AM0016 / Version 03
Sectoral Scopes: 13 and 15
03 March 2006

Revision to the approved baseline methodology AM0016

"Greenhouse gas mitigation from improved Animal Waste Management Systems in confined animal feeding operations"

Source

This methodology is based on the draft CDM-PDD "Granja Becker GHG Mitigation Project" whose baseline study, monitoring and verification plan and project design document were prepared by AgCert Canada Co. on behalf of Granja Becker, L.B.Pork, Inc. and AgCert Canada Co. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0034-rev.2: "Granja Becker GHG Mitigation Project" 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 Animal Waste Management Systems (AWMS) project activities aiming at mitigating greenhouse gases (GHG) where the proposed improvements result in:

- The captured gas being flared, or
- The captured gas is used to produce energy (e.g. electricity/thermal energy), but no emission reductions are claimed for displacing or avoiding energy from other sources[1].

This methodology is applicable to AWMS with the following conditions:

- Farms with livestock populations managed under confined conditions which operate in a competitive market;
- Livestock populations comprising: Cattle, buffalo, swine, sheep, goats, and/or poultry;
- AWMS – including both the baseline scenario and the manure management system introduced via the proposed project activity – are in accordance with the regulatory framework of the host country and are excluding the discharge of manure into natural water resources (e.g. rivers or estuaries);
- On-farm systems that introduce AWMS practices and technology change to reduce GHG emissions.

This baseline methodology shall be used in conjunction with the approved monitoring methodology AM0016 ("Greenhouse gas mitigation from improved Animal Waste Management Systems in confined animal feeding operations").

Baseline scenario and 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.

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[1] Although in this case no emission reductions are claimed for displacing or avoiding energy from other sources, all possible financial revenues and/or emission leakages shall be taken into account in the analyses performed.

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:

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(e) 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 and greater than one month.

(f) 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.

(g) 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 and greater than one month.

(h) 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.

(i) 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 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 manure 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 in the company and region;

- Availability of waste treatment technology;
- Future developments of technological innovations for manure management systems.

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**~~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 equipments needed)				
Installation costs				
Maintenance costs				
Additional costs (Operation, consultancy, engineering)				
Revenue from the sale of electricity or other project-related products, where applicable				
SUBTOTAL				
TOTAL				
NPV (USD) (specify discount rate)				
IRR (%)				

For each scenario, the internal rate of return (IRR) and the net present value (NPV) should be calculated. The calculation of the IRR must include incremental investment costs, operation and maintenance costs, all revenues generated by each manure management scenario, including revenue from the sale of fertilizer and electricity and cost savings due to avoided electricity purchases, except revenue 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, for the project activity assumptions and parameters should be chosen in a way that they tend to lead to a higher IRR and NPV. For all other scenarios, assumptions and parameters should be chosen in a way 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 validation of the project activity.

If the IRR cannot be calculated due to 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. The robustness of the results should be demonstrated via a sensitivity analysis.

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 where the IRR 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 the IRR of the project is clearly and significantly lower than the IRR of that baseline scenario that is determined as the most likely result of the barrier analysis.

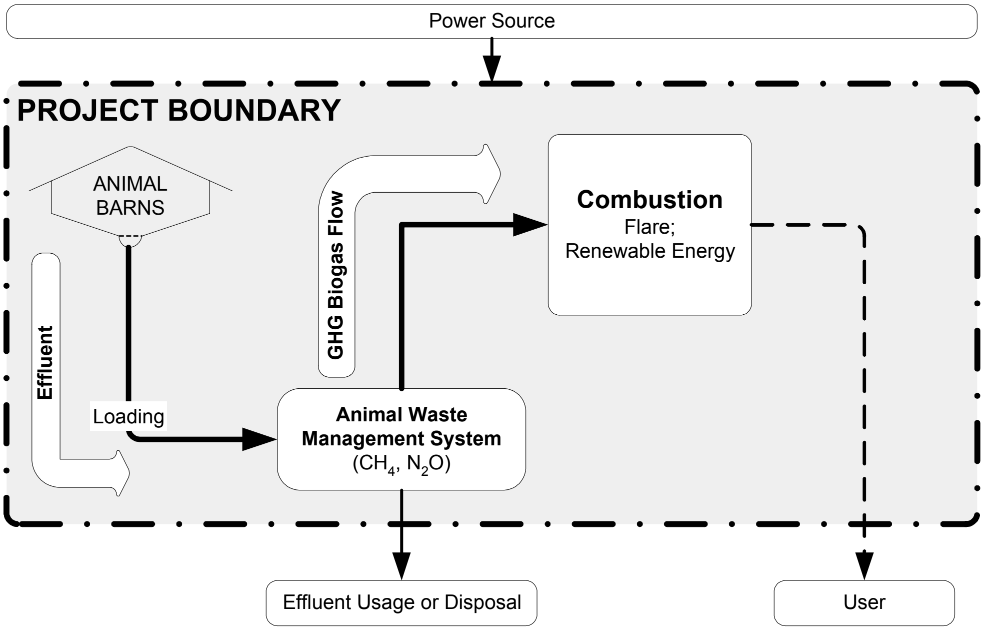
As part of the barrier assessment, project participants should analyse whether and why the technology or technique of the project activity is not nationally and/or worldwide commonly used, due to investment barriers, technological barriers, barrier due to prevailing practice or other barriers to implement the project activity technology or technique, despite of the environmental benefits that this technology or technique can produce. For all barriers identified, it should be explained how they apply to the project context.

Step 5: Analysis of development during the crediting period
As a final step, project participants should assess whether the basis in choosing the baseline scenario (economic performance, legal constraints, common practice, etc.) is expected to change during the crediting period. The results of this assessment should be documented and summarized.

Project boundary

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 as the least-cost, most plausible scenario. The project boundary is illustrated in figure 1 below.

Figure 1: Boundary for the calculation of baseline emissions



The animal barn is included in the project boundary for the purposes of monitoring livestock parameters, such as species, genetics, animal count (by population type) and herd weight gains, and feed formulation; as these parameters affect waste-loading. Emissions from barn systems and barn flushing systems should not be included in either the baseline scenario or the project activity.

Data characterization

(a) Phase 1 of data characterization: To estimate AWMS GHG emissions, the data comprising the farm system and its elements, including farm location (continent, country and geographic coordinates) must be obtained. Based on this information:

(i) Select appropriate emission factors based upon country specific or climatic conditions, or

(ii) Gather meteorological data (including monthly average temperature and rainfall information) for use in calculating emission factors.

The characterization process also includes identifying farm livestock types, including species and genetic source, and the practice(s) employed for waste management. Large farm systems sometimes employ different management methods for different species or animal groupings on the farm. A farm system block diagram should be developed to depict the various segments (i.e. waste production, management & disposition) and to define the interfaces and interrelationships between them. In addition to the "baseline emission scenario" diagram, a "project (post) implementation of mitigation measures" diagram must be developed. Care should be taken to identify all interfaces and technical factors relevant to estimating uncertainties and leakage.

For AWPS, define the population of animals by number, type (genetics) and other characteristics including feed formulations, and diet regimen. For AWMS, depict the structure, size and flow of effluent between the storage elements. If multiple lagoons are present, the volumes of each and removal dynamics are detailed. The IPCC has established numerous classifications[2] for storage of waste including; liquid/slurry, anaerobic lagoon(s), pit storage below animals (<30 days, >30 days), anaerobic digestion, etc.

In addition to defining the waste storage method(s), identify the method and frequency of waste disposal. In the case of some operations, such as "free range" cattle, the disposal dynamics may be delineated via the IPCC categories (i.e. pasture/range). In other operations mechanisms are more complex; practices may even vary between farms utilizing similar AWMS. An example is swine farms utilizing anaerobic lagoons. Some farms may recycle effluent to periodically irrigate and fertilize crops. Some farms may empty the lagoon annually; others may not. Document all management practice dynamics (type, volumes & frequency) critical for characterizing both the "baseline" and "new" technologies.

(b) The second phase of data characterization involves collecting information relating to the animal population. For example, the animal classes that should be considered for IPCC Tier 2 swine and dairy operations are:

i) Swine
  a) Sows - subdivided into farrowing & gestation if possible.
  b) Boars.
  c) Growing animals - subdivided into nursery, growing & finishing pigs.

ii) Cattle – Dairy
  a) Cows (dry & lactating).
  b) Heifer replacements.
  c) Calves.

Within each class, the number of resident animals (per month) should be determined[3]. This can be obtained from detailed farm records, when available, or by calculations using: numbers born, death rates, animal purchases and marketing (in effect, minimally considering 'animals in' and 'animals

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[2] IPCC 1996, "Revised IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual" Table 4-8 pp 4.25 and Table B-6 pp 4.46

[3] EPA (2003) "U.S. GHG Emissions and Sinks 1990-2001", Annex L

out' for each category). Calculated monthly numbers should also consider the animal weight and weight gains occurring within each grouping over time. Where possible, it is preferable to use measured animal weights. If farm operations do not include average weight (ID number 11-AWi) measurements (recognizing that many CAFOs, even in developed nations, do not possess scales), monthly farm estimates or calculations should be made based upon the farm's experience. The referenced Hamilton paper (2003) documents that livestock raised in consistent conditions yield extremely consistent and predictable results, including weight (and weight gain) as a function of time. The most conservative approach should be used between the use of defaults and that suggested by Hamilton (2003) used in conjunction with abattoir measured "sale" weights ("out" weight). Animal population data should be correlated with records documenting manure management practice/facility for each animal group.

(c) Animal waste practice (or facility) for each type/class of resident animal. Important attributes include the energy content, intake volumes and digestibility of feed. The specific parameters prerequisite to performing these calculations are dependent upon animal type and, in some cases, are applicable only to a farm system element (i.e. AWPS). Key AWPS and AWMS parameters are given below.

Parameter determination

In the following sections, several means are presented for determining specific emission terms or coefficients, depending on available data and circumstances. When site data exist, site-specific parameters may be determined using relevant equations. Appropriate IPCC default values may be chosen to simplify calculations. Figure 2, emission factor determination test, proposes a series of tests for determining whether IPCC "developed country" or "developing country" coefficients are appropriate.

The test first determines whether host-country published factors exist. After, it sequences through a series of questions to determine applicability for choosing IPCC "developed country" parameters (failure to meet any of these tests indicates that IPCC "developing country" parameters should be used instead):

Figure 2: Emission factor determination test

Emission factor determination test for AWMS applications

1. **Has the project activity host Party published country-specific, emission factors that apply to the project activity?**
    a. If yes, go to "A."
    b. If no, proceed to question 2.
2. **Does the genetic source of the production operations livestock originate from an Annex I Party?**
    a. If yes, go to question 3.
    b. If no, proceed to "B."
3. **Does 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?**
    a. If yes, go to question 4.
    b. If no, proceed to "B."
4. **Can the use of FFR be validated (through on-farm record keeping, feed supplier, etc.)?**
    a. If yes, use IPCC Guidelines "developed nation" emission factors in conjunction with equations A3-8 through A3-11 to determine methane emissions.
    b. If no, proceed to "B."

A. Use country-specific default emission factors provided by host Party or determine applicable site-specific factors.

B. Use default value emission factor for developing countries (1996 Rev IPCC Guidelines, Annex B of Chapter 4.2 or 2000 Rev IPCC Guidelines, Chapter 4).

AWPS – Animal Waste Production System

The key parameters and information required for calculating emissions are:

- Volatile solids excretion rate (V_s);
- Maximum methane producing capacity (B_0) for the animal waste;
- Nitrogen excretion rate (N_{ex}), and
- Average animal weights per class.

V_s can be determined in one of four ways:

1) Utilizing published IPCC defaults.
2) Using published country specific data.
3) Scaling V_s to adjust for a site-specific average animal weight as shown in equation-1.

$$V_s = (W_{site}/W_{default}) * V_{sIPCC} \quad \textbf{(1)}$$

where

$W_{site}/W_{default}$ Is the ratio of site-specific weight to IPCC default weight (82 kg for swine).

4) Calculating for farm or region as:

$$Vs = GE * (1/ED)*(1-DE/100)*(1-Ash/100) \quad \textbf{(2)}$$

where

Vs:	*Daily volatile solid excretions [on a dry matter weight basis (kg-dm/day)*
GE:	*Daily average gross energy intake in MJ/day*
DE:	*Digestible energy of the feed in percent (IPCC defaults available)*
Ash:	*Ash content of the manure relative to the dry matter of the manure and not to the total matter (% - IPCC defaults),*
ED:	*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.) The project proponent will record the composition of the feed to enable the DOE to verify the energy density of the feed.*

The maximum methane potential, B_0, can be obtained from IPCC default tables, other country-specific calculations, or obtained from a standardized laboratory method. The DOE has to ensure that there is adequate justification in case the most conservative value is not used.

The nitrogen excretion rate, N_{ex}, is the Kjeldahl excreted nitrogen content of the manure expressed in kg/animal/year. Values for N_{ex} are provided in IPCC tables and may reflect the best estimates available. Country/practice information may also be available. IPCC also provides the relationship necessary to directly estimate N_{ex}:

$$N_{ex} = N_{intake} * (1- N_{retention}) \quad \textbf{(3)}$$

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.

N_{intake} may be calculated using:

$$N_{intake} = IV * P/6.25 \quad \textbf{(3a)}$$

where

P	Percent of protein (decimal).
IV	Intake volume of dry matter in kg/day

Similar to methane, the reference N_{ex} can also be scaled to a site-specific weight by:

$$N_{ex} = (W_{site}/W_{default}) * N_{ex\text{-}IPCC} \quad \textbf{(4)}$$

where

$W_{site}/W_{default}$	Ratio of site-specific weight to IPCC default weight (82 kg for swine).
$N_{ex\text{- }IPCC}$	Default N_{ex} published by IPCC.

Within the animal waste production system it may be desirable to characterise and estimate GHG emissions as a means to define inputs to the AWMS. AWPS emissions can, in some cases, impact the emissions that will occur “downstream” in subsequent manure processing or disposition. GHG emissions (methane and nitrous oxide) are largely attributable to two sources: (a) Enteric fermentation within an animal’s digestive system (causing methane emanations from the animal), and (b) partial decomposition of the animal waste prior to it being transported into the AWMS (manifesting barn methane and nitrous oxide emissions).

Methane emissions arising from the waste prior to its entry to the AWMS are a function of the time interval the material resides in the AWPS and the temperature of the environment. Indirect N_2O emissions are expressed by:

$$N_2O_{i\text{-}barns} = N_{ex} * EF_4 * F_{gasm\text{-}barns} * C_m \tag{5}$$

where

$N_2O_{i\text{-}barns}$	Indirect nitrous oxide emission in kg/year/animal.
N_{ex}:	Average annual N excretion per head per category in kg – N/animal-year.
EF_4:	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces in kg N_2O-N per kg NH_3-N and NO_X-N emitted.
$F_{gasm\text{-}barns}$	Fraction of animal manure N that volatizes as NH_3 and NO_X in the barns (kg NH_3-N and NO_X-N per kg of N).
C_m	Conversion factor from [N_2O – N] to N_2O (C_m= 44/28).

Should this relationship be employed it is important to reduce the subsequent nitrification/de-nitrification potential by adjusting the value for the parameter N_{ex} as:

$$N_{ex\text{-}after} = N_{ex\text{-}before} * (1-F_{gasm\text{-}barns}) \tag{6}$$

AWMS – Animal Waste Management System

Good Practice Guidance (IPCC, 2000) publishes default methane conversion factors ranging from *0% to 100%*, reflecting a wide range of performance in various AWMSs. The IPCC provides tabular default values for various climatic regions (cold, temperate, warm) and different forms of AWMS storage (lagoons, pits, etc.). When implementing specific farm-based technology changes, however, it may be desirable to more precisely calculate anticipated emissions and to implement robust measures for monitoring, verification and validation.

Two of the primary contributors to uncertainty in methane conversion factors for liquid systems are variation in climatic conditions and the premature removal and utilization of un-digested effluent. Mangino, et. al, (2002) and the U.S. EPA, (2003) delineate a methodology for incorporating these variables directly in the estimation of methane emission factors. This stepwise process allows the direct calculation of monthly and annual emission factors and is based on the van’t Hoff-Arrhenius equation used to forecast performance of biological reactions. Using a base temperature of thirty degrees centigrade, the equation is given as:

$$f = exp[E*(T_2-T_1)/(R*T_1*T_2)] \tag{7}$$

where

f	Conversion efficiency of V_s to CH_4 per month.
E	Activation energy constant (15,175 cal/mol).
T_2	Ambient temperature (Kelvin) for the climate.
T_1	303.16 ($273.16^\circ + 30^\circ$).
R	Ideal gas constant (1.987 cal/ K mol).

The factor ‘f’ represents the proportion of volatile solids that are biologically available for conversion to methane based upon the temperature of the system. The assumed temperature is equal to the ambient temperature. For colder temperatures a minimum temperature of 5° C was given for anaerobic lagoons and 7.5° C for other liquid systems. This considers lagoon depths and heat generated as a by-product of biologic activity.

The MCFs for liquid anaerobic lagoon systems are calculated as follows:

(1) The monthly average temperature for the area is obtained from published national weather service information[4].

(2) Monthly temperatures are used to calculate a monthly van’t Hoff – Arrhenius ‘f’ factor using Equation-7. A minimum temperature of 5° C is used for anaerobic lagoons and 7.5° C is used for liquid slurry and deep pit systems.

(3) Monthly production of volatile solids added to the system is calculated by summing the number of animals present, by weight grouping, by month. The result is multiplied by a Management Design Practices (MDP) factor, which reflects uncertainties arising from barn losses (AWPS).

(4) The amount of volatile solids available for conversion to methane is assumed to be equal to the amount of volatile solids produced during the month (from step 3). For anaerobic lagoons, the amount of volatile solids available also includes volatile solids that may remain in the system from previous months.

(5) The amount of volatile solids consumed during the month is equal to the amount available for consumption multiplied by the ‘f’ factor.

(6) For anaerobic lagoons, the amount of volatile solids carried over from one month to the next equals to the amount available for conversion minus the amount consumed and minus the amount removed from the lagoon. In the case of the emptying of the lagoon, the accumulation of volatile solids restarts with the next inflow. For partial removal (e.g., dewatering for irrigation) the volatile solid carryover should be reduced by an amount that is proportional to the partial fraction (of the lagoon’s storage capacity or ‘HRT’) that is removed.

(7) The estimated amount of methane generated during the month is equal to the monthly volatile solids consumed multiplied by the maximum methane potential (B_0).

(8) It is then possible to calculate both monthly and annual MCFs as:

$$MCF = CH_{4\,generated} / (V_{s\,generated} * B_0) \qquad \textbf{(8)}$$

where

MCF	Methane conversion factor.
$CH_{4\,generated}$	See step 7 above.

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[4] www.weatheronline.co.uk, for instance, provides access to published data for a wide range of global locations.

$V_{s\ generated}$	Volatile solids entering lagoon monthly.
B_0	Maximum methane producing potential of the waste.

In order to account for the carry-over of volatile solids from the year prior to the year of calculation, it is assumed that data (or an estimate) is available from which a calculation of prior year ending balances can be made.

This procedure permits a determination of MCF that accounts for temperature variation throughout the year, residual volatile solids in the system (carry-over) and management and design practices (such as effluent removal) that will reduce the volatile solids available for conversion.

Emissions reductions - calculation methods

This methodology is applicable to most combinations of waste management practices, excluding uncontrolled deposition in rivers and estuaries.

All manure-induced nitrous oxide emissions from soil and land application are to be considered independent from the waste treatment facility.

In the following sections, several means are presented for determining specific emissions terms or coefficients, depending on available data and circumstances. When site data exists, site-specific parameters may be determined using relevant equations. IPCC default values can be chosen in lieu of calculated results. A test for determining whether 'developed country' or 'developing country' coefficients are appropriate is included above in Figure 2. Emission Factor Determination Test. Finally, if site specific terms are calculated, they should be compared to IPCC defaults for 'developed country' conditions (if applicable), and the more conservative result used.

The following sections treat methane and nitrous oxide calculations separately:

Methane Emissions

The AWMS methane emissions (expressed in terms of CO_2 equivalents) is given as:

$$CO_{2eq\ methane} = CH_{4\ annual} * GWP_{CH4}/1000 \qquad \textbf{(9)}$$

where

$CO_{2eq\ methane}$	Carbon dioxide equivalent emission in metric tonnes.
$CH_{4\ annual}$	Methane produced in kg/year.
GWP_{CH4}	Global Warming Potential of methane ($GWP_{CH4} = 21$).

The annual CH_4 emissions are obtained by summing the monthly emissions using:

$$CH_{4\ annual} = \sum_{mj} EF_{month} * Population_{month} * MS\%j \qquad \textbf{(10)}$$

where

EF_{month}	Emission Factor in kg/head/month.
$Population_{month}$	Number of head in the defined population that month.
m	Months 1, 2, 3,…,12.
$MS\%j$	Fraction of animal manure handled in system j.

The emission factor for the animal group for any given month is:

$$EF_{month} = V_s * n_m * B_0 * 0.67 kg/m^3 * MCF_{month} \tag{11}$$

where

V_s	Volatile solids excreted in kg/day.
n_m	Number of days in the month.
B_o	Maximum methane potential m^3/kg $V_{s.}$
MCF_{month}	Methane conversion factor for the month.

One AWMS practice yielding results differing from those calculated above is an anaerobic digester. In such (digester) systems the effluent is placed in an enclosed containment vessel and the resulting methane emissions are captured and combusted. Here, the methane conversion factors for resulting methane emissions relate primary to losses resulting from improper sealing, efficiency losses of the combustion device, temperature of treatment and latency time in the digester. The IPCC has published separate default values for anaerobic digesters.

The combustion of methane in the presence of oxygen produces carbon dioxide according to the following stoichiometric equation:

$$\begin{array}{lll} CH_4 + 2O_2 \rightarrow & CO_2 + 2H_2O & \\ 16 & 44 & \text{(molar equivalent)} \end{array} \tag{12}$$

In Equation-12, the GWP of methane is replaced by the molar mass quotient of CO_2 to CH_4, which is 2.75 (44/16), and the MCF used to calculate EF becomes the baseline anaerobic lagoon MCF. (This equation is presented for reference in the event that CO_2 generated through the combustion of CH_4 is ever deemed non-biogenic in nature.)

Nitrous Oxide Emissions

The nitrous oxide emission (expressed in terms of CO_2 equivalents) is given as:

$$CO_{2equiv\ N2O} = GWP_{N2O} * N_2O_{total\ annual}/1000 \tag{13}$$

and

$$N_2O_{total\ annual} = \sum_{mj} (N_2O_d + N_2O_i) * Population_{month} * MS\%j \tag{14}$$

where

$CO_{2equiv\ N2O}$	Carbon dioxide equivalent emissions of nitrous oxide in metric tonnes.
$N_2O_{total\ annual}$	Nitrous oxide in emissions annually in kg/year.
GWP_{N2O}	Global Warming Potential of nitrous oxide (GWP_{N2O} = 310).
N_2O_d	*Direct* nitrous oxide emission in kg/month/animal.
N_2O_i	*Indirect* nitrous oxide emission in kg/month/animal.
$Population_{month}$	Number of head in the defined population that month.
m	Months 1, 2, 3,…,12.

MS%j:	Fraction of animal manure handled in system j.

Note: The divisor of 1000 converts from kg to metric tonnes.

The equation that describes the direct nitrous oxide emissions is:

$$N_2O_d = N_{ex\ month} * EF_3 * (1- F_{gasm}) * C_m \quad \textbf{(15)}$$

And the equation that describes indirect nitrous oxide emissions is:

$$N_2O_i= N_{ex\ month} * EF_4 * F_{gasm} * C_m \quad \textbf{(16)}$$

where

$N_{ex\ month}$	Average annual N excretion per head per category in kg - N/animal-month and adjusted for prior losses.
EF_4	Emission factor for indirect N_2O emissions from atmospheric deposition of N on soils and water surfaces in kg N_2O-N per kg NH_3-N and NO_X-N emitted.
F_{gasm}	Fraction of animal manure N that volatizes as NH_3 and NO_X in kg NH_3-N and NO_X-N per kg of N.
C_m	Conversion factor from $[N_2O – N]$ to N_2O (C_m= 44/28).

Leakage calculations

The baseline methodology considers potential leakage by summing all calculable leakage terms for the project activity and deducting the leakage terms from the project GHG emission reduction yield.

Potential AWMS project activity leakage can be divided into these categories:

- Electrical power

  Electricity used by project activity equipment, such as fans, blowers, motors, pumps, igniters. The electricity emission leakage during any given year (EE_Y) is the project activity's share of the emissions associated with the electricity used to power any additional equipment during the year (EP_Y).

$$EE_y = (EP_{y\text{-}project} – EP_{p\text{-}project}\text{-} EP_{\text{-}baseline}) * EC_y / 1000 \quad \textbf{(17)}$$

where

EE_y	Electricity emission during any given year.
$EP_{y\text{-}project}$	Electricity used by project activity during any given year (metered).
$EP_{y\text{-}baseliine}$	Electricity used during baseline operations in the given baseline year (metered).
$EP_{p\text{-}project}$	Electricity cogenerated (produced) by the project activity during any given year (metered).
EC_y	Emission coefficient for the electricity used measured in $kgCO_2e/kWh$.

The combination of (metered) electricity usage records and relevant GHG emission factors (whether supplied by the electric utility, the national government, or other public references) will be used to make this determination. In equation-17, EP_y is the metered electricity used by the project equipment during the year in kWh, and EC_y is the emissions coefficient for the electricity used measured in kgCO_2e/kWh. Division by 1000 converts the emissions to metric tons of CO_2e. Determination of the emissions coefficient requires considering regional electric generation GHG factors.

When cogeneration equipment is installed and operational, “green energy” produced by the proposed project activity will be measured and may be used to offset electricity used by the proposed project activity. In equation-17, EP_p is the metered electricity produced through cogeneration.

- Potential Increased Emissions from Pumping

  Covered and uncovered lagoons, properly managed, never require agitation and require only infrequent pumping. However, the AWMS may be dewatered, as needed, to increase the holding capacity or to utilize the fluid as fertilizer. Solids are often retained, resulting in a more comprehensive conversion of the volatile solids. Provisions for determining the methane conversion factors attendant to effluent removal are included in the methodology. *By calculating or measuring emissions monthly, with site specific farm parameters, periodic maintenance or operational repair should never result in loss of emission reductions for a period longer than one month. Proper design of covered lagoon cell(s) will permit effluent removal with no loss of biogas. DOE has to verify if the design of the covered lagoon cell is proper.*

- Potential Increased Emissions during Land Application

  Many factors influence the land emissions of nitrous oxide including temperature, precipitation, application method, etc. Leakage resulting from the land application of lagoon effluent can be expressed as the net difference between the ‘business as usual’ baseline scenario (if any) wherein the effluent is applied from an AWMS (e.g. uncovered storage system), and the application of effluent from the project activity AWMS. In effect, this term represents the land application emission differences that are attributable to (possibly) changed effluent chemistry that occurs as a result of the project activity.

$$\text{Land Leakage} = \text{Project activity land emissions} - \text{Baseline land emissions} \qquad \textbf{(18)}$$

In land applications, the ammonium concentration of the AWMS effluent is an indirect contributor to the emissions of nitrous oxide. Ammonium is oxidized to nitrate with potential N_2O emission during the nitrification process and denitrification under anaerobic soil conditions.

If a project considers a multi-lagoon AWMS, wherein the project activity covers some (but not all) of the AWMS lagoons, the increased ammonium concentration in the covered lagoon(s) (resulting from very low ammonia volatilisation) is offset by subsequent effluent storage in the one (or more) open secondary lagoons where (unencumbered) volatilisation occurs.

Note: According to Raoult's law, the vapour pressure of a solution is directly proportional to the mole fraction of solvent present. For instance, when biodigester effluent is pumped into an open secondary lagoon, the vapour pressure returns to its “original” state (that is, pre biodigester treatment); hence, ammonia / ammonium concentrations will return to pre biodigester values. Because effluent moves from the digester to secondary lagoon continually (as opposed to batch processing), the re-equilibration to pre-digester vapour pressure typically happens relatively quickly (a few hours). Given that most secondary lagoons have retention times measured in weeks or months, re-equilibration has sufficient time to occur.

The nitrogen emissions from soil application of animal waste are characterised by both direct and indirect contributory elements and given as:

$$N_2O_{land} = N_{ex} * N * (1-F_{gasm}) * EF_1 * C_m \tag{19}$$

and

$$N_2O_{runoff} = N_{ex} * N * (1-F_{gasm}) * F_{leach} * EF_5 * C_m \tag{20}$$

and

$$N_2O_i = N_{ex} * EF_4 * F_{gasm} * C_m \tag{21}$$

where

N_2O_{land}	Direct nitrous oxide emission in Kg N_2O/year.
N_2O_{runoff}	Indirect nitrous oxide emission in Kg N_2O/year.
N_2O_i	Indirect N_2O emissions from ammonia volatilization.
F_{gasm}	Fraction of animal manure N that volatizes as NH_3 and NO_X in kg NH_3-N and NO_X-N per kg of N.
N	Number of resident animals.
N_{ex}	Average annual N excretion per head per category in kg - N/animal-year.
EF_1	Emission factor for direct emission of N_2O from soils in Kg N_2O-N/kg N.
EF_5	Emission factor for indirect emission of N_2O from runoff in Kg N_2O-N/kg N.
F_{leach}	Non-volatized runoff.
C_m	Conversion factor from [N_2O – N] to N_2O (C_m= 44/28).

$$N_2O_{total} = (N_2O_{land} + N_2O_i + N_2O_{runoff}) * N/1000 \tag{22}$$

Note: The divisor of 1000 converts from kg to metric tonnes.

$$N_2O_{CO2\text{-}equiv} = GWP_{N2O} * N_2O_{total} \tag{23}$$

To calculate leakage using these relationships the project developers insert the appropriate value for N_{ex}**,** representing reductions in effluent nitrogen levels related to differences in ammonia volatilization (or other N reducing sources), between baseline and project activities within the project boundaries.

Total emissions

The total emissions are represented by the sum of the methane equivalents (or CO_2, if applicable) and, the nitrous oxide equivalents. Mathematically this is given as (from equations 9 and 13):

$$Total\ Emissions_{mt} = CO_{2eq\ methane} + CO_{2equiv\ N2O} \tag{24}$$

where the emissions are in carbon dioxide equivalent metric tonnes, and

$$Total\ Emissions_{kt} = Total\ Emissions_{mt}/1000 \tag{25}$$

which expresses emissions in Gg (kilo tonnes).

Net emission reductions are calculated by differencing the project emissions from the baseline emissions and adjusting the result for leakage (increased GHG emissions outside the boundaries that are a result of the project). Mathematically this is expressed by:

$$ER_{net} = BE - PE - L_o \tag{26}$$

The ex-ante baseline and project methane emissions and to be reported in the CDM-PDD are based on estimation equations defined earlier. Whereas, for the purpose of claiming emissions reductions, 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.

where

ER_{net}	Net emission reduction due to the project activity.
BE	Total baseline emissions.
PE	Total project emissions.
L_o	Leakage losses outside the boundary.

If L_0 is negative it should not be used in the calculation of ER_{net}.

BE and PE are to be estimated/calculated for the AWMS corresponding to the baseline scenario and project activity scenario by applying formulae 9 to16.

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 for the flares can’t be measured a conservative destruction efficiency factor should be used – 99% for enclosed flares and 50% for open flare.

Revision to the approved monitoring methodology AM0016

"Greenhouse gas mitigation from improved Animal Waste Management Systems in confined animal feeding operations"

Source

This methodology is based on the draft CDM-PDD "Granja Becker GHG Mitigation Project" whose baseline study, monitoring and verification plan and project design document were prepared by AgCert Canada Co. on behalf of Granja Becker, L.B.Pork, Inc. and AgCert Canada Co. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0034–rev.2: "Granja Becker GHG Mitigation Project" on http://cdm.unfccc.int/methodologies/approved.

Applicability

This methodology is applicable to the monitoring of Animal Waste Management Systems (AWMS) greenhouse gases (GHG) mitigation projects where the proposed improvements result in:

- The captured gas being flared, or
- The captured gas is used to produce energy (e.g. electricity/thermal energy), but no emission reductions are claimed for displacing or avoiding energy from other sources[5].

This methodology is applicable to AWMSs with the following conditions:

- Farms with livestock populations managed under confined conditions which operate in a competitive market;
- Livestock populations comprising: Cattle, buffalo, swine, sheep, goats, and/or poultry;
- AWMS systems – including both the baseline scenario and the manure management system introduced via the proposed project activity – that are in accordance with the regulatory framework of the host country, excluding the discharge of manure into natural water resources (e.g. rivers or estuaries);
- On-farm systems that introduce AWMS practice and technology changes to reduce GHG emissions.

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0016 ("Greenhouse gas mitigation from improved Animal Waste Management Systems in confined animal feeding operations").

Monitoring methodology

This monitoring methodology (NMM) is compatible with various project activities using the proposed baseline methodology: Greenhouse gas mitigation from improved Animal Waste Management Systems in confined animal feeding operations.

The methodology first requires that the project participants identify monitoring requirements as illustrated in figure 1, monitoring methodology.

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[5] Although in this case no emission reduction are claimed for displacing or avoid energy from other sources, all possible financial revenues and/or emission leakages shall be taken into account in the analyses performed.

Data monitoring requirements are determined pursuant to the AWMS practice changes specified by the project activity. The formulae and algorithms that determine AWMS GHG emissions are obtained from the baseline methodology AM0016 (**"**Greenhouse gas mitigation from improved Animal Waste Management Systems in confined animal feeding operations**").**

Once the project activity has begun, the project developer will monitor the identified parameters. These are measured, estimated, or calculated. The parameters listed in tables 1and 2 include data to be measured in the barn, AWMS, and those parameters needed to determine leakage outside the project boundary.
The parameters listed in table 3 are needed to determine ex-post baseline emissions (biogas collected, percentage of biogas that is methane, flare efficiency).
Monitored parameters are recorded and archived as described in table 1,2 and 3.

Upon completion of the analysis, all information is stored and protected from loss (tampering, corruption, force majeure, etc.)

The application of quality auditing techniques at each stage of the process is integral to the monitoring methodology. Additionally, visual inspections shall be conducted. Equipment anomalies and significant changes in animal feed regimen, if any, are examples of items that would be checked.

The key parameters and emission factors used to determine GHG emission levels for a particular project can be determined using any of the methods described below:

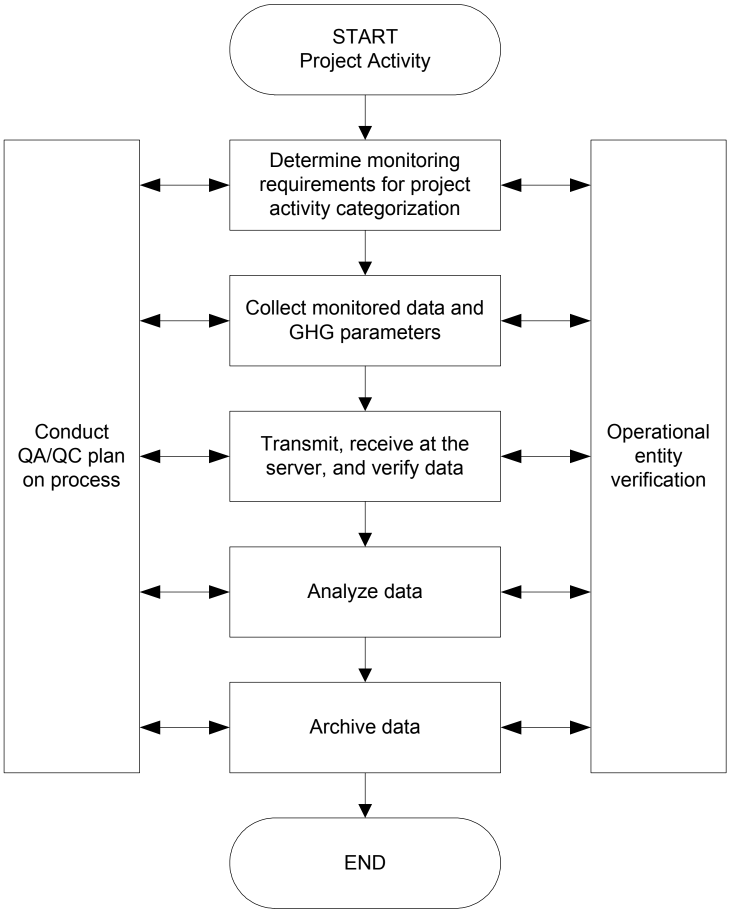
(a) Determination of GHG emissions using IPCC default parameters.

(b) Determination of GHG emissions using country specific parameters published by a National Authority.

(c) Determination of GHG emissions using scaled default values.

(d) Direct determination of GHG emissions based on the IPCC methodology, using parameters such as: Animal genetics and site or region specific feed to calculate parameters such as volatile solids (V_S) and Kjeldahl nitrogen excreted (N_{ex}), etc. The parameters used to determine these values are described in table 1.

Figure A4-1. Monitoring methodology



The net project emissions are established by first determining the total emissions resulting from the project activity using one of the methods described above. The results are then compared to the baseline. The net project emissions are calculated by subtracting any leakage as described below:

$$\text{Net Project Emissions} = \text{Baseline Emissions} - \text{Project Activity} - \text{Leakage} \qquad \textbf{(1)}$$

A source of emissions outside the project boundaries can occur if the project activity requires the use of electrical power. For example, a project may require electric power to drive pumps or equipment used for combustion. Another source of emissions is related to any practice changes associated with the method of effluent disposal.

The parameters to be monitored represent the key factors that can influence the net project emissions. These parameters are listed in tables 1 and 2. They are classified as:

a) Inputs to the AWMS such as all of the practice changes in the barn that influence the composition and quantity of manure being flushed into the AWMS.

b) Parameters that can influence the capture and combustion of emissions of from the AWMS. 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:

Table 1: Key parameters used to monitor project activity emissions

ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of data to be monitored	How will the data be archived?	For how long is archived data to be kept?	Comment
1. Population $_{month}$	Integer, Classification	Herd/breed counts per type	#, Type	m	Entrance - exit records of animals to the barn	100%	electronic	Duration of project + 5 yrs	Animal counts by population classification and genetics. Classification data also includes age, and other parameters. Exceptions such as purchases, sales, and mortality are recorded.
2. AF	Mass	Animal feed	Kg	m	Entrance - exit records of animals to the barn	100%	electronic	Duration of project + 5 yrs	Amount and type of animal feed with a specific crude fat and protein composition.
3. TF	Classification	Type of flush	Type	m	Weekly	100%	electronic	Duration of project + 5 yrs	Type of flush system used.
4. FW	Volume	Barn inflow flush volume	l	m	Once, and whenever referenced parameters change (see Comments) as ‘steady state’ may change.	100%	electronic	Duration of project + 5 yrs	Volume of water used to flush the barn including a consideration of water usage over several days. This parameter is used both to size the project activity AWMS and (in conjunction with 5-WF) to verify manure management volume requirements. This parameter is measured again if 2-AF (Animal Feed), 3-TF (flush type) or 1-Population$_{month}$ (Herd breed – genetics) is changed.

ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of data to be monitored	How will the data be archived?	For how long is archived data to be kept?	Comment
5. WF	Volume	Barn outflow effluent volume	1	m	Once, and whenever referenced parameters change (see Comments) as 'steady state' may change.	100%	electronic	Duration of project + 5 yrs	Volume of total effluent exiting barn including inflow flush water), over several days. This parameter is used both to size the project activity AWMS and (in conjunction with 4-FW) to verify manure management volume. This parameter is measured again if 2-AF (Animal Feed), 3-TF (flush type) or 1-Population$_{month}$ (Herd breed – genetics) is changed.
6. BA	Classification	Type of barn and AWMS	Type	m	Entrance - exit records of animals to the barn	100%	electronic	Duration of project + 5 yrs	Barn and AWMS layout and configuration.
7. AM	Classification	Application method	Type	m	Land application records	100%	electronic	Duration of project + 5 yrs	Land application type and frequency.
8. CA	Classification	Combustion approach	Type	m	Monthly	100%	electronic	Duration of project + 5 yrs	Combustion approach used.

ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of data to be monitored	How will the data be archived?	For how long is archived data to be kept?	Comment
9. TR	Integer, volume	Temperature and rainfall	°C, cm	m	Monthly	100%	electronic	Duration of project + 5 yrs	Monthly ambient temperature and rainfall from national or regional authority.
10. TS	Mass	Total solids	Kg	m / c	Measured once, and whenever referenced parameters change (see Comments) as ‘steady state’ may change / calculated Monthly	100%	electronic	Duration of project + 5 yrs	This parameter is used both to size the project activity AWMS and (in conjunction with 4-FW and 5-FW to determine and verify manure under management. This parameter is measured again if 3-TF (Flush type) or 1-$\text{Population}_{\text{month}}$ (Herd breed – genetics) is changed. This parameter is used in conjunction with animal excretion rates for all populations /classifications.
11. AW_i	Mass	Average weight	Kg	m / c	Entrance - exit records of animals to the barn	100%	electronic	Duration of project + 5 yrs	Collected for each livestock group. Average weights recorded for size and life stage.

ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of data to be monitored	How will the data be archived?	For how long is archived data to be kept?	Comment
12. CF	Volume	Biogas produced	M^3	m	Cumulative monthly production recorded monthly	100%	electronic	Duration of project + 5 yrs	Applicable to projects that include an anaerobic digester. This parameter enables verification of the anaerobic digestion process. Considered over several months, this parameter helps establish "typical" performance for an anaerobic digester.
13. CD	Volume	CO_2 produced	M^3	m	Quarterly	100%	electronic	Duration of project + 5 yrs	Applicable to projects that include an anaerobic digester. This parameter monitors digester operation.
14. INT	N/A	Operational status	N/A	m	Weekly	100%	electronic	Duration of project + 5 yrs	Operational status of all project equipment is checked. This parameter helps ensure proper digester operation.
15. DR	Classification	Reference data from standard tables	Type	m	Entrance - exit records of animals to the barn	100%	electronic	Duration of project + 5 yrs	Data from standard references and IPCC tables.

Note: Parameters 4-FW and 5-FW provide means for directly confirming the effluent under management in the AWMS, as contrasted to various indirect approaches that may not correlate with all AWMS solutions. Differencing these two terms provides a measure of the effluent, less flush water, flowing from the barn - which can be used to establish a performance metric for a given farm/genetics/flush system/animal feed combination. Changing any of these individual parameters will trigger another measurement of 4-FW and 5-FW. The performance metric is used in conjunction with 10-TS for calculated monthly totals.

Potential sources of emissions outside the project boundary are directly dependent on practice changes imposed by the project activity (if any) and can be found in listed in table 2.

Potential leakage outside the project boundary is related to any practice changes imposed by the project activity. The category of parameters to be monitored includes:

(a) Electrical power used by the project activity, such as fans, blowers, motors, pumps, igniters, etc.

(b) Covered and uncovered lagoons, properly managed, never require agitation and require only infrequent pumping. However, the AWMS may be dewatered, as needed, to increase the holding capacity or to use the liquid as fertilizer. Provisions for determining the methane conversion factors attendant to partial effluent removal are included in the methodology.

(c) Potential increased emissions during land applications. Many factors influence the land emissions of nitrous oxide including temperature, precipitation, application methods, etc. Leakage resulting from the land application of lagoon effluent can be expressed as the net difference between the 'business as usual' baseline scenario (if any) wherein the effluent is applied from an AWMS, and the application of effluent from the project activity, wherein the project effluent may have a different chemical composition than that of the baseline.

Table 2: Emissions potentially generated outside of the project boundary (Leakage)

ID No.	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of data to be monitored	How will the data be archived?	For how long is archived data to be kept?	Comment
16. EP_y	Electricity	Power	kWh	m	Monthly	100%	electronic	Duration of project + 5 years	Electricity used for project equipment.
17. EFL	Volume	Effluent disposal	l	m / c	Monthly and by exception	100%	electronic	Duration of project + 5 yrs	Effluent disposal.
18. AM	Classification	Application method	Type	m	Entrance - exit records of animals to the barn	100%	electronic	Duration of project + 5 yrs	Method used for effluent application.
19. EP_p	Electricity	Power	kWh	m	Monthly	100%	electronic	Duration of project + 5 years	If electricity is produced through cogeneration by the project equipment it must be measured.

Table 3: Ex-post Baseline emissions

ID No.	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of data to be monitored	How will the data be archived?	For how long is archived data to be kept?	Comment
20 F	Flow rate	Biogas flow extracted by digester	SCFM/day (standard cubic feet meter/day)	measured	Continuosly	100%	paper	At least two years from completion of authorisation period or last CERs issued	This parameter guarantees the correct performance of digester and gas recovery.

ID No.	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of data to be monitored	How will the data be archived?	For how long is archived data to be kept?	Comment
21 %CH4	Percentile	Percentage of biogas that is methane	%	measured	Continuosly or with periodical measurement		paper	At least two years from completion of authorisation period or last CERs issued	If periodical measurement are adopted, the confidence level should be at least 95%.
22 %FE[6]	Percentile	Flare efficiency determined by the operation hours (1) and the methane content in the exhaust gas (2)	%	m and c	(1) Continuosly (2) quarterly, monthly if unstable	n/a	electronic	Duration of crediting period	This parameter guarantees the correct performance of digester and gas recovery. (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

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[6] 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. If the efficiency for the flare process can’t be measured a conservative destruction efficiency factor should be used – 99% for enclosed flares and 50% for open flare.

Table 4: Quality Control and Quality Assurance

Data	**Uncertainty level of data (High/Medium/Low)**	**Are QA/QC procedures planned for these data?**	**Outline explanation why QA/QC procedures are or are not being planned.**
1. $\text{Population}_{month}$	Low	Yes	Correct data collection & transfer required to ensure product reliability.
2. AF	Low	Yes	Correct data collection & transfer required to ensure product reliability.
3. TF	Low	Yes	Correct data collection & transfer required to ensure product reliability.
4. FW	Low	Yes	Correct data collection & transfer required to ensure product reliability.
5. WF	Low	Yes	Correct data collection & transfer required to ensure product reliability.
6. BA	Low	Yes	Correct data collection & transfer required to ensure product reliability.
7. AM	Low	Yes	Correct data collection & transfer required to ensure product reliability.
8. CA	Low	Yes	Correct data collection & transfer required to ensure product reliability.
9. TR	Low	Yes	Correct data collection & transfer required to ensure product reliability.
10. TS	Low	Yes	Correct data collection & transfer required to ensure product reliability.
11. AW_i	Low	Yes	Correct data collection & transfer required to ensure product reliability.
12. CF	Low	Yes	Correct data collection & transfer required to ensure product reliability.

Data	Uncertainty level of data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation why QA/QC procedures are or are not being planned.
13. CD	Low	Yes	Correct data collection & transfer required to ensure product reliability.
14. INT	Low	Yes	Correct data collection & transfer required to ensure product reliability.
15. DR	Low	Yes	Correct data collection & transfer required to ensure product reliability.
16. EP_y	Low	Yes	Correct data collection & transfer required to ensure product reliability.
17. EFL	Low	Yes	Correct data collection & transfer required to ensure product reliability.
18. AM	Low	Yes	Correct data collection & transfer required to ensure product reliability.
19. EP_p	Low	Yes	Correct data collection & transfer required to ensure product reliability.
20. F	Low	Yes	Correct data collection & transfer required to ensure product reliability.
21. %CH4	Low	Yes	Correct data collection & transfer required to ensure product reliability.
22. %FE	Low	Yes	Correct data collection & transfer required to ensure product reliability.