduction of nitrogen depends on the treatment technology and should be estimated in a conservative manner. Default values for different treatment technologies can be found in Annex 1 |
| $EF_5$ | = | Emission factor for indirect emission of $N_2O$ from runoff in kg $N_2O$-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3, 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 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 |
| $EF_4$ | = | Emission factor for $N_2O$ emissions from atmospheric deposition of N on soils and water surfaces, [kg N- $N_2O$ / (kg $NH_3$-N + NOx-N volatilized)], estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3, chapter 11, volume 4 of IPCC 2006. |

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

$$LE_{P,N_2O} = GWP_{N_2O} \cdot CF_{N_2O-N,N} \cdot 10^{-3} \cdot \left(LE_{P,N_2O,land} + LE_{P,N_2O,runoff} + LE_{P,N_2O,vol}\right) \quad \textbf{(33)}$$

$$LE_{P,N_2O,land} = EF_1 \cdot \sum_{m=1}^{12} \left(Q_{DE,m} \cdot [N]_{DE,m}\right) \quad \textbf{(34)}$$

$$LE_{P,N_2O,runoff} = EF_5 \cdot F_{leach} \cdot \sum_{m=1}^{12} \left( Q_{DE,m} \cdot [N]_{DE,m} \right) \quad \textbf{(35)}$$

$$LE_{P,N_2O,vol} = EF_4 \cdot F_{gasm} \cdot \sum_{m=1}^{12} \left( Q_{DE,m} \cdot [N]_{DE,m} \right) \quad \textbf{(36)}$$

Where:

| | | |
|---|---|---|
| $LE_{P,N_2O}$ | = | $N_2O$ emissions released during project scenario from land application of the treated residues, in $tCO_2e$/year |
| $GWP_{N_2O}$ | = | Global Warming Potential (GWP) for $N_2O$ |
| $CF_{N_2O-N,N}$ | = | Conversion factor (44/28) |
| $LE_{P,N_2O,land}$ | = | Project case direct $N_2O$ emission from application of treated effluent, in kg $N_2O$-N/year |
| $LE_{P,N_2O,runoff}$ | = | Project case $N_2O$ emission due to leaching and run-off, in kg $N_2O$-N/year |
| $LE_{P,N_2O,vol}$ | = | Project case $N_2O$ emissions due to nitrogen volatilization as $NH_3$ and NOx, in kg $N_2O$-N/year |
| $F_{gasm}$ | = | Fraction of total N that volatizes as $NH_3$ and NOx in kg $NH_3$-N and NOx-N per kg of N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3, chapter 11, volume 4 of IPCC 2006 guidelines can be used |
| $Q_{DE,m}$ | = | Total monthly quantity of treated effluent disposed outside the project boundary (DE) ($m^3$ or tons of dry matter) |
| $[N]_{DE,m}$ | = | Mean monthly nitrogen concentration of treated effluent disposed outside the project boundary (DE) (kg N/$m^3$ or kg N/ton of dry matter) |
| $EF_1$ | = | Emission factor for direct emission of $N_2O$ from soils in kg $N_2O$-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.1, chapter 11, volume 4 of IPCC 2006 guidelines can be used |
| $EF_5$ | = | Emission factor for indirect emission of $N_2O$ from runoff in kg $N_2O$-N/kg N, estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 11.3, 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 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 |
| $EF_4$ | = | Emission factor for $N_2O$ emissions from atmospheric deposition of N on soils and water surfaces, [kg N- $N_2O$ / (kg $NH_3$-N + NOx-N volatilized)], estimated with site-specific, regional or national data if such data is available. Otherwise, default values from table 11.3, chapter 11, volume 4 of IPCC 2006 |

*(iii) Methane emissions from disposal of treated residues*

$$LE_{B,CH_4} = GWP_{CH4} \cdot \rho_{CH4,n} \cdot MCF_d \cdot \left[ \prod_{n-1}^{N} \left( 1 - R_{VS,n} \right) \right] \sum_{j,LT} \left( B_{0,LT} \cdot N_{LT,y} \cdot VS_{LT,y} \cdot MS\%_{BL,j} \right) \quad \textbf{(37)}$$

$$LE_{P,CH_4} = GWP_{CH_4} \cdot \rho_{CH_4,n} \cdot MCF_d \cdot \sum_{m=1}^{12}\left(Q_{DE,m} \cdot VS_{DE,m}\right)\cdot 10^3 \cdot \frac{\sum_{LT}\left(B_{0,LT} \cdot N_{LT,y} \cdot VS_{LT,y}\right)}{\sum_{LT}\left(N_{LT,y} \cdot VS_{LT,y}\right)} \quad \textbf{(38)}$$

Where:

| | | |
|---|---|---|
| $LE_{B,CH_4}$ | = | Methane leakage emissions in the baseline ($tCO_2e$/yr) |
| $LE_{P,CH_4}$ | = | Methane leakage emissions in the project case (t $CO_2e$/yr) |
| $R_{VS,n}$ | = | Fraction of volatile solid degraded in AWMS n prior to sludge being treated. Values for $R_{VS}$ should be taken from Annex 1 |
| $GWP_{CH_4}$ | = | Global Warming Potential (GWP) of $CH_4$ |
| $\rho_{CH_4,n}$ | = | $CH_4$ density [$6.7x10^{-4}$ t/$m^3$ at room temperature (20 ºC) and 1 atm pressure] |
| $B_{0,LT}$ | = | $CH_4$ production capacity from manure for livestock type LT, in m3 $CH_4$/kg-VS, to be chosen based on procedure provided for in the baseline methodology section |
| $N_{LT,y}$ | = | Number of animals of type LT for the year y, expressed in numbers |
| $VS_{LT,y}$ | = | Annual volatile solid for livestock LT entering all AWMS [on a dry matter weight basis (kg-dm/animal/year)] |
| $MS\%_{Bl,j}$ | = | Fraction of manure handled in system *j* in the baseline scenari |
| $Q_{DE,m}$ | = | Total monthly volume of treated residues disposed outside the project boundary (DE) ($m^3$ or tons of dry matter) |
| $VS_{DE,m}$ | = | Monthly volatile solids concentration of the disposed residues (ton VS/$m^3$or ton VS/ton of dry matter) |
| $MCF_d$ | = | Methane conversion factor for leakage calculation assumed to be equal 1 |

**Emission reductions**

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \textbf{(39)}$$

Where:

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

Further, in estimating emissions reduction for claiming certified emissions reductions, if the calculated CH4 emissions from the baseline are higher than the measured CH4 generated in the anaerobic digester in the project situation (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/reactor shall be compared to the ($BE_{CH_4,y} - PE_{AD,y} - PE_{PL,y}$) and if found lower, then ($BE_{CH_4,y} - PE_{AD,y} - PE_{PL,y}$) (which is a component of $BE_y - PE_y$) in equation 39 is replaced by actual methane captured.

**Data and parameters not monitored**

In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

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

| **ID Number:** | 2 |
|---|---|
| **Parameter:** | $EF_{N_2O,ID}$ |
| Data unit: | kg $N_2O$-N/ kg $NH_3$-N and NOx-N |
| Description: | Indirect $N_2O$ emission factors |
| Source of data: | IPCC 2006 Guidelines |
| 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. |

| **ID Number:** | 3 |
|---|---|
| **Parameter:** | $F_{gasm}$ |
| Data unit: | Fraction |
| Description: | Percent of total nitrogen that volatilises as $NH_3$ and NOx in the treatment stage $j$ |
| Source of data: | IPCC 2006 Guidelines |
| 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. |

| **ID Number:** | 4 |
|---|---|
| **Parameter:** | $EF_1$, $EF_4$ **and** $EF_5$ |
| Data unit: | kg $N_2O$-N/ kg N for $EF_1$and $EF_5$; kg $N_2O$-N/ kg $NH_3$-N and NOx-N for $EF_4$ |
| Description: | $N_2O$ emission factor from soil and runoff water |
| Source of data: | IPCC 2006 Guidelines |
| 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. |

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

| **ID Number:** | 6 |
|---|---|
| **Parameter:** | $EG_{Bl,y}$ |
| Data unit: | MWh |
| Description: | Electricity consumption by Baseline AWMSs |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically for the duration of project plus 5 years |
| Any comment: | Estimation is based on one year 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. |

| **ID Number:** | 7 |
|---|---|
| **Parameter:** | $HG_{Bl,y}$ |
| Data unit: | MJ |
| Description: | Heat used by baseline AWMSs |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronic for the duration of project + 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:** | 8 |
|---|---|
| **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:** | 9 |
| **Parameter:** | $GWP_{CH_4}$ **and** $GWP_{N_2O}$ |
| Data unit: | Dimensionless |
| Description: | Global warming potential for $CH_4$ and $N_2O$, respectively. |
| Source of data: | IPCC 2006 Guidelines |
| Measurement procedures (if any): | 21 and 310, respectively, for the first commitment period. Shall be updated according to any future COP/MOP decisions. |
| Any comment: | --- |

| | |
|---|---|
| **ID Number:** | 10 |
| **Parameter:** | $\rho_{CH_4,n}$ |
| Data unit: | t/m$^3$ |
| Description: | Density of methane at normal (at room temperature 20°C and 1 atm pressure)conditions |
| Source of data: | Technical literature |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Any comment: | $6.7 \times 10^{-4}$ t/m$^3$ |

| | |
|---|---|
| **ID Number:** | 11 |
| **Parameter:** | $MCF_d$ |
| Data unit: | --- |
| Description: | Methane conversion factor for leakage calculation assumed to be equal 1 |
| Source of data: | See Leakage section |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Any comment: | --- |

| | |
|---|---|
| **ID Number:** | 12 |
| **Parameter:** | $CF_{N_2O-N,N}$ |
| 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: | --- |

| **ID Number:** | 13 |
|---|---|
| **Parameter:** | $NCV_f$ |
| Data unit: | TJ/t or TJ/$m^3$ |
| Description: | Net calorific value of fuel type *f* in TJ per volume or mass units |
| Source of data: | IPCC 2006 Guidelines |
| 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 |

| **ID Number:** | 14 |
|---|---|
| **Parameter:** | $EF_{CO_2,f}$ |
| Data unit: | $tCO_2e$/TJ |
| Description: | $CO_2$emission factor of the fossil fuel type *f* used in transportation vehicles |
| Source of data: | IPCC 2006 Guidelines |
| 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 |

| **ID Number:** | 15 |
|---|---|
| Parameter: | $W_{default}$ |
| Data unit: | Kg |
| Description: | Default average animal weight of a defined population in kg from where the data on default $VS_{LT}$ values is sourced |
| Source of data: | IPCC 2006 Table 10A-4 to 10A-9, Chapter 10, Volume 4 or US-EPA, whichever is lower |
| Measurement procedures (if any): | --- |
| Any comment: | --- |

| **ID Number:** | 16 |
|---|---|
| **Parameter:** | $MCF_{Aer}$ |
| Data unit: | --- |
| Description: | Methane Conversion Factor (MCF) for aerobic system |
| Source of data: | 0.1 |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Any comment: | --- |

| **ID Number:** | 17 |
|---|---|
| **Parameter:** | $MCF_{res}$ |
| Data unit: | --- |
| Description: | Methane Conversion Factor (MCF) for composting system |
| Source of data: | IPCC 2006 table 10.17 volume 4 chapter 10 |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Any comment: | --- |

| **ID Number:** | 18 |
|---|---|
| Parameter: | $VS_{default}$ |
| Data unit: | kg-VS-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, Table 10A-4 to 10A-9, Chapter 10, Volume 4 or US-EPA, whichever is lower |
| Measurement procedures (if any): | --- |
| Any comment: | --- |

## III. MONITORING METHODOLOGY

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

(1) In the case where residues are collected with tank trucks, those must be equipped with flow meters and GPS devices. For every charging and discharging operation a geo-reference must be acquired, and the quantity of residues collected should be measured ($m^3$). This information will also be used for DOEs to check the periodicity of the manure collection activities;
(2) In the cases where residues are led to the central treatment plant though pipes, the piping system shall be detailed in the CDM-PDD. The quantity of residues collected through the pipes system should be measured ($m^3$). It shall be depicted in the CDM-PDD whether the residues are continuously directed to the central treatment plant or not.

The precise location of manure collection points shall be identified in the CDM-PDD (e.g., coordinates using global positioning system) and the road distances of the itineraries between them and the manure central treatment plant shall be documented using information from official sources.

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

Prior to the verification, project proponents shall calculate the baseline emission from each site separately. Then, project participants shall ordinate, in decreasing order, the sites where most of the baseline emissions would occur. DOEs shall perform site inspections on the sites that are individually responsible for an amount of baseline emissions equal or higher than 900 tCO2e ("upper rank"). This guarantees that the most preponderant baseline GHG sources are properly verified. For the remaining sites ("lower rank"), DOEs shall perform site inspections on a number n of randomly selected sites, being n determined as:

$$n = \frac{N}{1 + NE^2} \tag{40}$$

Where:

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

Then, a $CH_4$ emission reduction deviation factor ( $DF_{site}$ ) shall be calculated for each "lower rank" site.

$$DF_{site} = \frac{BE_{site}^{obs}}{BE_{site}^{claimed}} \tag{41}$$

Where:

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

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

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

$$\overline{DF} = \frac{\sum_{site}\left(DF_{site} \cdot BE_{site}^{obs}\right)}{\sum_{site} BE_{site}^{obs}} \tag{42}$$

Where:

| | | |
|---|---|---|
| $\overline{DF}$ | = | Average deviation factor for the "lower rank" sites visited by the DOE (dimensionless); |
| $DF_{site}$ | = | Deviation factor for the "lower rank" sites visited by the DOE (dimensionless); |
| $BE_{site}^{obs}$ | = | Baseline emissions verified by DOE after "lower rank" sites inspection ($tCO_2e$) |

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

$$BE_{LR,total}^{corrected} = \overline{DF} \cdot \sum_{site} BE_{site}^{claimed} \tag{43}$$

Where:

| | | |
|---|---|---|
| $BE_{LR,total}^{corrected}$ | = | Total corrected baseline emissions from the "lower rank" sites ($tCO_2e$) |
| $\overline{DF}$ | = | Deviation factor for the "lower rank" sites visited by the DOE (dimensionless) |
| $BE_{site}^{claimed}$ | = | Baseline emissions claimed by project proponents for a given "lower rank" site ($tCO_2e$) |

Then, total baseline emissions shall be calculated as follows:

$$BE_{total} = BE_{LR,total}^{corrected} + BE_{UR,total} \quad (44)$$

Where:

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

**Data and parameters monitored**

| **Data / Parameter:** | $MCF_j$ |
|---|---|
| Data unit: | Fraction |
| Description: | Methane Conversion Factor for the stage *j* of the baseline AWMS |
| 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 10ºC and higher than 5ºC, Annual MCF should be estimated using linear interpolation assuming MCF = 0 at annual average temperature of 5ºC. |

| **Data / Parameter:** | $MCF_l$ |
|---|---|
| Data unit: | Fraction |
| Description: | Annual methane conversion factor for the project manure storage tank *l* |
| Source of data: | IPCC 2006 Guidelines - Table 10.17, Chapter 10, Volume 4 |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Annually |
| QA/QC procedures: | --- |
| Any comment: | |

| **Data / Parameter:** | $B_{0,LT}$ |
|---|---|
| Data unit: | $m^3$ $CH_4$/kg_VS_dm |
| Description: | Maximum methane producing potential of the volatile solid generated |
| Source of data: | IPCC 2006 Guidelines or directly measured |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Annually |
| QA/QC procedures: | --- |
| Any comment: | See guidance on how to estimate this parameter in the methodology |

| **Data / Parameter:** | $nd_y$ |
|---|---|
| Data unit: | Number |
| Description: | Number of days the central treatment plant was operational in year *y* |
| Source of data: | Project participants |
| Measurement procedures (if any): | Archive electronic for the duration of project plus 5 years |
| Monitoring frequency: | Annually |
| QA/QC procedures: | --- |
| Any comment: | --- |

| **Data / Parameter:** | $Q_{EM,Aer,m}$ |
|---|---|
| Data unit: | $m^3$/month |
| Description: | Monthly volume of the effluent entering the aerobic treatment step |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | 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: | --- |

| **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): | Archive electronically during project plus 5 years |
| Monitoring frequency: | This parameter shall be continuously monitored |
| QA/QC procedures: | Flow meters will undergo maintenance/calibration subject to appropriate industry standards. This maintenance/calibration practice should be clearly stated in the CDM-PDD |
| Any comment: | This parameter shall be monitored by continuous flow meters installed after the effluent admittance point or after the equalization tanks (if existent) |

| **Data / Parameter:** | $Q_{DE,m}$ |
|---|---|
| Data unit: | ($m^3$ or tons of dry matter)/month |
| Description: | Monthly quantity of treated effluent disposed outside the project boundary |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Discontinuous daily measurement aggregated monthly |
| QA/QC procedures: | --- |
| Any comment: | --- |

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

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

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

| **Data / Parameter:** | $VS_{EM,Aer,m}$ |
|---|---|
| Data unit: | Ton VS/m$^3$ |
| Description: | Average monthly volatile solids (VS) concentration of the effluent entering the aerobic treatment step |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Weekly aggregated for monthly average |
| QA/QC procedures: | Volatile solids determination should be performed according to the guidance provided in Annex 2 |
| Any comment: | --- |

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

| **Data / Parameter:** | $VS_{DE,m}$ |
|---|---|
| Data unit: | Ton VS/(m$^3$ or ton of dry matter) |
| Description: | Monthly volatile solids concentration of the disposed residues |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Weekly aggregated for monthly average |
| QA/QC procedures: | Volatile solids determination should be performed according to the guidance provided in Annex 2 |
| Any comment: | --- |

| **Data / Parameter:** | $[N]_{EM,m}$ |
|---|---|
| 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): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Weekly aggregated for monthly average |
| QA/QC procedures: | Sample collection procedures shall be performed as described in Annex 4. Total nitrogen determination should be performed according to the guidance provided in annex 3 |
| Any comment: | The effluent mix shall be collected after the effluent admittance point or after the equalization tanks (if existent) |

| **Data / Parameter:** | $[N]_{DE,m}$ |
|---|---|
| Data unit: | kg N/m$^3$ |
| Description: | Monthly total nitrogen concentration of the treated effluent mix disposed outside the project boundary |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Every batch disposed |
| QA/QC procedures: | Total nitrogen determination should be performed according to the guidance provided in Annex 3 |
| Any comment: | --- |

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

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

| **Data / Parameter:** | $CEF_{Bl,elec,y}$ |
|---|---|
| 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:** | $CEF_{Bl,therm,y}$ |
|---|---|
| Data unit: | $tCO_2/MJ$ |
| Description: | Emission factor for thermal energy |
| Source of data: | Refer to baseline methodology |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | At the start of the project activity |
| QA/QC procedures: | --- |
| Any comment: | Calculated as per procedure described in the baseline methodology. If heat used is produced using biogas, the factor is zero |

| **Data / Parameter:** | $EG_{d,y}$ |
|---|---|
| Data unit: | MWh |
| Description: | Electricity exported to grid |
| 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:** | $LF_{AD}$ |
|---|---|
| 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: | Project proponents or Annex 1 |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Monthly |
| QA/QC procedures: | If no appropriate default values are available, project proponents shall used site specific data in order to calculate this parameter. The data used for this purpose shall be included in the monitoring plan of the CDM-PDD. Project proponents may directly measure the ratio of the total nitrogen content in the effluents entering and leaving a given treatment stage. Total nitrogen determination should be performed according to the guidance provided in Annex 3. |
| Any comment: | For baseline and project emissions calculations this parameter may be estimated from Table provided in Annex 1. The most conservative value for the given technology must be used |

| **Data / Parameter:** | $EF_{N_2O,D,n}$ |
|---|---|
| Data unit: | kg $N_2O$-N/ kg N |
| Description: | Direct N2O emission factor for treatment stage *n* |
| Source of data: | Project proponents or IPCC 2006 Guidelines |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Monthly |
| QA/QC procedures: | If no appropriate default values are available, for project emission calculations, project proponents shall used site specific data in order to calculate this parameter.  The data used for this purpose shall be included in the monitoring plan of the CDM-PDD. |
| Any comment: | IPCC 2006 default values may be used, if country specific or region specific data are not available |

| **Data / Parameter:** | $EF_{N_2O,Comp,D}$ |
|---|---|
| Data unit: | kg $N_2O$-N/ kg N |
| Description: | Direct $N_2O$ emission factor for composting |
| Source of data: | Project proponents or IPCC 2006 Guidelines |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Monthly |
| QA/QC procedures: | If no appropriate default values are available, for project emission calculations, project proponents shall used site specific data in order to calculate this parameter.  The data used for this purpose shall be included in the monitoring plan of the CDM-PDD. |
| Any comment: | IPCC 2006 default values may be used, if country specific or region specific data are not available |

| **Data / Parameter:** | T |
|---|---|
| Data unit: | ºC |
| Description: | Monthly average ambient temperature at the livestock farms included in the project boundary. |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Daily aggregated for monthly average |
| QA/QC procedures: | --- |
| Any comment: | Used to select the annual $MCF_j$ from IPCC 2006 Guidelines |

| **Data / Parameter:** | $T_{2,m}$ |
|---|---|
| Data unit: | Kelvin |
| Description: | Monthly average ambient temperature at the manure storage tanks |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Daily aggregated for monthly average |
| QA/QC procedures: | --- |
| Any comment: | |

| **Data / Parameter:** | $FV_{RG,h}$ |
|---|---|
| Data unit: | $m^3/h$ |
| Description: | Volumetric flow rate of the captured biogas in dry basis at normal conditions in hour *h* |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Continuously by flow meter |
| 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: | --- |

| **Data / Parameter:** | $fv_{CH_4,RG,h}$ |
|---|---|
| Data unit: | Fraction |
| Description: | Volumetric fraction of methane in the captured biogas on dry basis in hour *h* |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Continuously |
| QA/QC procedures: | --- |
| Any comment: | --- |

| **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: | “Tool to determine project emissions from flaring gases containing Methane” |
| 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: | 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” |
| 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: | --- |

| **Data / parameter:** | $Dist_{i,y}$ |
|---|---|
| Data unit: | km |
| Description: | Average distance per trip travelled by transportation vehicles type *i* |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Based on the estimation of actual distance used for transportation in the project activity |
| Monitoring frequency: | Discontinuous daily data averaged for the year |
| QA/QC procedures: | --- |
| Any comment: | --- |

| **Data / parameter:** | $FC_{i,f}$ |
|---|---|
| Data unit: | tons or $m^3$ (mass or volume units)/km |
| Description: | Specific consumption of fuel type *f* in volume or mass units per km for vehicle type *i* |
| Source of data: | Project proponents |
| Measurement procedures (if any): | On-site data sheets recorded according to the monitoring frequency |
| Monitoring frequency: | Monthly |
| QA/QC procedures: | Data will be acquired based on measurement of quantity of fuel used. Measurement equipment / meters will be calibrated according to the suppliers’ specifications |
| Any comment: | --- |

| **Data / parameter:** | $N_{vehicles,i,y}$ |
|---|---|
| Data unit: | Number |
| Description: | Number of trips of vehicles type *i* used for transportation, with similar loading capacity |
| Source of data: | Project proponents |
| Measurement procedures (if any): | On-site monitoring records |
| Monitoring frequency: | Daily |
| QA/QC procedures: | **---** |
| Any comment: | --- |

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

| **Data / parameter:** | $VS_{LT,y}$ |
|---|---|
| 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 10 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, whichever is lower) shall be recorded and archived |

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

| | |
|---|---|
| **Data / parameter:** | $N_{da}$ |
| 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: | |

| | |
|---|---|
| **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 |

| | |
|---|---|
| **Data / parameter:** | $N_{AA}$ |
| Data unit: | Number |
| Description: | Daily stock of animals in the farm, discounting dead and discarded animals |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Daily |
| QA/QC procedures: | --- |
| Any comment: | This parameter is only used if the project developer can monitor in a reliable and traceable way the daily stock of animals in the farm, discounting dead animals and animals discarded from the productive process from the daily stock |

| **Data / parameter:** | $W_{site}$ |
|---|---|
| Data unit: | kg |
| Description: | Weight of livestock |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Monthly |
| QA/QC procedures: | --- |
| Any comment: | The PDD should describe the system on monitoring the weight of livestock |

| **Data / parameter:** | $W_{manure;LT}$ |
|---|---|
| Data unit: | kg/animal/day |
| Description: | Average manure weight excreted by a defined population |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Daily |
| QA/QC procedures: | --- |
| Any comment: | The PDD should describe the system on monitoring the weight of manure excreted |

| **Data / parameter:** | $GE_{LT}$ |
|---|---|
| Data unit: | MJ/day |
| Description: | Daily average gross energy intake on dry matter basis |
| Source of data: | Calculated as per Equation 10.16. Chapter 10, Volume 4 of IPCC 2006 or use default value of 18.45 MJ/kg of dry matter if field specific information is not available |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Annually |
| QA/QC procedures: | --- |
| Any comment: | --- |

| **Data / parameter:** | $DE_{LT}$ |
|---|---|
| Data unit: | Fraction |
| Description: | Digestible energy of the feed in percent |
| Source of data: | IPCC 2006 Table 10.2, Chapter 10, Volume 4 |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | --- |
| QA/QC procedures: | --- |
| Any comment: | --- |

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

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

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

| **Data / parameter:** | End use of the treated manure |
|---|---|
| Data unit: | - |
| Description: | End use of the treated manure. |
| Source of data: | Project proponents |
| Measurement procedures (if any): | |
| Monitoring frequency: | Monthly |
| QA/QC procedures: | |
| Any comment: | If the treated residue is used as fertilizer in the baseline, project proponents must ensure that this end use remains the same throughout the project activity |

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

| **Data / parameter:** | $B_{0,EM,m}$ |
|---|---|
| Data unit: | $m^3CH_4$/ton-VS |
| Description: | Average monthly $CH_4$ production capacity of effluent manure entering the aerobic treatment stage |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Measured as per:<br>• ISO 11734:1995;<br>• ASTM E2170-01 (2008) and;<br>• ASTM D 5210-92. |
| Monitoring frequency: | Weekly aggregated for monthly average |
| QA/QC procedures: | |
| Any comment: | |

| **Data / parameter:** | $B_{0,res,m}$ |
|---|---|
| Data unit: | $m^3CH_4$/ton-VS |
| Description: | Average monthly $CH_4$ production capacity of residues entering the composting step |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Measured as per:<br>• ISO 11734:1995;<br>• ASTM E2170-01 (2008) and;<br>• ASTM D 5210-92. |
| Monitoring frequency: | Weekly aggregated for monthly average |
| QA/QC procedures: | |
| Any comment: | |

| **Data / parameter:** | $PE_{EC,y}$ |
|---|---|
| Data unit: | $tCO_2$ |
| Description: | Project emissions from electricity consumption by the project activity during the year *y* |
| Source of data: | Calculated as per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” |
| 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:** | $PE_{FC,j,y}$ |
|---|---|
| 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” |
| 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:** | $AI_l$ |
|---|---|
| Data unit: | Days |
| Description: | Annual average interval between manure collection procedures at a given storage tank *l* |
| Source of data: | Project proponents |
| Measurement procedures (if any): | Archive electronically during project plus 5 years |
| Monitoring frequency: | Discontinuous daily for estimating annual average |
| QA/QC procedures: | **---** |
| Any comment: | --- |

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

# IV. REFERENCES AND ANY OTHER INFORMATION

Not applicable.

## Annex 1: Anaerobic Unit Process Performance

### Table 8-10. Anaerobic Unit Process Performance

| Anaerobic Treatment | HRT | COD | TS | VS | TN | P | K |
|---|---|---|---|---|---|---|---|
| | days | Percent Reduction | | | | | |
| Pull plug pits | 4-30 | — | 0-30 | 0-30 | 0-20 | 0-20 | 0-15 |
| Underfloor pit storage | 30-180 | — | 30-40 | 20-30 | 5-20 | 5-15 | 5-15 |
| Open top tank | 30-180 | — | — | — | 25-30 | 10-20 | 10-20 |
| Open pond | 30-180 | — | — | — | 70-80 | 50-65 | 40-50 |
| Heated digester effluent prior to storage | 12-20 | 35-70 | 25-50 | 40-70 | 0 | 0 | 0 |
| Covered first cell of two cell lagoon | 30-90 | 70-90 | 75-95 | 80-90 | 25-35 | 50-80 | 30-50 |
| One-cell lagoon | >365 | 70-90 | 75-95 | 75-85 | 60-80 | 50-70 | 30-50 |
| Two-cell lagoon | 210+ | 90-95 | 80-95 | 90-98 | 50-80 | 85-90 | 30-50 |

HRT=hydraulic retention time; COD=chemical oxygen demand; TS=total solids; VS=volatile solids; TN=total nitrogen; P=phosphorus; K= potassium; — =data not available.

Source: Moser and Martin, 1999

## Annex 2: Method for determination of Volatile Solids in animal waste

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

Definitions

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

Determination method

1 - Evaporate free water on steam able and dry in oven at 103°C for 24 hours or until constant weight to obtain the Total Solids.
2 - Place Total Solids residue in furnace at 600ºC for at least 1 hour. Volatile Solids are determined from weight difference of total and Fixed Solids.

$$Volatile\,matter\ (dry\,basis) = \frac{W_2 - W_f}{W_2 - W_1}$$

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

## Annex 3: Determination of Total Nitrogen in animal waste

Definitions

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

Principles and guidelines for Total Nitrogen Determination

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

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

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

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

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

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

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

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

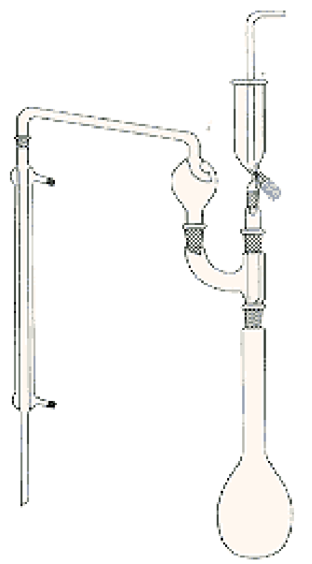
The use of oxidizing can cause loss of nitrogen (Peters & Van Slyke, 1932). There the use of such agents is not recommended for the purposes of the project activities employing this methodology.

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

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

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

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



Assembly of the Kjeldahl apparatus.

## References

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## Annex 4: Guidance on sample extraction and statistical procedures

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

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

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

Where:

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

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

| v | 75% | 80% | 85% | 90% | 95% | 97.5% | 99% | 99.5% | 99.75% | 99.9% | 99.95% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 31.82 | 63.66 | 127.3 | 318.3 | 636.6 |
| 2 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 | 14.09 | 22.33 | 31.60 |
| 3 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 | 7.453 | 10.21 | 12.92 |
| 4 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 | 5.598 | 7.173 | 8.610 |
| 5 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 | 4.773 | 5.893 | 6.869 |
| 6 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 | 4.317 | 5.208 | 5.959 |
| 7 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 | 4.029 | 4.785 | 5.408 |
| 8 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 | 3.833 | 4.501 | 5.041 |
| 9 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 | 3.690 | 4.297 | 4.781 |
| 10 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 | 3.581 | 4.144 | 4.587 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **11** | 0.697 | 0.876 | 1.088 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 | 3.497 | 4.025 | 4.437 |
| **12** | 0.695 | 0.873 | 1.083 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 | 3.428 | 3.930 | 4.318 |
| **13** | 0.694 | 0.870 | 1.079 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 | 3.372 | 3.852 | 4.221 |
| **14** | 0.692 | 0.868 | 1.076 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 | 3.326 | 3.787 | 4.140 |
| **15** | 0.691 | 0.866 | 1.074 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 | 3.286 | 3.733 | 4.073 |
| **16** | 0.690 | 0.865 | 1.071 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 | 3.252 | 3.686 | 4.015 |
| **17** | 0.689 | 0.863 | 1.069 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 | 3.222 | 3.646 | 3.965 |
| **18** | 0.688 | 0.862 | 1.067 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 | 3.197 | 3.610 | 3.922 |
| **19** | 0.688 | 0.861 | 1.066 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 | 3.174 | 3.579 | 3.883 |
| **20** | 0.687 | 0.860 | 1.064 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 | 3.153 | 3.552 | 3.850 |
| **21** | 0.686 | 0.859 | 1.063 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 | 3.135 | 3.527 | 3.819 |
| **22** | 0.686 | 0.858 | 1.061 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 | 3.119 | 3.505 | 3.792 |
| **23** | 0.685 | 0.858 | 1.060 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 | 3.104 | 3.485 | 3.767 |
| **24** | 0.685 | 0.857 | 1.059 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 | 3.091 | 3.467 | 3.745 |
| **25** | 0.684 | 0.856 | 1.058 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 | 3.078 | 3.450 | 3.725 |
| **26** | 0.684 | 0.856 | 1.058 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 | 3.067 | 3.435 | 3.707 |
| **27** | 0.684 | 0.855 | 1.057 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 | 3.057 | 3.421 | 3.690 |
| **28** | 0.683 | 0.855 | 1.056 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 | 3.047 | 3.408 | 3.674 |
| **29** | 0.683 | 0.854 | 1.055 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 | 3.038 | 3.396 | 3.659 |
| **30** | 0.683 | 0.854 | 1.055 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 | 3.030 | 3.385 | 3.646 |
| **40** | 0.681 | 0.851 | 1.050 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 | 2.971 | 3.307 | 3.551 |
| **50** | 0.679 | 0.849 | 1.047 | 1.299 | 1.676 | 2.009 | 2.403 | 2.678 | 2.937 | 3.261 | 3.496 |
| **60** | 0.679 | 0.848 | 1.045 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 | 2.915 | 3.232 | 3.460 |
| **80** | 0.678 | 0.846 | 1.043 | 1.292 | 1.664 | 1.990 | 2.374 | 2.639 | 2.887 | 3.195 | 3.416 |
| **100** | 0.677 | 0.845 | 1.042 | 1.290 | 1.660 | 1.984 | 2.364 | 2.626 | 2.871 | 3.174 | 3.390 |
| **120** | 0.677 | 0.845 | 1.041 | 1.289 | 1.658 | 1.980 | 2.358 | 2.617 | 2.860 | 3.160 | 3.373 |
| ∞ | 0.674 | 0.842 | 1.036 | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 2.807 | 3.090 | 3.291 |

# Annex 5: Table 10.17 from 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. |

## Annex 6: Procedure for estimating NEX

(1) $$NEX = N_{intake} \cdot (1 - N_{retention})$$

Where:

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

$N_{intake}$ may be calculated using:

(2) $$N_{intake} = \left(\frac{GE}{18.45}\right) \cdot \left(\frac{CP \cdot 0.01}{6.25}\right)$$

Where:

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

In absence of availability of project specific information on Protein intake, which should be justified in the CDM-PDD, site-specific national or regional data should be used for the nitrogen excretion NEX, if available. In the absence of such data, default values from table 10.19 of the IPCC 2006, volume 4, chapter10) may be used and should be corrected for the animal weight at the project site in the following way:

(3) $$NEX_{site} = \frac{W_{site}}{W_{default}} \cdot NEX_{IPCC,default}$$

Where:

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

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**History of the document**

| Version | Date | Nature of revision(s) |
|---|---|---|
| 01 | EB 44, Annex 4<br>28 November 2008 | Initial adoption. |