Draft approved consolidated baseline methodology ACMXXXX

"Avoided methane emissions from organic waste-water treatment"

Source

This methodology is based on the Bumibiopower Methane Extraction and Power Generation Project, Malaysia, whose baseline study, monitoring and verification plan and project design document were prepared by Mitsubishi Securities on behalf of Bumibiopower, the Vinasse Anaerobic Treatment Project whose baseline study, monitoring and verification plan and project design document were prepared by Compañía Licorera de Nicaragua, S. A, and the Methane Gas Capture and Electricity Production at Chisinau Wastewater Treatment Plant project, Moldova whose baseline methodology, monitoring methodology and project design document were prepared by COWI A/S, Denmark.

For more information regarding the proposals and its considerations by the Executive Board please refer to cases NM0039: "Bumibiopower Methane Extraction and Power Generation Project", NM0085 "Vinasse Anaerobic Treatment Project", and NM0038-rev "Methane Gas Capture and Electricity Production at Chisinau Wastewater Treatment Plant" on http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

Selected approach from paragraph 48 of the CDM modalities and procedures

"Existing actual or historical emissions as applicable."

Applicability

The methodology is applicable to methane avoidance project activities involving organic wastewater treatment plants with the following applicability conditions:

- The existing waste water treatment system is an open lagoon system with an 'active' anaerobic condition, which is characterized as follows:
  - The depth of the open lagoon system is at least 1 m;
  - The temperature of the anaerobic lagoons is higher than 10°C. If monthly average temperature in a particular month is less than 10 °C, this month is not included in the estimations, as it is assumed that no anaerobic activity occurs below such temperature.
  - The residence time of the organic matter should be at least 30 days.
- Sludge produced during project activity is not be stored onsite before land application to avoid any possible methane emissions from anaerobic degradation.

This baseline methodology shall be used in conjunction with the approved monitoring methodology ACMXXX ("Avoided methane emissions from organic waste-water treatment").

Project activity

The project activity involves the avoidance of methane emissions from open lagoons through one or combination of the following treatment options:

- Installation of an anaerobic digester with biogas extraction capacity at an existing organic wastewater treatment plant to treat the majority of the degradable organic content in the wastewater. In this case, there is a process change from open lagoon to accelerated CH_4 generation in a closed tank digester or similar technology. Therefore, depending only on the amount of captured methane emissions to establish baseline emissions will not be adequate as the project activity may extract more CH_4 than would be emitted in the baseline case. The extracted biogas may be flared or used to generate electricity and/or heat. The project activity therefore reduces the amount of CH_4 allowed to dissipate into the atmosphere. By also utilizing the biogas, instead of flaring the CH_4, the project will also contribute to the displacement of grid electricity or fossil fuel consumption, further reducing GHG emissions. The residual from the anaerobic digester after treatment is either dewatered and applied to land or directed to anaerobic lagoons.

- Treatment of the sludge in aerobic conditions through dewatering and land application.

Project Boundary

This project boundary includes existing waste water treatment plant, where sludge is degraded in open sludge lagoons under mainly anaerobic conditions. The following emission sources are included:

	Source	Gas		Justification / Explanation
Baseline	Direct emissions from the waste treatment processes.	CH_4	Included	The major source of emissions in the baseline
		N_2O	Excluded	Excluded for simplification. This is conservative.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted.
	Emissions from electricity consumptio n / generation	CO_2	Included	Electricity may be consumed from the grid or generated onsite in the baseline scenario.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	Emissions from thermal energy generation	CO_2	Included	If thermal energy generation is included in the project activity
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
Project Activity	On-site fossil fuel consumptio n due to the project activity	CO_2	Included	May be an important emission source
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from on-site electricity use	CO_2	Included	May be an important emission source. If electricity is generated from collected biogas, these emissions are not accounted for.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Direct emissions from the waste treatment processes.	N_2O	Excluded	Excluded for simplification. Not and important emission source.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted.
		CH_4	Included	The emission from uncombusted methane and also leakage in case of anaerobic digesters. In case of dewatering and land application, conservative estimates of methane are included.

Identification of baseline Scenario

Project participants shall determine the most plausible baseline scenario through the application of the following steps.

Step 1: Draw up a list of possible realistic and credible alternatives for the treatment of the sludge.

This list shall include commonly used treatment methods such as:

- Sludge is brought to sludge pits (BAU)
- Methane recovery and flaring
- Methane recovery and utilization for electricity or heat generation
- Landfilling
- Aerobic composting
- Mineralization
- Composting
- Land application of the sludge

Step 2: Eliminate alternatives that are not complying with applicable laws and regulations

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

Step 3: Eliminate alternatives that face prohibitive barriers

Scenarios that face prohibitive barriers should be eliminated by applying step 3 of the latest version of the "Tool for demonstration assessment and of additionality" agreed by the CDM Executive Board.

Step 4: Compare economic attractiveness of remaining alternatives

Compare the economic attractiveness without revenues from CERs for all alternatives that are remaining by applying Step 2 of the latest version of the "Tool for demonstration assessment and of additionality" agreed by the CDM Executive Board. The economic investment analysis shall use the IRR analysis, and explicitly state the following parameters:

- Incremental investment costs
- O&M costs and;
- All other costs of implementing the technology of the each alternative option.
- All revenues generated by the implementation of the technology except carbon revenues.
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Compare the IRR of the different scenarios and select the most cost-effective scenario (i.e. with the highest IRR) as the baseline scenario. Include a sensitivity analysis applying Sub-step 2d of the latest version of the "Tool for demonstration assessment and of additionality" agreed by the CDM Executive Board. The investment analysis provides a valid argument that the most cost-effective scenario is the baseline scenario if it consistently supports (for a realistic range of assumptions) this conclusion. In case the sensitivity analysis is not fully conclusive, select the baseline scenario alternative with least emissions among the alternatives that are the most economically attractive according to the investment analysis and the sensitivity analysis.

This methodology is only applicable if the continuation of the use of open anaerobic lagoons for the treatment of the wastewater throughout the crediting period is the most plausible baseline scenario.

Additionality

Additionality is addressed:
Option A) By determining the most likely course of action, taking into account economic attractiveness and barriers or
Option B) Using the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the CDM Executive Board, which is available on the UNFCCC CDM web site[1].

Option A)
The additionality of a project can be established in the following manner.

Investment barriers
In the context of meeting discharge limits, there is no incentive to change to a more costly technology unless stricter discharge limits are imposed or more incentives are provided. The project activity, however, involves not only the extraction and subsequent destruction of CH_4 or land application of sludge, but also electricity generation, which is either sold to the grid or used on site as a replacement for electricity currently purchased, or heat production and displacement of fossil fuel.

Therefore, in order to establish that the project will not occur in the absence of the project activity, it is necessary to show that the return on investment or the saved cost of grid electricity or to the displacement of fossil fuel is too low to justify a change in the treatment system. A financial analysis involving such concepts as the IRR, NPV and cost comparison should be conducted and show that the project is not more economically/financially attractive than the current waste water treatment system or other feasible alternatives. The analysis should include, as a minimum, the variables below:

- Engineering, Procurement and Construction cost;
- Labor cost;
- Operation and Maintenance cost;
- Administration cost;
- Fuel cost;
- Capital cost and interest;
- Revenue from electricity sales.

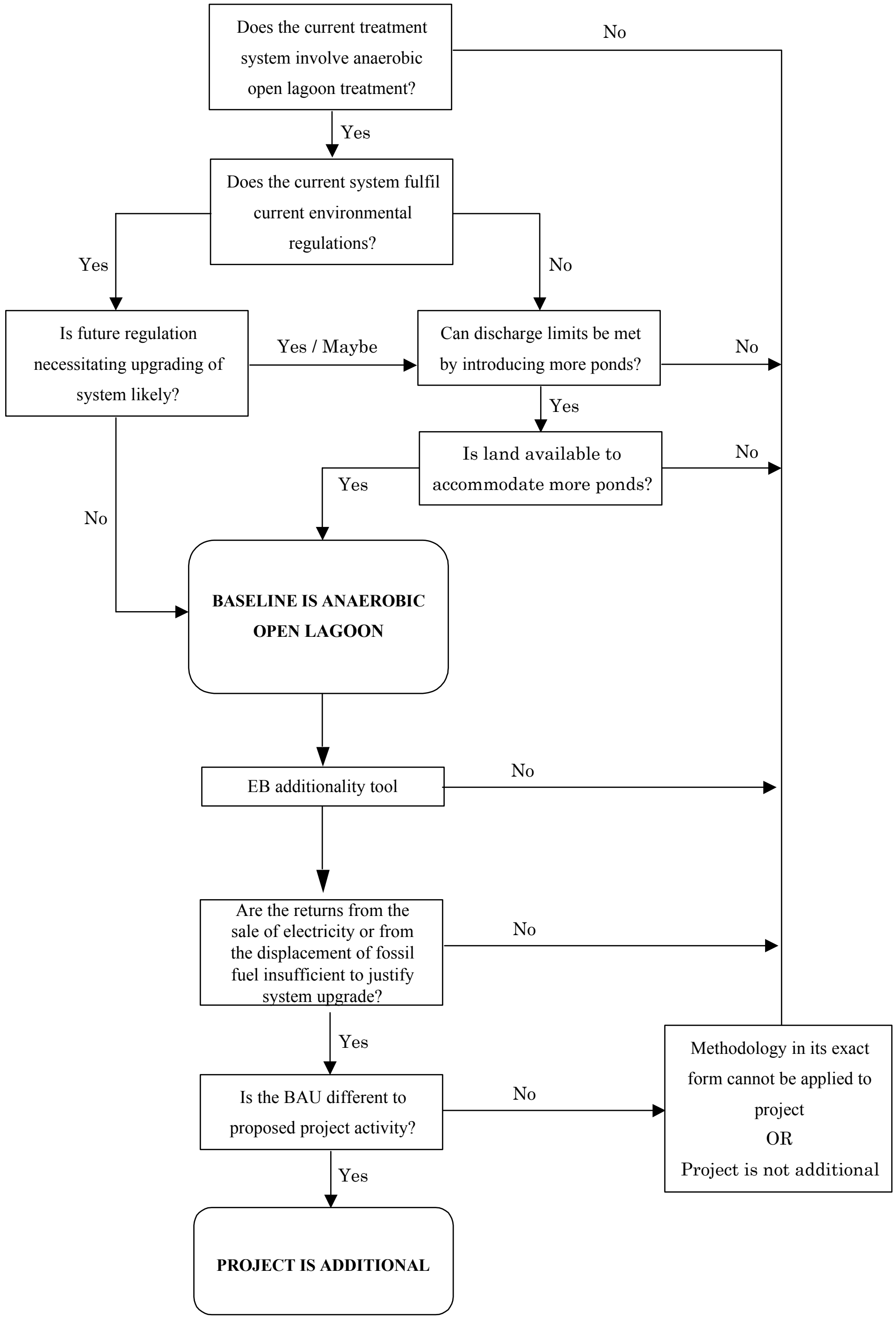
Data sources used should be identified in the CDM-PDD, and can include either project-specific or typical industry values. Where project-specific data are used, this should not deviate from the range of accepted industry values. Should a deviation be identified, this should be justified so as to ensure conservatism. The basis of the calculation will be provided to the DOE during validation.

It is noted that both Project and Equity IRRs are acceptable, depending on which is more relevant to the investment decision of the project's investors.

Current prevalent mode of organic wastewater treatment
Current practices for organic wastewater treatment in the relevant host country should be discussed and it should be established that similar anaerobic digestion and/or land application of sludge as proposed for the project activity does not constitute a common practice. Where this technology is already in use, a difference in circumstances must be shown to exist and documented. An example of these circumstances is a different locality, leading to differing regional regulations/incentives, (vicinity to residential populations and land availability) among others. If a less GHG emitting treatment system is seen as the most common method, the additionality of the project cannot be established through the use of this methodology.

[1] Please refer to: < http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>

The steps for establishing the baseline scenario and project additionality in Option A are simplified in the diagram below.



Baseline Emissions

Baseline emissions are the CH_4 emissions from open lagoon wastewater treatment systems, the CO_2 emissions associated with grid electricity generation that is displaced by the project, and the CO_2 emissions associated with fossil fuel combustion in the industrial process heating equipment.

(i) Lagoon baseline emissions

The baseline emissions from the lagoon are estimated based on the chemical oxygen demand (COD) of the effluent that would enter the lagoon in the absence of the project activity, the maximum methane producing capacity (Bo) and a methane conversion factor (MCF) that expresses what proportion of the effluent would be anaerobically digested in the open lagoons.

These CH_4 emissions from wastewater should be calculated according to the IPCC Guidelines as follows:

$$\underset{(kg/yr)}{CH_4 \text{ emissions}} = \underset{(kg\ COD/yr)}{\text{Total } COD_{baseline}} \times \underset{(kg\ CH_4/kg\ COD)}{B_o} \times MCF_{baseline}$$

where:

$COD_{baseline}$	Is Chemical Oxygen Demand of effluent entering lagoons (measured)
B_o	Is maximum methane producing capacity
$MCF_{baseline}$	Is methane conversion factor (fraction)

$COD_{baseline}$ is to be directly measured by the project as the baseline activity level since the effluent that goes into the lagoon in the baseline situation is the same as the one that goes into the digester or to land application treatment in the project situation. $COD_{baseline}$ is calculated as the product of $COD_{c,baseline}$ concentration (kg COD/m^3) in the wastewater input to the digester or directed to land application and the flow rate F_{dig} (m^3/yr)

In case there is an effluent from the lagoons in the baseline, $COD_{baseline}$ values should be adjusted by multiplying $COD_{baseline}$ by the following factor AD:

$$AD = 1 - \left(\frac{COD_{a,out}}{COD_{a,in}} \right)$$

where:

$COD_{a,out}$	is the COD that leaves the lagoon with the effluent
$COD_{a,in}$	is the COD that enters the lagoon

COD_{out} and COD_{in} should be based on one year historical data

The default IPCC value for B_o, the maximum amount of CH_4 that can be produced from a given quantity of wastewater, is 0.25 kg CH_4/kg COD. Taking into account the uncertainty of this estimate, project participants should use a value of 0.21 kg CH_4/kg COD [2] as a conservative assumption for B_o.

$MCF_{baseline}$ is estimated as the product of the fraction of anaerobic degrading due to depth (f_d) and the fraction of anaerobic degrading due to temperature (f_t):

$$MCF = f_d * f_{t,annual} * 0.89$$

[2] Lowest value provided by IPCC Good Practice guidance, 2000, Page 5.19

where:

f_d is the fraction of anaerobic degradation due to depth as per table 1
f_t is the fraction of anaerobic degradation due to temperature
0.89 is an uncertainty conservativeness factor (for an uncertainty range of 30% to 50%) to account for the fact that the equation used to estimate $f_{t,monthly}$ assumes full anerobic degradation at 30 ^oC.

Table 1 default values of fraction due to depth (f_d)

	Deep > 5m	Medium depth 1-5 m	Small depth <1m
Fraction of degradation under anaerobic conditions due to depth of sludge pit	70%	50%	0

Annual MCF can be estimated from the following equation:

$$\mathbf{f_{t,annual}} = \frac{\sum_{m=1}^{12} \mathbf{CH_{4,m}}}{\mathbf{B_0} * \sum_{m=1}^{12} \mathbf{COD_{baseline,m}}}$$

$$\mathbf{CH_{4,m}} = \mathbf{B_0} * \mathbf{COD_{baseline,m}} * \mathbf{f_{t,monthly}}$$

where:

$CH_{4,m}$ estimated monthly methane production
B_0 is the maximum methane producing potential of organic waste
$COD_{baseline,m}$ monthly COD available for degradation in the baseline.
$f_{t,monthly}$ Monthly conversion efficiency of VS to CH_4 due to temperature. Months were the average temperature is less than 10 ^oC, $f_{t,monthly} = 0$. The value of $f_{t,monthly}$ to be used cannot exceed unity.

$f_{t,monthly}$ is calculated as follows:

$$f_{t,monthly} = \exp[\frac{E * (T_2 - T_1)}{R * T_1 * T_2}]$$

where:

$f_{t,monthly}$ anaerobic degradation factor due to temperature.
E Activation energy constant (15,175 cal/mol).
T2 Ambient temperature (Kelvin) for the climate.
T1 303.16 (273.16° + 30°).
R Ideal gas constant (1.987 cal/ K mol).

The factor '$f_{t,monthly}$' represents the proportion of organic matter that are biologically available for conversion to methane based upon the temperature of the system. The assumed temperature is equal to the ambient temperature. The value of f_t to be used cannot exceed unity.

Monthly values for $f_{t,monthly}$ is calculated as follows:

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

(2) Monthly temperatures are used to calculate a monthly van't Hoff – Arrhenius '$f_{t,monthly}$' factor above. A minimum temperature of 10 °C is used.

(3) The amount of organic matter available for conversion to methane is assumed to be equal to the amount of organic matter produced during the month. (COD input to the digesters or to the land application treatment) For sludge pits, the amount of organic matter available also includes organic matter that may remain in the system from previous months.

(4) The amount of organic matter consumed during the month is equal to the amount available for consumption multiplied by MCF.

(5) For anaerobic sludge pits, the amount of organic matter 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 sludge pit. In the case of the emptying of the sludge pit, the accumulation of organic matter restarts with the next inflow.

(6) It is the possible to calculate the MCF both monthly and annual.

Carry on calculations are limited to a maximum of one year. In case the residence time is less than one year carry-on calculations are limited to this period where the sludge resides in the lagoon. Project participants should provide evidence of the residence time of the organic matter in the lagoon.

The total baseline CH_4 emissions are translated into CO_2 equivalent emissions by multiplying by its global warming potential (GWP) of 21.

(ii) Electricity baseline emissions

$$BE_{elec/heat} = EG_y * CEF_{Bl,elec,,y} + EG_{d,y} * CEF_{grid} + HG_{Bl,y} * CEF_{Bl,therm,y}$$

where,

EG_y	is the amount of electricity in the year y that would be consumed at the project site in the absence of the project activity (MWh).
$CEF_{Bl,, elec,y}$	is the CO_2 emission factor for electricity consumed at the project site in the absence of the project activity (tCO_2/MWh)
$EG_{d,y}$	is the amount of electricity generated utilizing the biogas collected during project activity and exported to the grid during the year y (MWh)
CEF_{grid}	is the CO_2 emission factor for the grid where electricity is exported (tCO_2/MWh)
$HG_{Bl,y}$	is the quantity of thermal energy that would be consumed in year y at the project site in the absence of the project activity (MJ) using fossil fuel.
$CEF_{Bl, therm}$	is the CO_2 emissions intensity for thermal energy generation (tCO_2 e/MJ)

Note: Project proponents need to estimate electricity component only if the captured methane is used for generation of electricity, which is atleast as much as the project requirement,and the Project participants wish to claim emissions reduction due to the same. Similarly if the Heat in project case is completely met by biogas and project participants do not wish to claim the credits, the CO_2 emission from heat can be ignored.

Determination of $CEF_{Bl,elec}$:

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

- In cases where electricity would in the absence of the project activity be purchased from the grid, the emission factor $CEF_{Bl,elec}$ should be calculated according to methodology ACM0002 ("Consolidated baseline methodology for grid-connected electricity generation from renewable sources"). If electricity consumption is less than small scale threshold (15 GWh/yr), AMS. 1.D.1 may be used.

Determination of CEF_{grid}:

- CEF_{grid} should be calculated according to methodology ACM0002 ("Consolidated baseline methodology for grid-connected electricity generation from renewable sources").

Determination of $CEF_{Bl,therm}$: The emission factor is estimated as product of (i) CO_2 emission factor for fuel used (tCO_2/MJ), and (ii) oxidation factor for the thermal device.

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

Project Emissions

The physical delineation of the project is defined as the plant site. Project emissions mainly consist of methane emissions from the lagoons, physical leakage from the digester system, stack emissions from flaring and energy generating equipment, emissions related with the consumption of electricity in the digester auxiliary equipment, emissions from land application of sludge, and emissions from wastewater removed in the dewatering process.

(i) Methane emissions from lagoons

After the majority of the COD is treated and reduced by anaerobic digestion, the effluent will pass through the ponds prior to release. A significant majority of the COD load will have been reduced by anaerobic digestion and the ponds are expected to operate under largely aerobic conditions. The MCF value for fully aerobic systems is 0, as no methane is produced.

However, due to the uncertainty regarding the exact extent of aerobic/anaerobic digestion after project implementation, the calculation of these CH_4 emissions is conservatively carried out in the same way as for the baseline, using the same values for B_o and the methane conversion factor (MCF):

CH_4 emissions from the lagoons (kg/yr)	=	COD_{dig_out} (kg COD/yr)	X	B_o (kg CH_4/kg COD)	x	MCF_{dig_out}

where:

COD_{dig_out} Is Chemical Oxygen Demand of effluent entering lagoons (measured)

B_o	Is maximum methane producing capacity
MCF_{dig_out}	Is methane conversion factor (fraction) estimated as described in the baseline section above

The CH_4 emissions are translated into CO_2 equivalent emissions by multiplying by its global warming potential (GWP) of 21.

(ii) Physical Leakage from biodigesters

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

(iii) Stack emissions from the flare or energy generation

Methane may be released as a result of incomplete combustion either in the flaring option or in case of biogas use for electricity and/or heat production. These emissions are estimated by monitoring the:

(i) The amount of biogas collected in the outlet of the Biodigester using a continuous flow meter, $CH4_{bio}$.
(ii) Percentage of biogas that is methane (P_{CH4}), 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 (T_{comb}) 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 ($1-P_{CH4,s} / P_{CH4,inlet}$).
(iv) If efficiency for the flares cannot be measured a conservative destruction efficiency factor should be used – 99% for enclosed flares and 50% for open flare.

(iv) Emissions from heat use and electricity use due to the project activity (PEelec/heat):

$$PE_{elec/heat} = EL_y * CEF_d + HG_{Pr,y} * CEF_{Pr,therm,y}$$

where,

$EL_{P,y}$	is the amount of electricity in the year y that is consumed at the project site for the project activity (MWh).
CEFd	is the CO_2 emissions factor for electricity consumed at the project site during the project activity (tCO_2/MWh), estimated as described below. Factor is zero if biogas is used to produce electricity.
$HG_{Pr,y}$	is the quantity of thermal energy consumed in year y at the project site due to the project activity (MJ).
$CEF_{Pr,\ therm,y}$	is the CO_2 emissions intensity for thermal energy generation (tCO2e/MJ), estimated as per method described for baseline thermal energy use. Factor is zero if biogas is used for generating thermal energy.

<u>Determination of CEF_d:</u> Where the project activity involves electricity generation from biogas, CEFd should be chosen as follows:

- In case the generated electricity on-site fossil fuel fired power plant, the default emission factor for a diesel generator with a capacity of more than 200 kW for small-scale project activities (0.8 tCO2/MWh, see AMS 1.D.1 in the simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories).

- In case the generated electricity is sourced the grid in the baseline, CEF_d should be calculated according to methodology ACM0002 ("Consolidated baseline methodology for grid-connected electricity generation from renewable sources"). If electricity consumption is less than small scale threshold (15 GWh/year), AMS. 1.D.1 may be used.

(v) Emissions from land application of sludge

For conservativeness, an MCF of 0.05 is to be used to estimate possible methane emissions from the land application treatment process to account for any possible anaerobic pockets. These emissions are to be estimated from the following equation:

$$\underset{(kg/yr)}{CH_4\ emissions} = \underset{(kg\ COD/yr)}{Total\ COD_{la}} \times \underset{(kg\ CH_4/kg\ COD)}{B_o} \times MCF_{la}$$

where:

COD_{la}	Is Chemical Oxygen Demand of the sludge used for land application after dewatering (measured)
B_o	Is maximum methane producing capacity
MCF_{la}	Is methane conversion factor (fraction) assumed to be equal to 0.05

Nitrous oxide emissions from land application of sludge are to be estimated as follows:

$$\underset{(kg/yr)}{N_2O\ emissions} = \underset{(kg\ sludge/yr)}{S_a} \times \underset{(kg\ N/kg\ sludge)}{NC} \times EF_{N2O}$$

where:

S_a	Is the amount of sludge applied to land in kg per year
NC	Is the nitrogen content in the sludge in (Kg N/Kg sludge)
EF_{N2O}	Is the emission factor of nitrogen from sludge applied to land to be assumed 0.016 kg N_2O/ Kg N[3]

(vi) Emissions from wastewater removed in the dewatering process

The wastewater removed from the dewatering process may contain some organic matter that has not been degraded/removed. Emissions from such wastewater should be estimated from the following equation:

$$\underset{(kg/yr)}{CH_4\ emissions} = \underset{(kg\ COD/yr)}{Total\ COD_{dw}} \times \underset{(kg\ CH_4/kg\ COD)}{B_o} \times MCF_{dw}$$

where:

COD_{dw}	Is Chemical Oxygen Demand in the wastewater from the dewatering process (measured)
B_o	Is maximum methane producing capacity
MCF_{dw}	Is methane conversion factor (fraction) estimated as described in the baseline section above

[3] Based on Stehfest, E. and Bouwman, A.F. N2O and NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modelling of global annual emissions. Nutr. Cycl. 29 Agroecosyst., in press. The average emission factor used is 0.01 kg N_2O-N / kg N.

Leakage

No leakage is associated with the project activity.

Emission Reductions

Emission reductions are calculated as the difference between baseline and project emissions, taking into account any adjustments for leakage.

The calculation based on ex ante information is the following:

Baseline emissions (tCO_2/yr)	=	Baseline emissions from open lagoons ($t\ CO_2e/yr$)	+	Baseline emissions from grid electricity generation (tCO_2/yr)	+	Baseline emissions from the portion of fossil fuel displaced by biogas used in heating equipment (tCO_2/yr)

Emission reductions (tCO_2/yr)	=	Baseline emissions (tCO_2e/yr)	-	Leakage ($t\ CO_2e/yr$)	-	Project emissions ($t\ CO_2e/yr$)

The ex-ante estimate of methane emissions reductions is the difference between “Baseline emissions from open lagoons” and “Project emission” (=$ER\_CH_{4exante}$).

Ex-post monitoring of the actual amount of CH_4 captured and flared or fed to the electricity generator and/or to the heating equipment leads to an ex-post estimate of methane emissions reductions (= $ER\_CH_{4expost}$).

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 lower of the two shall be assumed as the baseline emissions:

(i) baseline methane emissions less the physical leakage

(ii) the actual methane captured and flared/used for energy generation

If (ii) above is the baseline emissions then physical leakage from anaerobic digester for estimating emissions reduction shall be taken as zero.

The value of the actual methane captured and flared should be multiplied by the flare efficiency. Flare efficiency is estimated as per procedure explained above and monitored as per the monitoring methodology.

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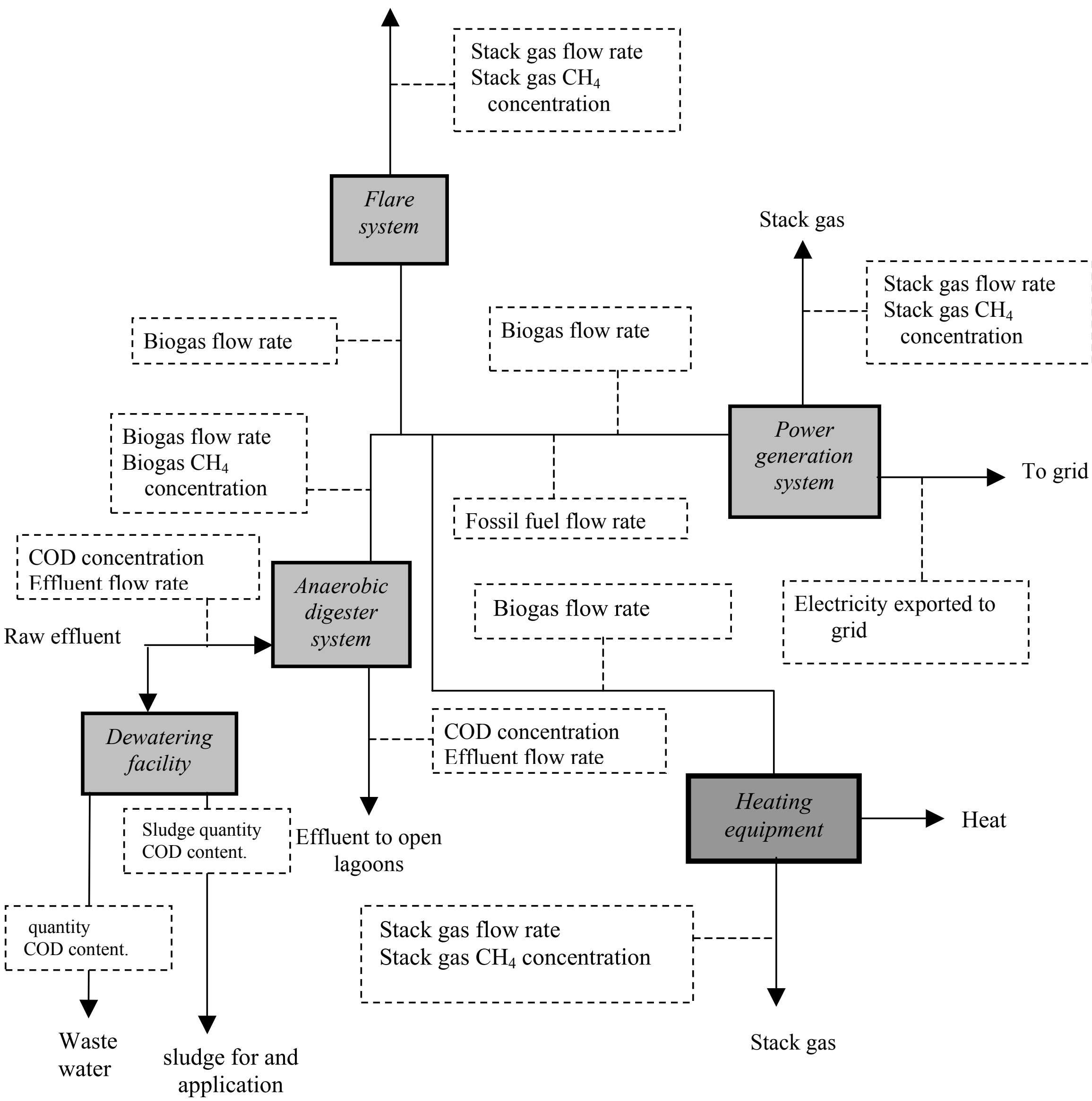
The methodology is applicable to methane avoidance project activities involving organic wastewater treatment plants with the following applicability conditions:

- The existing waste water treatment system is an open lagoon system with an 'active' anaerobic condition, which is characterized as follows:
    - The depth of the open lagoon system is at least 1 m;
    - The temperature of the anaerobic lagoons is higher than 10°C. If monthly temperatures are less than 10 ^{o}C, this month is not included in the estimations, as it is assumed that no anaerobic activity occurs below such temperature.
- Sludge produced during project activity should not be stored onsite before land application to avoid any possible methane emissions from anaerobic degradation.

Monitoring Methodology

The monitoring methodology is schematically represented in the figure below, showing the flows between the different parts of the project. The parameters for each of the flows to be monitored are shown in dashed boxes.



The monitoring methodology, therefore, involves monitoring of the following parameters after project implementation:

For determining baseline emissions

1. Flow rate of organic wastewater into the digester F_{dig} (Data # 1)
2. $COD_{c,baseline}$ concentration of organic wastewater into the digester (Data # 2)

3. $COD_{a,out}$ is the COD that leaves the lagoon with the effluent (Data # 3)
4. $COD_{a,in}$ is the COD that enters the lagoon which is assumed to be equal to the COD input to the digester or directed to land application (Data # 4)
5. Maximum methane producing capacity B_o (Ex-ante);
6. Temperature of lagoon T_{lag} (Data # 5)
7. Depth of lagoon D_{lag} (Data # 6)
8. Amount of electricity in the year y that would be consumed at the project site in the absence of the project activity EG_y (Data # 7).
9. CO_2 emission factor for electricity consumed at the project site in the absence of the project activity $CEF_{Bl,, elec,y}$ (Ex-ante);
10. Amount of electricity generated utilizing the biogas collected during project activity and exported to the grid during the year $EG_{d,y.}$ (Data # 8).
11. CO_2 emissions factor for the grid where electricity is exported CEF_{grid} (Ex-ante);
12. Quantity of thermal energy that would be consumed in year y at the project site in the absence of the project activity using fossil fuel $HG_{Bl,y}$ (Data # 9).
13. CO_2 emissions intensity for thermal energy generation $CEF_{Bl, therm}$ (Ex-ante).

For determining project emissions

1. Flow rate of organic wastewater into the digester F_{dig_out} (Data # 10)
2. COD_{c,dig_out} concentrations in discharged effluent from digester to estimate CH_4 emissions in the project case (Data # 11).
3. Amount of electricity in the year y that is consumed at the project site for the project activity $EL_{P,y}$ (Data # 12)
4. CO_2 emissions factor for electricity consumed at the project site during the project activity CEF_d (Ex-ante).
5. Quantity of thermal energy consumed in year y at the project site due to the project activity $HG_{Pr,y}$ (Data # 13)
6. CO_2 emissions intensity for thermal energy generation $CEF_{Pr, therm,y}$ (Ex-ante).
7. Flow rate of sludge used for land application after dewatering F_{la} (Data # 14)
8. $COD_{c,la}$ of the sludge used for land application after dewatering (Data # 15)
9. Maximum methane producing capacity B_o (Ex-ante)
10. Methane conversion factor for sludge used for land application MCF_{la} (Ex-ante)
11. Flow rate of organic wastewater from the dewatering process $F_{c,dw}$(Data # 16)
12. $COD_{c,dw}$ of the wastewater from the dewatering process (Data # 17)
13. Amount of biogas collected in the outlet of the Biodigester using a continuous flow meter FR_{bio} (Data # 18).
14. Percentage of biogas that is methane in the outlet of the biodigester $P_{CH4,bio}$ (Data # 19)
15. Flow rate of the biogas entering the flare $FR_{f,inlet}$ (Data # 20)
16. Flow rate of the flare stack gases $FR_{f,s}$ (Data # 21)
17. Methane content in stack gas of flare $P_{CH4,f,s}$ (Data #22)
18. Fraction of time gas is combusted in the flare $T_{comb,f}$ (Data # 23)
19. Flow rate of the biogas entering the electricity generation equipment $FR_{e,inlet}$[4] (Data # 24)
20. Flow rate of the electricity generation equipment stack gases $FR_{e,s}$ (Data # 25)
21. Methane content in stack gas of electricity generation equipment $P_{CH4,e,s}$ (Data #26)
22. Fraction of time gas is combusted in the heat generation equipment $T_{comb,e}$ (Data # 27)
23. Flow rate of the biogas entering the heat generation equipment $FR_{e,inlet}$[5] (Data # 28)

[4] The average annual amount of CH_4 monitored is to be compared to that back-calculated from energy balance calculations, using rated thermal efficiency and standard CH_4 heat value. A conservative estimate for the thermal efficiency rate (i.e. a high rate, for instance manufacturer's information on the engine efficiency) shall be used.
[5] The average annual amount of CH_4 monitored is to be compared to that back-calculated from energy balance calculations, using rated thermal efficiency and standard CH_4 heat value. A conservative estimate for the thermal efficiency rate (i.e. a high rate, for instance manufacturer's information on the engine efficiency) shall be used.

24. Flow rate of the heat generation equipment stack gases $FR_{e,s}$ (Data # 29)
25. Methane content in stack gas of heat generation equipment $P_{CH4,e,s}$ (Data #30)
26. Fraction of time gas is combusted in the heat generation equipment $T_{comb,e}$ (Data # 31)
27. Amount of sludge applied to land in kg per year S_a (Data # 32)
28. nitrogen content in the sludge NC (Data # 33)
29. emission factor of nitrogen from sludge applied to land to be assumed EF_{N2O} (Ex-ante)

Parameters to be monitored

Baseline emissions

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?	Comments
1.	Activity level (open lagoon)	F_{dig}	m^3/yr	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
2.	Activity level (open lagoon)	$COD_{c,Bl}$	kg/m^3	m	At least monthly	100%	Electronic	Minimum of two years after last issuance of CERs	
3.	Activity level (open lagoon)	$COD_{a,out}$	kg/yr	m	Historical 1 year data	100%	Electronic	Minimum of two years after last issuance of CERs	
4.	Activity level (open lagoon)	$COD_{a,in}$	kg/yr	m	Historical 1 year data	100%	Electronic	Minimum of two years after last issuance of CERs	
5.	Activity level (open lagoon)	T_{lag}	K	m	Daily	100%	Electronic	Minimum of two years after last issuance of CERs	
6.	Activity level (Open lagoon)	D_{lag}	m	m	Daily	100%	Electronic	Minimum of two years after last issuance of CERs	

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?	Comments
7.	Activity Level (Electricity use)	EG_y	MWh	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
8.	Activity level (Electricity Exported)	$EG_{d,y}$	kWh	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
9.	Activity Level (Heat Consumed)	$HG_{Bl,y}$	MJ	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	

Project emissions

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?	Comments
10.	Activity level (open lagoon)	F_{dig_out}	m^3/yr	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
11.	Activity level (Digester)	COD_{c,dig_out}	Kg/m^3	m	At least monthly	100%	Electronic	Minimum of two years after last issuance of CERs	

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?	Comments
12.	Activity level (Electricity Consumption)	$EL_{p,y}$	MWh	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
13.	Activity level (Heat Consumption)	$HG_{Pr,y}$	MJ	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
14.	Activity level (Land application)	F_{la}	m^3/yr	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
15.	Activity level (Land application)	$COD_{c,la}$	Kg/m^3	m	At least monthly	100%	Electronic	Minimum of two years after last issuance of CERs	
16.	Activity level (Dewatering)	$F_{c,dw}$	m^3/yr	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
17.	Activity level (Dewatering)	$COD_{c,dw}$	Kg/m^3	m	At least monthly	100%	Electronic	Minimum of two years after last issuance of CERs	
18.	Activity level (Digester)	FR_{bio}	m^3/yr	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	

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?	Comments
19.	Activity level (Digester)	$P_{CH4,bio}$	%	m	At least Quarterly	100%	Electronic	Minimum of two years after last issuance of CERs	
20.	Activity level (Flaring)	$FR_{f,inlet}$	m^3/yr	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
21.	Activity level (Flaring)	$FR_{f,s}$	m^3/yr	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
22.	Activity level (Flaring)	$P_{CH4,f,s}$	%	m	At least Quarterly	100%	Electronic	Minimum of two years after last issuance of CERs	
23.	Activity level (Flaring)	$T_{comb,f}$	fraction	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
24.	Activity level (Electricity Generation)	$FR_{e,inlet}$	m^3/yr	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
25.	Activity level (Electricity Generation)	$FR_{e,s}$	m^3/yr	m	Continuously	100%	Electronic	Minimum of two years after last issuance of CERs	
26.	Activity level (Electricity Generation)	$P_{CH4,e,s}$	%	m	At least Quarterly	100%	Electronic	Minimum of two years after last issuance of CERs	

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?	Comments
27.	Activity level (Electricity Generation)	$T_{comb,e}$	fraction	m	Continuously	100%	electronic	Minimum of two years after last issuance of CERs	
28.	Activity level (Heat Generation)	$FR_{e,inlet}$	m^3/yr	m	Continuously	100%	electronic	Minimum of two years after last issuance of CERs	
29.	Activity level (Heat Generation)	$FR_{e,s}$	m^3/yr	m	Continuously	100%	electronic	Minimum of two years after last issuance of CERs	
30.	Activity level (Heat Generation)	$P_{CH4,e,s}$	%	m	At least Quarterly	100%	electronic	Minimum of two years after last issuance of CERs	
31.	Activity level (Heat Generation)	$T_{comb,e}$	fraction	m	Continuously	100%	electronic	Minimum of two years after last issuance of CERs	
32.	Activity level (Land Application)	$S_{,e}$	Kg/yr	m	Monthly	100%	electronic	Minimum of two years after last issuance of CERs	
33.	Activity level (Land Application)	NC	Kg N / Kg Sludge	m	Monthly	100%	electronic	Minimum of two years after last issuance of CERs	

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?	Comments
34.	Qualitative	Regulations and incentives relevant to effluent	--	--	At renewal of crediting period	100%	Electronic	Minimum of two years after last issuance of CERs	

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 why QA/QC procedures are planned
1,10,14,16,18,20, 21,24,25,28,29.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
2,3,4, 11,15,17,19,22, 26, 30, 32, 33.	Low	Yes	Sampling will be carried out adhering to internationally recognized procedures.
7, 8,12.	Low	Yes	Electricity meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company.
9,13	Low	Yes	Fuel purchase records to be cross checked with estimates.
34.	Low	Yes	Quality control for the existence and enforcement of relevant regulations and incentives is beyond the bounds of the project activity. Instead, the DOE will verify the evidence collected.

Baseline Data

For default emission factors, IPCC 1996 Guidelines on GHG Inventory (The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC) and Good Practice Guidance Report (Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC) are to be referred not only for their default values but also for their monitoring methodology as well as uncertainty management to ensure data credibility. These documents are downloadable from http://www.ipcc-nggip.iges.or.jp/. The latter document is a new supplementary document of the former.

1996 Guidelines:
Vol. 2, Module 1 (Energy) for methodology,
Vol. 3, Module 1 (Energy) for application (including default values)

2000 Good Practice Guidance on GHG Inventory and Uncertainty Management
Chapter 2: Energy
Chapter 6: Uncertainty

IEA (Yearly Statistics)
CO_2 Emissions from Fuel Combustion
Energy Statistics of Non-OECD Countries