Draft revision to the approved baseline methodology AM0006

"GHG emission reductions from manure management systems"

Source

This methodology is based on the PDD "Methane capture and combustion of swine manure treatment for Peralillo" whose baseline study, monitoring and verification plan and project design document were prepared by Agricola Super Limitada. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0022: "Methane capture and combustion of swine manure treatment for Peralillo" on http://cdm.unfccc.int/methodologies/approved.

Selected approach from paragraph 48 of the CDM modalities and procedures

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

Applicability

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

- The project context is represented by farms operating under a competitive market;
- The manure management system introduced as part of the project activity, as well as the manure management system in the baseline scenario, must be in accordance with the regulatory framework in the country;
- Livestock populations are managed under confined conditions. Barn systems and barn flushing systems should neither be the baseline scenario nor the project activity;
- Livestock populations comprise only cattle, buffalo and/or swine;
- The manure management system introduced as part of the project activity, as well as the manure management system in the baseline scenario, may consist of several stages of manure treatment, including all options (or a combination of them) listed below in step 1 under "Additionality", but excluding the discharge of manure into natural water resources (e.g. rivers or estuaries);
- The project activity does not lead to a significant increase of electricity consumption.

Additionality

In this methodology, the baseline scenario and additionality are determined in several steps. A financial analysis of several possible scenarios is conducted and legal, as well as other relevant circumstances and barriers for their implementation are assessed. The economically most attractive course of action, taking into account barriers and local practices, is assumed as the baseline scenario. The project activity is additional, if this analysis shows that the project is economically less attractive than the identified baseline scenario.

Step 1: List of possible baseline scenarios.
In the first step a list of possible baseline scenarios for manure management should be drawn up. A manure management scenario can be composed of a combination of several manure treatment stages. In doing so, the complete set of possible manure management systems listed in the 1996 Revised IPCC Guidelines (Chapter 4, Table 4.8) and in the IPCC Good Practice Guidance and Uncertainty Management (Chapter 4, Table 4.10 and 4.11) should be taken into account. These include the following options:

- Solid Storage. Dung and urine are excreted in a stall. The solids (with or without litter) are collected and stored in bulk for a long period of time (months) before any disposal, with or without liquid runoff into a pit system.

- Dry lot. In dry climates animals may be kept on unpaved feedlots where the manure is allowed to dry until it is periodically removed. Upon removal the manure may be spread on fields.
- Liquid/Slurry. Dung and urine are collected and transported in liquid state to tanks for storage. The liquid may be stored for a long time (months) until it is applied to fields. To facilitate handling as a liquid, water may be added.
- Anaerobic lagoon. Anaerobic lagoon systems are characterised by flush systems that use water to transport manure to lagoons. The manure resides in the lagoon for periods from 30 days to over 200 days. The water from the lagoon may be recycled as flush water or used to irrigate and fertilise fields.
- Pit storage below animal confinements. Liquid swine manure may be stored below animal confinements in a pit before disposal. The length of storage time varies, and for this analysis is divided into two categories: Less than one month or greater than one month.
- Anaerobic digester. The dung and urine, in liquid or slurry form, are collected and anaerobically digested. Methane from the digestion process may be flared, vented or combusted for energy generation.
- Deep litter. Cattle/swine dung and urine are excreted on stall floor. The accumulated waste is removed after a long time. The length of storage time varies, and for this analysis is divided into two categories: Less than one month or greater than one month.
- Composting. Dung and urine are collected, stacked and regularly turned for aeration (extensive composting) or placed in a vessel or tunnel with forced aeration of the waste.
- Aerobic treatment. Dung and urine are collected as a liquid. The waste undergoes forced aeration, or is treated in aerobic pond or wetland systems to provide nitrification and denitrification.

In drawing up a list of possible scenarios, possible combinations of different Animal Waste Management Systems (AWMS) should be taken into account.

Step 2: Identify plausible scenarios
In the second step, a number of plausible scenarios should be identified from the list of possible options specified in step 1 above. The identified scenarios should at least include two scenarios, the project scenario and one other scenario. In selecting the plausible scenarios, project participants should provide convincing justification for the exclusion of animal waste management systems as potential baseline scenarios. The exclusion criteria are determined by:

- Legal constrains (the scenario must be in accordance with the regulatory framework of the country);
- Historical practice of manure management (e.g. in the company and region);
- Availability of waste treatment technology;
- Considerations of developments for manure management systems appropriate for the national conditions, including technological innovations.

Step 3: Economic comparison
In the third step, the plausible scenarios identified in step 2 are compared economically. For each scenario, all costs and economic benefits attributable to the waste management scenario should be illustrated in a transparent and complete manner, as in table 1 below.

Table 1: Calculation of NPV and IRR

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

For each plausible scenario, the internal rate of return (IRR) and/or the net present value (NPV) should be calculated. The calculation of the IRR must include investment costs, operation and maintenance costs, as well as any other appropriate costs (engineering, consultancy, etc.), all revenues generated by each manure management scenario, including revenue from the sale of electricity and cost savings due to avoided electricity purchases, except revenues from the sale of CERs.

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

If the IRR cannot be calculated due to the existence of only negative flows in the financial analysis, the comparison should be based on the NPV, stating explicitly the discount rate used. The baseline scenario is identified as the economically most attractive course of action. This is the scenario with the highest IRR, or where the IRR cannot be calculated, the highest NPV.

If the IRR of the project activity is clearly and significantly lower than the IRR of the identified baseline scenario, the project is not an economically attractive course of action and can be considered as additional. If IRR values cannot be calculated due to only negative flows in the financial analysis, this comparison should be applied with the NPV, stating and justifying explicitly the discount rate used.

Step 4: Assessment of barriers
Next to the economic comparison in step 3, project participants should conduct an assessment of barriers. This assessment should reinforce the evidence of additionality from step 3 or provide additional evidence for additionality when the results of the economic comparison (IRR or NPV of the baseline scenario and the project scenario) are not significantly different. In this latter case, the barrier assessment could demonstrate that a certain plausible scenario could be the most likely baseline scenario even though it is not the most cost effective option. In this case, the project activity can be considered additional if the economic analysis in step 3 shows that IRR of the project is clearly and significantly lower than the IRR of that baseline scenario that is determined clearly as most likely as a result of the barrier analysis.

As part of the barrier assessment, project participants should analyze whether and why the technology or technique of the project activity is not nationally and/or worldwide commonly used, due to different types of barriers such as: investment barriers, technological barriers, barrier due to prevailing practice or other barriers to implement the project activity technology or technique.

Project Activity and Baseline Scenario

The project activity consists of the implementation of an advanced manure management system that leads to less GHG emissions than the manure management system that would be used in the absence of the project activity. The appropriate baseline manure management system is identified above in the section on additionality.

The methodology includes the following emission sources for the project and baseline manure management system:

- Methane (CH_4) emissions from the decomposition of manure under anaerobic conditions.
- Nitrous oxide (N_2O) emissions during storage and handling of manure in the manure management system.

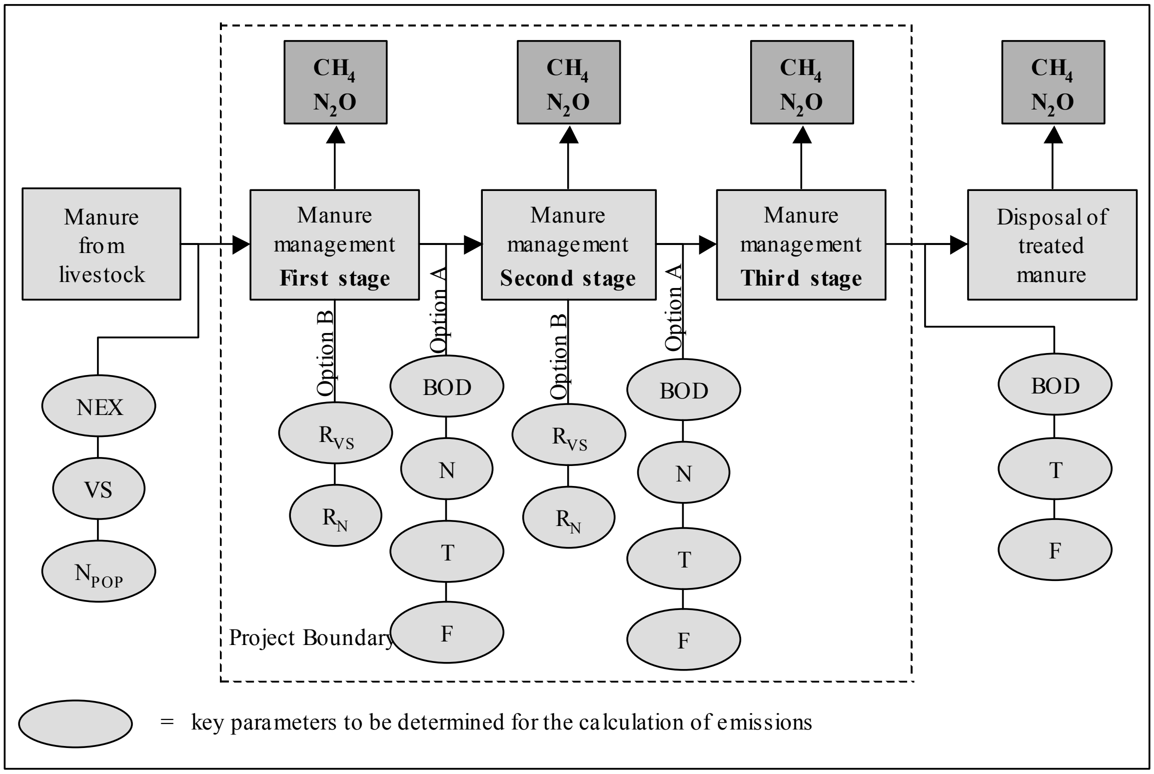
The following emission sources are not considered in the project and baseline boundary:

- Nitrous oxide (N_2O) emissions related to the application of treated manure to land (direct emissions, emissions due to leaching and run-off) and nitrous oxide (N_2O) emissions due to the volatilization of nitrogen and the deposition of that nitrogen on land and water surfaces.[1];
- Methane (CH_4) emissions from sludge deposition in the project manure management system, if the sludge is accumulated or deposited under anaerobic conditions (these emission source is addressed as leakage);
- Changes of the electricity demand due to the project activity;
- CO_2 emissions from any combustion, flaring or oxidation of methane, as the CO_2 emissions are considered to be from biogenic origins, that do not change carbon stocks.

Figure 1 below shows schematically the inclusion of emissions sources and gases considered in the project boundary (key parameters used are described in the text).

[1] An accurate estimation of nitrous oxide emissions from these two sources is difficult. The 1996 Revised IPCC Guidelines and the IPCC GPG estimate these emissions with the help of default emission factors that are independent from the manure management system used. If this approach would be applied to this methodology, emissions would only depend on the quantity of nitrogen excreted by the animals. However, the same nitrogen excretion quantities should be used in the baseline and project scenario, as the quantity and type of manure production is part of the project boundary. Therefore, a more sophisticated project-specific approach would need to be elaborated to estimate these emission sources. As uncertainty of these emissions is very large, and as emissions are assumed to be of similar quantity for the project and the baseline scenario, these sources are not considered in this methodology.

Figure 1: Project Boundary



Emission Reductions

Greenhouse gas emissions included in the project boundary are calculated for the project and the baseline manure management system separately, using the same methodological approach. Emission reductions result from the difference between project and baseline emissions. The methodology to calculate emissions is based on approaches presented in the 1996 Revised IPCC Guidelines and in the IPCC GPG 2000.

As illustrated in Figure 1 above, manure management systems may comprise several treatment stages. Manure management systems considered under this methodology may comprise several treatment stages and emissions should be determined for each treatment stage separately. The following steps are required for the calculation of both, baseline and project emissions:

1. Identification of the project and the baseline manure management system following the guidance under additionality above. Different treatment stages of the project activity should be clearly described and their relation illustrated in a flow diagram.
2. Identification of the livestock populations $N_{population}$ in the project site according to the categorization of (sub-)populations in the 1996 Revised IPCC Guidelines and the IPCC GPG 2000.
3. Determination of the volatile solids (*VS*) and the nitrogen (*NEX*) excretion rates for each population. Total volatile solids and nitrogen supplied to the manure management system are determined by the excretion rates *VS* and *NEX* and the monitored livestock populations. Emissions of the project and the baseline scenario are both calculated on the basis of the monitored total volatile solid and nitrogen quantities supplied to the manure management system.
4. Calculation of CH_4 and N_2O emissions from manure management in the first treatment stage, by applying appropriate emission factors to the quantity of volatile solids and nitrogen supplied to the manure management system.

5. In each treatment stage of the manure management system volatile solids and nitrogen loads are reduced. To calculate emissions from the treatment stage considered, the quantity of volatile solids and nitrogen supplied to the next treatment stage have to be determined. For this purpose two methodological approaches may be followed:

   Option A: Between each treatment stage of the manure waste management system the waste flow *F*, the biochemical oxygen demand *BOD*, the temperature *T* and the nitrogen content *N* are measured during monitoring. N_2O and CH_4 emissions are then calculated by applying appropriate emission factors to the measured quantity of biochemical oxygen and nitrogen supplied to the manure management system. This approach can only be applied to the project manure management system, as it requires regular monitoring of these parameters, which is not possible for hypothetical baseline scenario.

   Option B: The reduction of the volatile solids and 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 in step 3 and 4 above, but with volatile solid and nitrogen quantities adjusted for the reduction from the previous treatment stages. This approach can be applied to both the project and the baseline scenario.
6. Repetition of step 5 for any subsequent treatment stage.
7. Determination of CH_4 emissions from the final disposal of treated manure, if such disposal occurs under anaerobic conditions. Similarly to the two approaches in step 5, methane emissions estimates may be based on the biochemical oxygen demand (BOD) in the treated manure and appropriate emissions factors or on the remaining content of volatile solids in the treated manure.

Steps 1 to 7 should be applied to the manure management system of the project activity and to the manure management system that has been identified as the baseline scenario. Net emissions reductions are the difference between emissions in the baseline and project manure management system.

This methodology involves considerable uncertainties in the estimates of emissions, as some key parameters are rather uncertain and often only default values are available. For this reason, parameters should be chosen in a conservative manner, taking into account the local practices and the project context. This refers in particular to methane conversion factors (MCF), maximum methane production capacities (B_o), the volatile solid and nitrogen excretion rates (VS and N) and reduction rates for volatile solids and nitrogen (R_{VS} and R_N)[2]. The selection of parameters should be documented transparently in the PDD and the DOE should validate conservativeness in their choice. Project participants may also neglect an emission source, if this adds conservativeness.

The following sources should be used to calculate baseline emissions:

- 1996 Revised IPCC Guidelines, Chapter 4 of the Reference Manual
- IPCC Good Practice Guidance and Uncertainty management in National GHG Inventories, Chapter 4
- 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)
- Site-specific data, such as the average animal weight and number of animals.

Methane emissions from manure management

The main factors affecting methane emissions from manure management are the amount of manure that is produced and the portion of manure that decomposes under anaerobic conditions. The type of manure management system used and the climate (primarily temperature) are the primary factors that de-

[2] In this context a conservative approach is to choose for the parameters *MCF*, B_o, R_{VS} and R_N values at the lower end of the possible range for the baseline scenario and at the higher end of the possible range for the calculation of project emissions. For the volatile solid and nitrogen rates (*VS* and *N*), conservative choices are values at the lower end of the possible range.

termine the extent of anaerobic decomposition that takes place. In some manure management systems, methane emissions are reduced by constructing lids or caps for lagoons or tanks where manure is kept. The recovered methane may also be flared or used as fuel in boiler, engines or turbines.

The approach to calculate CH_4 emissions from manure management follows the Tier 2 approach in the 1996 Revised IPCC Guidelines and the IPCC GPG 2000.

For the first treatment stage of the manure management system, CH_4 emissions are calculated following the approach outlined in steps 3 and 4 above:

$$E_{CH4,mm,1,y} = GWP_{CH4} \cdot MCF_1 \cdot D_{CH4} \cdot \frac{365}{1000} \cdot \sum_{population} VS_{population} \cdot B_{0,population} \cdot N_{population} \quad (1)$$

where:

$E_{CH4,mm,1,y}$	Are the CH_4 emissions from manure management in the first treatment stage of a manure management system during the year y in tons of CO_2 equivalent.
GWP_{CH4}	Is the approved Global Warming Potential (GWP) of CH_4.
MCF_1	Is the methane conversion factor (MCF) for treatment of manure in the first treatment stage in per cent.
D_{CH4}	Is the CH_4 density (0.67 kg/m^3 at room temperature (20 ºC) and 1 atm pressure).
$VS_{population}$	Is the volatile solid excretion per day on a dry-matter basis for a defined livestock population in kg-dm/animal/day.
$B_{0,population}$	Is the maximum CH_4 production capacity from manure per animal for a defined livestock population m^3 CH_4/kg-dm.
$N_{population}$	Is the livestock of a defined population.

Where the project includes different sub-populations, methane emissions from manure management should be estimated separately for these sub-populations, according to Appendix B of Chapter 4.2 in the Reference Manual of the 1996 Revised IPCC Guidelines. For the calculation of both, baseline and project emissions, the monitored livestock of each defined population should be used.

In selecting appropriate values for the methane conversion factor *MCF*, the maximum methane production capacity B_0 and the volatile solid excretion per animal *VS*, project participants should use site-specific measured data or regional or national data, where such data is available or can be measured with reasonable costs. Where site-specific data is not available or measured is very costly, conservative default values shall be used following the guidance below.

The maximum methane production capacity B_0 varies by species and diet. Where default values are used, they should be taken from Appendix B of Chapter 4.2 in the Reference Manual of the 1996 Revised IPCC Guidelines, taking into account the site-specific characteristics. Where diets in the project are more similar to diets in developed countries, appropriate default values from developed countries may be selected.

Methane conversion factors (MCFs) define the portion of the methane production capacity B_0 that is converted to methane. The MCFs depend on the type of manure management system, the temperature of the stored manure, the duration of storage and the handling practices of the system. Values should be taken from Tables 10 A-4 up to 10 A-8, contained in Annex 10A.2 Chapter 10 Volume 4 IPCC Guidelines 2006.

Volatile solids are the degradable organic material in livestock manure. Project participants should use site-specific measured data for the volatile solid excretion rate VS, where such data can be measured with reasonable costs. However, there may be circumstances when the VS values may need to be estimated from regional, national or default values; for example, when the wastewater management system has a discontinuous wastewater flow rate and when the wastewater management system has several inlets to the treatment process, therefore requiring high costs to measure flow rates. In such a case, daily or weekly monitoring would need to be implemented, which is typically costly and often involves operating problems, such as pump and flow meter obstruction (due to the high solids content in the wastewater stream).

Where default values are used for the volatile solid excretion, they should be taken from Appendix B of Chapter 4.2 in the Reference Manual of the 1996 Revised IPCC Guidelines. In the application of IPCC default values, it should be ensured that the definitions used by IPCC reflect appropriately the project context.

Any default data used should be corrected for the animal weight at the project site in the following way, assuming that the volatile solid excretion is proportional to the weight of the animal:

$$VS_{site} = \left(\frac{w_{site}}{w_{default}} \right) \cdot VS_{default} \qquad \textbf{(2)}$$

where:

VS_{site}	Is the adjusted volatile solid excretion per day on a dry-matter basis for a defined livestock population at the project site in kg-dm/animal/day.
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.
$VS_{default}$	Is the default value (IPCC or US-EPA) for the volatile solid excretion per day on a dry-matter basis for a defined livestock population in kg-dm/animal/day.

For second and subsequent treatment stages, methane emissions can be calculated with two different approaches, corresponding to option A and B in step 5 above. Following option A, methane emissions are calculated based on the measurement of the biochemical oxygen demand (BOD) and the quantity of manure flowing to that treatment stage:

$$E_{CH4,mm,i,y} = 0.25 \cdot BOD_{lt,i,y} \cdot F_{i,y} \cdot MCF_i \cdot GWP_{CH4} \cdot \frac{1}{1{,}000{,}000} \qquad \textbf{(3)}$$

where:

$E_{CH4,mm,i,y}$	Are the CH_4 emissions from manure management in the second or subsequent treatment stage i of the project activity during the year y in tons of CO_2 equivalents.
$BOD_{lt,i,y}$	Is the average long-term biochemical oxygen demand of the manure flow to treatment stage i during the year y in mg/l.
$F_{i,y}$	Is the manure flow to the treatment stage i during the year y in m^3.
MCF_i	Is the methane conversion factor (MCF) for the treatment of manure in stage i in per cent.
GWP_{CH4}	Is the approved Global Warming Potential (GWP) of CH_4.

Both, the biochemical oxygen demand *BOD* and the manure flow *F* between the treatment stages should be monitored for the project manure management system. Usually, the five-day biochemical oxygen demand BOD_5 is measured. The long-term biochemical oxygen demand can then be calculated with the BOD_5 and the reaction constant *k* as follows:

$$BOD_{lt} = \frac{BOD_5}{\left(1 - 10^{-5k}\right)} \quad (4)$$

where:

$BOD_{lt,i}$	Is the long term biochemical oxygen demand of the manure flow to treatment stage i in mg/l.
$BOD_{5,i}$	Is the five-day biochemical oxygen demand of the manure flow to treatment stage i in mg/l.
K	Is the reaction constant for the biochemical oxygen demand.

The reaction constant can be assumed as approximately 0.1 for wastewater at 20°C (Metcalf & Eddy, 1991)[3], but varies with the temperature. Values for the reaction constant k at different temperatures can be calculated with the help of the Van't Hoff-Arrhenius relationship, where θ is 1.056 for temperatures between 20 and 30ºC, and 1.135 for temperatures between 4 and 20ºC. Frequently a referential value of 1.047 is used for wastewater in lukewarm conditions (Metcalf & Eddy, 1991).

$$k_T = k_{20} \cdot \theta^{(T - 20°C)} \quad (5)$$

where:

k_T	Is the reaction constant for the biochemical oxygen demand at the temperature T.
k_{20}	Is the reaction constant for the biochemical oxygen demand at 20°C.
T	Is the temperature of the manure flow to the treatment stage i in degree Celsius.
Θ	Is a constant in the Van't-Hoff-Arrhenius relationship.

Alternatively to equations 3, 4 and 5, methane emissions from second and subsequent treatment stages can be calculated following option B outlined in step 5 above. In this case, methane emissions of second or subsequent treatment stages are calculated on the basis of total volatile solids applied to the manure management system adjusted for volatile solid reductions in previous treatment stages:

$$E_{CH4,mm,i,y} = GWP_{CH4} \cdot MCF_i \cdot D_{CH4} \cdot \left[\prod_{n=1}^{i-1} \left(1 - R_{VS,n}\right)\right] \cdot \frac{365}{1000} \cdot \sum_{population} VS_{population} \cdot B_{0,population} \cdot N_{population} \quad (6)$$

where:

$E_{CH4,mm,i,y}$	Are the CH_4 emissions from manure management in the first treatment stage of a manure management system during the year y in tons of CO_2 equivalent.
GWP_{CH4}	Is the approved Global Warming Potential (GWP) of CH_4.
MCF_i	Is the methane conversion factor (MCF) for the treatment of manure in stage i in per cent.
D_{CH4}	Is the CH_4 density (0.67 kg/m^3 at room temperature (20 ºC) and 1 atm pressure).
$R_{VS,n}$	Is the relative reduction of volatile solids in the treatment stage n in per cent.
$VS_{population}$	Is the volatile solid excretion per day on a dry-matter basis for a defined livestock population in kg-dm/animal/day.
$B_{0,population}$	Is the maximum CH_4 production capacity from manure per animal for a defined livestock population m^3 CH_4/kg-dm.
$N_{population}$	Is the livestock of a defined population.

[3] Metcalf and Eddy. Wastewater Engineering: Treatment, disposal, reuse. McGraw-Hill International Editions, Civil Engineering Series. International Edition 1991.

The relative reduction of volatile solids depend on the treatment technology and should estimated in a conservative manner. Default values for different treatment technologies can be found in Chapter 8.2 in US-EPA (2001). Equation 3 or equation 6 should be applied to the second and, where relevant, any following treatment stages.
Finally, methane emission reductions due to changes in the manure management are calculated as the differences between emissions in the baseline scenario and emissions in all stages of the project manure management system:

$$ER_{CH4,mm,y} = E_{CH4,mm,1,y,baseline} - E_{CH4,mm,1,y,project} - \sum_{i} E_{CH4,mm,i,y} \quad \textbf{(7)}$$

where:

$ER_{CH4,mm,y}$	Are the CH_4 emission reductions due to the project activity during the year y in tons of CO_2 equivalents.
$E_{CH4,mm,1,ybaseline}$	Are the CH_4 emissions from manure management in the baseline scenario during the year y, calculated with equation 1, in tons of CO_2 equivalents.
$E_{CH4,mm,1,yproject}$	Are the CH_4 emissions from manure management in first stage of the project manure management system during the year y, calculated with equation 1, in tons of CO_2 equivalents.
$E_{CH4,mm,i,y}$	Are the CH_4 emissions from manure management in the second or subsequent treatment stage i of the project activity during the year y in tons of CO_2 equivalents.

Nitrous oxide emissions from manure management
Nitrous oxide (N_2O) from manure management is produced from the combined nitrification-denitrification process that occurs on the nitrogen in manure. The majority of nitrogen in manure is in ammonia (NH_3) form. Nitrification occurs aerobically and converts this ammonia into nitrate, while denitrification occurs anaerobically, and converts the nitrate into N_2O. Temperature, pH, biochemical oxygen demand (BOD), and nitrogen concentration affect the N_2O generation rate.

N_2O emissions from manure management systems are calculated based on the approach in the 1996 Revised IPCC Guidelines and the IPCC GPG 2000.

Similarly, as in the case of CH_4 emissions, the approach to calculate N_2O emissions for the first stage of manure treatment is different from approaches for subsequent stages. In the first stage of manure treatment, direct N_2O emissions from manure management are calculated by multiplying the amount of N excretion for each defined livestock population by an emission factor for the type of manure management system:

$$E_{N2O,mm,1,y} = GWP_{N2O} \cdot EF_{N2O,mm,1} \cdot CF_{N2O-N,N} \cdot \frac{1}{1000} \cdot \sum_{populations} NEX_{population} \cdot N_{population} \quad \textbf{(8)}$$

where:

$E_{N2O,mm,1,y}$	Are the nitrous oxide emissions from the first stage of the manure management systems in tonnes of CO_2 equivalents per year.
GWP_{N2O}	Is the approved Global Warming Potential (GWP) for N_2O.
$EF_{N2O,mm,1}$	Is the N_2O emission factor for the first treatment stage of the manure management system in kg N_2O-N/kg N (EF_3 in 1996 Revised IPCC Guidelines and IPCC GPG).
$CF_{N2O\text{-}N,N}$	Is the conversion factor N_2O-N to N (44/28).
$NEX_{population}$	Is annual average nitrogen excretion per animal of the defined livestock population in kg N/animal/year.
$N_{population}$	Is the livestock of a defined population.

The N_2O emission factor for the treatment of manure $EF_{N2O,mm,1}$ should be estimated with site-specific, regional or national data if such data is available. Otherwise, default values from Table 4.12 and Table 4.13 of the IPCC GPG 2000 may be used.

Similarly, site-specific, regional or national data should be used for the nitrogen excretion *NEX* if available. In the absence of such data, default values from Table 4.20 in the IPCC Guidelines (adjusted with the factors in Table 4.14 of the IPCC GPG for young animals) may be used and should be corrected for the animal weight at the project site in the following way, assuming that the nitrogen excretion is proportional to the weight of the animal:

$$NEX_{site} = \frac{w_{site}}{w_{default}} \cdot NEX_{default} \quad \textbf{(9)}$$

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.
$NEX_{default}$	Is the default value (IPCC or US-EPA) for the nitrogen excretion per head of a defined livestock population in kg N/animal/year.

For second and subsequent treatment stages, nitrous oxide emissions can be calculated with two different approaches, corresponding to options A and B in step 5 above. Following option A, N_2O emissions are calculated based on measurements of the nitrogen content in the manure flowing to that treatment stage:

$$E_{N2O,mm,i,y} = GWP_{N2O} \cdot EF_{N2O,mm,i} \cdot N_{i,y} \cdot F_{i,y} \quad \textbf{(10)}$$

where:

$E_{N2O,mm,i,y}$	Are the N_2O emissions from manure management in the second or subsequent treatment stage i of the project activity during the year y in tons of CO_2 equivalents.
GWP_{N2O}	Is the approved Global Warming Potential (GWP) for N_2O.
$EF_{N2O,mm,i}$	Is the N_2O emission factor for the treatment stage i of the manure management system in kg N_2O-N/kg N (EF_3 in 1996 Revised IPCC Guidelines and IPCC GPG).
$N_{,i,y}$	Is the average nitrogen content in the manure flowing to the treatment stage i during the year in kg N/m^3.
$F_{i,y}$	Is the manure flow to the treatment stage i during the year y in m^3.

Alternatively to equations 10, nitrous oxide emissions from second and subsequent treatment stages can be calculated following the option B outlined in step 5 above. In this case, nitrous oxide emissions of second or subsequent treatment stages are calculated on the basis of the nitrogen quantity applied to the manure management system adjusted for nitrogen reductions in previous treatment stages:

$$E_{N2O,mm,1,y} = GWP_{N2O} \cdot EF_{N2O,mm,i} \cdot CF_{N2O-N,N} \cdot \left[\prod_{n=1}^{i-1}(1-R_{N,n})\right] \cdot \frac{1}{1000} \cdot \sum_{populations} NEX_{population} \cdot N_{population} \quad \textbf{(11)}$$

where:

$E_{N2O,mm,1,y}$	Are the nitrous oxide emissions from the first stage of the manure management systems in tonnes of CO_2 equivalents per year.
GWP_{N2O}	Is the approved Global Warming Potential (GWP) for N_2O.
$EF_{N2O,mm,i}$	Is the N_2O emission factor for the treatment stage i of the manure management system in kg N_2O-N/kg N (EF_3 in 1996 Revised IPCC Guidelines and IPCC GPG).
$CF_{N2O\text{-}N,N}$	Is the conversion factor N_2O-N to N (44/28).
$R_{VS,n}$	Is the relative reduction of nitrogen in the treatment stage n in per cent.
$NEX_{population}$	Is annual average nitrogen excretion per animal of the defined livestock population in kg N/animal/year.
$N_{population}$	Is the livestock of a defined population.

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 Chapter 8.2 in US-EPA (2001).

Equation 10 or equation 11 should be applied to the second and, where relevant, any following treatment stages.

Finally, N_2O emission reductions due to changes in the manure management are calculated as the differences between emissions in the baseline scenario and emissions in all stages of manure management that are part of the project activity:

$$ER_{N2O,mm,y} = E_{N2O,mm,baseline} - E_{N2O,mm,project} - \sum_i E_{N2O,mm,i,y} \qquad \textbf{(12)}$$

where:

$ER_{N2O,mm,y}$	Are the N_2O emission reductions due to the project activity during the year y in tons of CO_2 equivalents.
$E_{N2O,mm,baseline}$	Are the N_2O emissions from manure management in the baseline scenario during the year y, calculated with equation 1, in tons of CO_2 equivalents.
$E_{N2O,mm,project}$	Are the N_2O emissions from manure management in first stage of the project activity during the year y, calculated with equation 1, in tons of CO_2 equivalents.
$E_{N2O,mm,i,y}$	Are the N_2O emissions from manure management in the second or subsequent treatment stage i of the project activity during the year y in tons of CO_2 equivalents.

Total emission reductions

Total emission reductions of the project are the sum of CH_4 and N_2O emission reductions, adjusted for leakage effects:

$$ER_y = ER_{CH4,mm,y} + ER_{N2O,mm,y} - L_y \qquad \textbf{(13)}$$

where:

ER_y	Are the net emission reductions due to the project activity during the year y in tons of CO_2 equivalents.
$ER_{CH4,mm,y}$	Are the CH_4 emission reductions due to the project activity during the year y in tons of CO_2 equivalents.
$ER_{N2O,mm,y}$	Are the N_2O emission reductions due to the project activity during the year y in tons of CO_2 equivalents.
L_y	Are the leakage effects due to the project activity during the year y in tons of CO_2 equivalents.

The ex-ante baseline and project methane emissions to be reported in the CDM-PDD are based on estimation equations defined earlier. Whereas, for the purpose of claiming emissions reductions, for project activities involving capture and destruction of methane in anaerobic lagoons, the baseline methane emissions are the lower of the actual methane captured and flared or those estimated by equations estimating baseline methane emissions. The value of the actual methane captured and flared should be multiplied by the flare efficiency. Flare efficiency is estimated as per procedure explained below and monitored as per the monitoring methodology. If actual methane captured and flared is lower than the estimated baseline methane emission, the project methane emissions for the project AWMS, where the biogas is captured, is considered as zero.

The amount of methane actually flared will be determined by monitoring the:

(i) The amount of biogas collected in the outlet of the Biodigester using a continuous flow meter.
(ii) Percentage of biogas that is methane, which should be measured either with continuous analyzer or alternatively with periodical measurement at 95% confidence level using calibrated portable gas meters and taking a statistically valid number of samples.
(iii) The flare efficiency shall be calculated as fraction of time the gas is combusted in the flare multiplied by the efficiency of the flaring process. Efficiency of the flaring process is defined as fraction of methane completely oxidized by the flaring process.
(iv) If efficiency of the flares is not measured, a conservative destruction efficiency factor of 50% should be used for enclosed and open flares.

Leakage

Leakage effects under this methodology comprise only methane emissions from the project activity due to the disposal of treated manure (e.g. sludge) to the environment, if the treated manure is accumulated or deposited under anaerobic conditions. For example, sludge from an aerobic treatment may be used as fertiliser in land application programs or may be disposed on a controlled landfill, outside the project boundaries. As a conservative approach, this emission source is not considered for the baseline scenario.

The potential methane emissions depend mainly on the degradability of the treated manure. Similarly to equation 3 above, the calculation of methane emissions is based on the biochemical oxygen demand of the treated manure:

$$L_y = GWP_{CH4} \cdot 0.25 \cdot BOD_{treated\ manure,y} \cdot F_{treated\ manure,y} \cdot \frac{1}{1{,}000{,}000} \qquad \textbf{(14)}$$

where:

L_y	Are the leakage effects due to the project activity during the year y in tons of CO_2 equivalents.
GWP_{CH4}	Is the approved Global Warming Potential (GWP) of CH_4.
$BOD_{treated\ manure,y}$	Is the average long term biochemical oxygen demand of the treated manure during the year y in mg/l.
$F_{treated\ manure,,y}$	Is the annual quantity of treated manure that is deposited under anerobic conditions during the year y in m^3.

As a further conservative assumption, it is assumed in equation 14 that all degradable carbon in the treated manure would be oxidized to methane (no methane conversion factor is considered).

Other sources of leakage effects (e.g. changes in other nitrous oxide emissions or changes in electricity demand) are considered to be small compared to the emission reductions and are, therefore, not considered in this methodology. The project participant shall nevertheless provide an estimation of the possible changes in electricity demand in order to demonstrate that the project activity complies with the last applicability condition of this methodology (i.e. the project activity does not lead to a significant increase of electricity consumption).

Draft revision to the approved monitoring methodology AM0006

"GHG emission reductions from manure management systems"

Source

This methodology is based on the PDD "Methane capture and combustion of swine manure treatment for Peralillo" whose baseline study, monitoring and verification plan and project design document were prepared by Agricola Super Limitada. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0022: "Methane capture and combustion of swine manure treatment for Peralillo" on http://cdm.unfccc.int/methodologies/approved.

Applicability

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

- The project context is represented by farms operating under a competitive market;
- The manure management system introduced as part of the project activity, as well as the manure management system in the baseline scenario, must be in accordance with the regulatory framework in the country;
- Livestock populations are managed under confined conditions. Barn systems and barn flushing systems should neither be the baseline scenario nor the project activity;
- Livestock populations comprise only cattle, buffalo and/or swine;
- The manure management system introduced as part of the project activity, as well as the manure management system in the baseline scenario, may consist of several stages of manure treatment, including all options (or a combination of them) listed below in step 1 under "Additionality", but excluding the discharge of manure into natural water resources (e.g. rivers or estuaries);
- The project activity does not lead to a significant increase of electricity consumption.

Monitoring Methodology

In this methodology, monitoring comprises several activities. To determine the quantity of nitrogen and volatile solids that are supplied to the manure management system, the following information should be collected:

- The livestock populations have to be monitored in accordance with IPCC categories. This includes the heads of each population and the average animal weight in each population;
- The volatile solid excretion and the nitrogen excretion per animal and day have to be determined. Where site-specific data is used, regular monitoring is required. In case of regional or national data or default data, values may need to be updated.

These monitored values should be used for the calculation of both baseline and project emissions.

The monitoring methodology for methane and nitrous oxide emissions depends on the approach followed (option A or B in step 5 of approved baseline methodology AM00XX *"GHG emission reductions from manure management systems"*):

- Where Option A is followed to determine emissions of the project activity, the biochemical oxygen demand (BOD), the nitrogen content (N), the temperature (T) and the flow rate (F) of the manure should be monitored between each treatment stage.
- Where Option B is followed, no additional parameters need to be monitored.

In projects using anaerobic digesters, the biogas flow and the CO_2 concentration in that flow are monitored to ensure proper functioning of the digester. However, these parameters are not directly used for the calculation of emission reductions.

Finally, for the calculation of leakage emissions it is necessary to monitor the biochemical oxygen demand (BOD) and the flow rate (F) of treated manure flows.

Parameters to be monitored

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Propor-tion of data moni-tored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1	number	Animal Popu-lation	Heads	measured	weekly	100%	paper	At least two years from completion of authorisation period or last CERs issued	To be collected for each livestock population from 1996 Revised IPCC Guide-lines and IPCC GPG 2000.
2	mass	Average weight of Animals	kg	measured	Records of entrance and exit of animals to the barn	100%	paper	At least two years from completion of authorisation period or last CERs issued	To be collected for each livestock population from 1996 Revised IPCC Guide-lines and IPCC GPG 2000.
3	concen-tration	Volatile solid excretion per animal and day)	kg dry matter / animal / day	measured	monthly	100%	paper	At least two years from completion of authorisation period or last CERs issued	Monitoring of this data is only required if measured site-specific data is used. To be collected for each livestock population from 1996 Revised IPCC Guide-lines and IPCC GPG 2000.

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
4	concentration	Nitrogen excretion per animal and day)	kg dry matter / animal / day	measured	monthly	100%	paper	At least two years from completion of authorisation period or last CERs issued	Monitoring of this data is only required if measured site-specific data is used. To be collected for each livestock population from 1996 Revised IPCC Guidelines and IPCC GPG 2000.
5	flow rate	Manure flow between each treatment stage	m^3/day	measured	monthly	100%	paper	At least two years from completion of authorisation period or last CERs issued	Only required for option A in step 5 of the baseline methodology. To be measured between each treatment stage of the project manure management system.
6	concentration	5 days Biochemical Oxygen Demand (BOD) in manure between each treatment stage	mg/l	measured	monthly	100%	paper	At least two years from completion of authorisation period or last CERs issued	Only required for option A in step 5 of the baseline methodology. To be measured between each treatment stage of the project manure management system.

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
7	concentration	Total nitrogen content in manure between each treatment stage	mg/l	measured	monthly	100%	paper	At least two years from completion of authorisation period or last CERs issued	Only required for option A in step 5 of the baseline methodology. To be measured between each treatment stage of the project manure management system.
8	Temperature	Temperature of manure between each treatment stage	ºC	measured	monthly	100%	paper	At least two years from completion of authorisation period or last CERs issued	Only required for option A in step 5 of the baseline methodology. To be measured between each treatment stage of the project manure management system.
9	flow rate	biogas flow extracted by digester	SCFM/day (standard cubic feet meter/day)	measured	Every working day	100%	paper	At least two years from completion of authorisation period or last CERs issued	Only applicable to project activities including an anaerobic digester. This parameter guarantees the correct performance of digester and gas recovery. This parameter will verify the correct anaerobic fermentation process in the baseline scenario (considering the effect of inhibitors).

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
10	percentage	CO_2 concentration in gas flow	%	measured	daily	100%	paper	At least two years from completion of authorisation period or last CERs issued	Only applicable to project activities including an anaerobic digester. This parameter guarantees the correct performance of digester and gas recovery.
11	percentage	Flare efficiency determined by the operation hours (1) and the methane content in the exhaust gas (2)	%	m and c	Semi-annual, monthly if unstable	n/a	electronic	Duration of crediting period	Methane content of flare exhaust gas. Only applicable to project activities where gas is captured and flared . (1) Continuous measurement of operation time of flare using a run time meter connected to a flame detector or a flame continuous temperature controller (2) Periodic measurement of methane content of flare exhaust gas

Leakage

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
11	Flow rate	Flow of treated manure that is deposited under anaerobic conditions	m^3/day	measured	monthly	100%	paper	At least two years from completion of authorisation period or last CERs issued	Only required if treated is deposited under anaerobic conditions.
12	Concentration	5 days Biochemical Oxygen Demand (BOD) in treated manure that is deposited under anaerobic conditions	mg/l	measured	monthly	100%	paper	At least two years from completion of authorisation period or last CERs issued	Only required if treated is deposited under anaerobic conditions.
13	Temperature	Temperature in treated manure that is deposited under anaerobic conditions	ºC	measured	monthly	100%	paper	At least two years from completion of authorisation period or last CERs issued	Only required if treated is deposited under anaerobic conditions.

Quality Control (QC) and Quality Assurance (QA) Procedures

Data	Uncertainty Level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
1	Low	Yes	QA/QC procedures are established.
2	Low	Yes	QA/QC procedures are established.
3	Medium	Yes	QA/QC procedures are established. The parameter is particularly sensitive to the calculation of emission reductions.
4	Medium	Yes	QA/QC procedures are established. The parameter is particularly sensitive to the calculation of emission reductions.
5	Low	Yes	QA/QC procedures are established.
6	Low	Yes	QA/QC procedures are established.
7	Low	Yes	QA/QC procedures are established.
8	Low	Yes	QA/QC procedures are established.
9	Low	Yes	QA/QC procedures are established.
10	Low	Yes	QA/QC procedures are established.
11	Low	Yes	QA/QC procedures are established.
12	Low	Yes	QA/QC procedures are established.
13	Low	Yes	QA/QC procedures are established.