

**Annex 4****Approved baseline methodology AM0013****“Forced methane extraction from organic waste-water treatment plants for grid-connected electricity supply”****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. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0039: “Bumibiopower Methane Extraction and Power Generation Project” on <http://cdm.unfccc.int/methodologies/approved>

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 recovery 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 i.e. with a high level of CH₄ generation;
- The methodology applies to forced CH₄ extraction project cases, as there is a process change from open lagoon to accelerated CH₄ 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 CH₄ than would be emitted in the baseline case;
- The captured methane is used for electricity generation, which avoids emissions due to displaced electricity in a well-defined grid electricity;
- For projects with a renewable power generation capacity lower than 15 MW.

This baseline methodology shall be used in conjunction with the approved monitoring methodology AM0013 (“Forced methane extraction for grid-connected electricity supply”).

Project activity

The project activity involves the 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. After this primary treatment, the wastewater will enter the existing open lagoon system with a reduced organic load. The extracted biogas will be used to generate electricity. The project activity therefore reduces the amount of CH₄ allowed to dissipate into the atmosphere. By also utilizing the biogas to produce electricity for the grid, instead of flaring the CH₄, the project will also contribute to the displacement of grid electricity, further reducing GHG emissions.

Leakage

No leakage is associated with the project activity.

**Baseline**

Baseline emissions are the CH₄ emissions from open lagoon wastewater treatment systems and the CO₂ emissions associated with grid electricity generation that is displaced by the project.

Lagoon baseline emissions

The baseline emissions from the lagoon is initially estimated ex-ante based on IPCC methane conversion factors (MCF) that assumes what proportion of the effluent would be anaerobically digested in the lagoons (=B_{exante}).

According to the IPCC Guidelines, CH₄ emissions from wastewater are calculated as follows:

$$\text{CH}_4 \text{ emissions (kg/yr)} = \text{Total COD (kg COD/yr)} \times \text{B}_0 \text{ (kg CH}_4\text{/kg COD)} \times \text{MCF}$$

where

COD Is Chemical Oxygen Demand of effluent entering lagoons (measured)

B₀ Is maximum methane producing capacity

MCF Is methane conversion factor (fraction)

COD 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 in the project situation.

The default IPCC value for B₀, the maximum amount of CH₄ that can be produced from a given quantity of wastewater, is 0.25 kg CH₄/kg COD¹. The IPCC guidelines do not provide a single default factor for MCF, but provide the following system MCF values, as shown below²:

System	MCF
Anaerobic	1.0
Aerobic	0
Africa	0.9
Asia	0.9
North America	0.7
Latin America & Caribbean	0.9
Australia & New Zealand	0.7

The total baseline CH₄ emissions are translated into CO₂ equivalent emissions by multiplying by its global warming potential (GWP) of 21³.

Electricity baseline emissions

The electricity baseline emissions are determined from a weighted average emission factor of the grid mix and electricity generated from project activity and exported to the electricity grid under consideration.

Electricity generated from the captured biogas is expected to be small hence the grid mix as provided by fuel consumption data from official sources in the host country can be used to determine electricity baseline emissions.

¹ Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, p. 6.20

² Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, tables 6-8

³ The IPCC revised the GWP of CH₄ to 23 in its Third Assessment Report. Once this is formally adopted, this will be used in lieu of the current GWP.



Where such data is unavailable, assumed efficiencies or other official sources of data such as the IEA may be used to calculate the grid carbon emission factor CEF.

Total CO₂ emissions of the grid can be calculated from fuel consumption data, as follows:

$$\begin{array}{ccccccc} \text{CO}_2 & & \text{Fuel} & & \text{Net calorific} & & \text{Carbon emission} & & \text{Fraction} & & \text{Mass conversion} \\ \text{emissions} & = & \text{Consumption} & \times & \text{value} & \times & \text{factor} & \times & \text{of C oxidised} & \times & \text{factor} \\ (\text{t CO}_2) & & (10^3 \text{ toe}) & & (\text{TJ}/10^3 \text{ toe}) & & (\text{t C}/\text{TJ}) & & & & (\text{t CO}_2/\text{t C}) \\ & & & & 41.868^4 & & & & & & 44/12 \end{array}$$

The grid CEF (t CO₂/MWh) is then calculated by dividing the CO₂ (t CO₂) emission by the total grid electricity generated in the grid (MWh).

Alternatively, where thermal efficiency data are used, the grid CEF is calculated as follows:

$$\begin{array}{ccccccc} \text{CO}_2 \text{ emission} & & \text{C emission} & & \text{Fraction of C} & & \text{Mass conversion} & & \text{Energy} & & \text{Efficiency} \\ \text{factor} & = & \text{factor} & \times & \text{oxidised} & \times & \text{factor} & \times & \text{conversion factor} & \div & \\ (\text{t CO}_2/\text{MWh}) & & (\text{t C}/\text{TJ}) & & & & (\text{kg CO}_2/\text{t C}) & & (\text{TJ}/\text{kWh}) & & \end{array}$$

The grid CEF is the weighted average CEF of all resources, based on what each plant generates.

Emission Reductions

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

Project emissions:

The physical delineation of the project is defined as the plant site. Project emissions mainly consist of methane emissions from the 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 IPCC default MCF value for aerobic systems is 0, and a typical value of 0.001 is given for aerobic ponds.

However, due to the uncertainty regarding the exact extent of aerobic/anaerobic digestion after project implementation, the calculation of these CH₄ emissions is conservatively carried out in the same way as for the baseline, using the same conversion factor:

$$\begin{array}{ccccccc} \text{CH}_4 \text{ emissions} & = & \text{COD at digester outlet} & \times & \text{B}_0 & \times & \text{MCF} \\ (\text{kg}/\text{yr}) & & (\text{kg COD}/\text{yr}) & & (\text{kg CH}_4/\text{kg COD}) & & \end{array}$$

where

COD Is Chemical Oxygen Demand of effluent entering lagoons (measured)
 B₀ Is maximum methane producing capacity
 MCF Is methane conversion factor (fraction)

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 IPCC default MCF value for aerobic systems is 0, and a typical value of 0.001 is given for aerobic ponds⁵.

⁴ Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook, table 1-1.

⁵ In the agricultural sector. No equivalent could be found for the waste sector. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, table 4.11.



The total project CH₄ emissions are translated into CO₂ equivalent emissions by multiplying by its global warming potential (GWP) of 21⁶.

There are several other minor sources of project emissions associated with fossil fuel use (if any), fugitive CH₄, and stack gas CH₄. These do not need to be estimated *ex ante*, unless it is known that a large amount of fossil fuel is to be used as supplementary fuel. After project implementation, these emissions will be monitored. If the emissions from an emission source are greater than 1% of the annual total CERs, they will be included as project emissions.

Emission reductions:

The calculation based on ex ante information is the following:

$$\begin{array}{rcccccc} \text{Emission} & & \text{Baseline} & & \text{Project} & & \text{Project} & & \text{Baseline emissions} \\ \text{reductions} & = & \text{emissions from} & - & \text{emission from} & - & \text{emissions from} & + & \text{from grid electricity} \\ & & \text{open lagoons} & & \text{open lagoons} & & \text{minor sources} & & \text{generation} \\ & & \text{(t CO}_2\text{e/yr)} & & \text{(t CO}_2\text{e/yr)} & & \text{(t CO}_2\text{e/yr)} & & \text{(tCO}_2\text{/yr)} \\ \text{(tCO}_2\text{/yr)} & & & & & & & & \end{array}$$

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

Ex-post monitoring of the actual amount of CH₄ captured and fed to the electricity generator leads to an ex-post estimate of methane emissions reductions (= ER_CH_{4expost}).

The lowest figure between ER_CH_{4exante} and ER_CH_{4expost} is to be adopted for emissions reduction determination.

Additionality

Additionality is addressed, by determining the most likely course of action, taking into account economic attractiveness and barriers. The additionality of a project, which avoids CH₄ emitted from wastewater and displaces grid electricity, 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 CH₄, but also electricity generation, which is either sold to the grid or used on site as a replacement for electricity currently purchased.

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 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;
- Labour cost;
- Operation and Maintenance cost;

⁶ The IPCC revised the GWP of CH₄ to 23 in its Third Assessment Report. Once this is formally adopted, this will be used in lieu of the current GWP.



- Administration cost;
- Fuel cost;
- Capital cost and interest;
- Revenue from electricity sales.

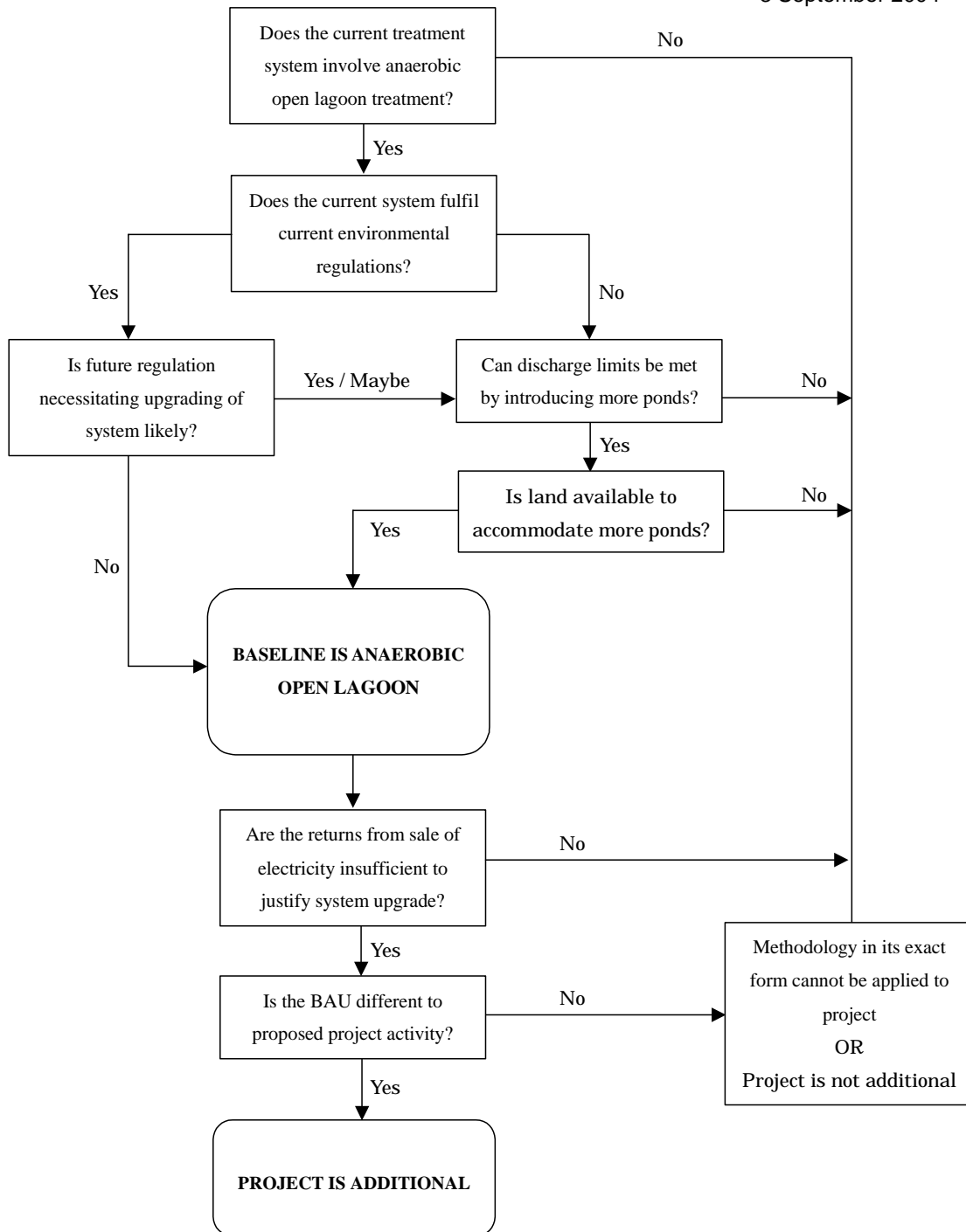
Data sources used should be identified in the CDM-PDD, and can include either project-specific or typical industry values. Where project-specific data are used, this should not deviate from the range of accepted industry values. Should a deviation be identified, this should be justified so as to ensure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

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





Approved monitoring methodology AM0013

“Forced methane extraction for grid-connected electricity supply”

Source

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Applicability

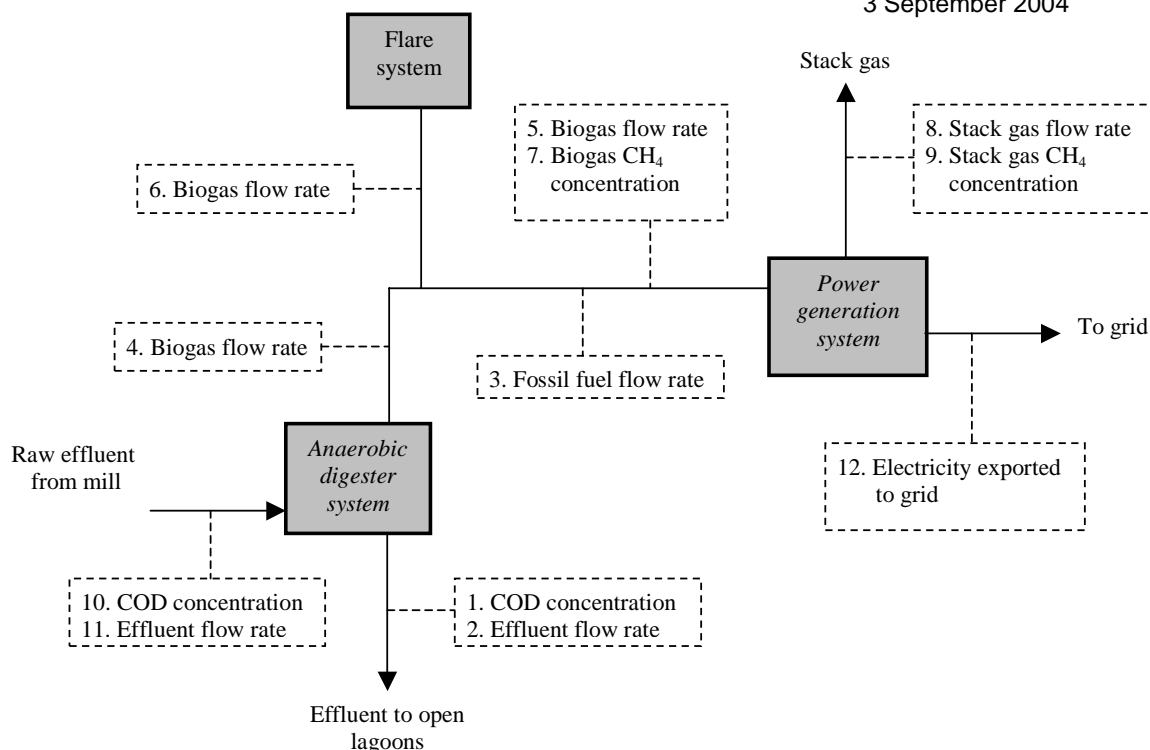
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- The methodology applies to forced CH₄ extraction project cases, as there is a process change from open lagoon to accelerated CH₄ generation in a closed tank digester or similar technology. Therefore, depending only on the amount of captured methane emissions to establish baseline emissions will not be adequate as the project activity may extract more CH₄ than would be emitted in the baseline case;
- The captured methane is used for electricity generation, which avoids emissions due to displaced electricity in a well-defined grid electricity;
- For projects with a renewable power generation capacity lower than 15 MW.

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0013 (“Forced methane extraction from organic waste-water treatment plants for grid-connected electricity supply”).

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. Volume and COD concentration of organic wastewater into the digester (Data 10 and 11 in the graph and subsequent tables) and at the outlet (Data 1 and 2 in the graph and subsequent tables);
2. Electricity supplied to the grid from the project activity to estimate CO₂ emissions from displaced electricity from the grid (Data point 12 in the graph and subsequent tables);
3. Weighted grid emission factor.

For determining project emissions

1. COD concentrations in discharged effluent from digester to estimate CH₄ emissions in the project case (Data 1 and 2 in the graph and subsequent tables);
2. Biogas into the electricity generator and CH₄ content stack (Data 5, 6, 7, 8 and 9).
The amount of CH₄ destructed in the gas engine is obtained by monitoring the flow rate and CH₄ content of the biogas entering the gas engine⁷ and subtracting the amount of methane escaping from the stack. Stack gas CH₄ is monitored through the stack gas flow rate and the CH₄ content⁸;

⁷ It is noted that the proposed methodology mandates only a quarterly sampling of the CH₄ content in biogas, although more frequent monitoring can be expected at the project-specific level. This is due to the simple correlation between CH₄ entering the gas engine and electricity output. The average annual amount of CH₄ monitored is to be compared to that back-calculated from energy balance calculations, using rated thermal efficiency and standard CH₄ 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.

⁸ Here again, being only a minor source of emissions, periodic sampling of CH₄ content to derive an average annual emission rate is considered appropriate.



3. On-site fossil fuel use (Data 3).
The GHG emissions from fossil fuel use are obtained by measuring fuel usage and multiplying with the appropriate emission factors⁹;
4. Fugitive emissions from biogas at the digester outlet and at the inlet of the electricity generator, CH₄ content (Data 4, 5 and 6).
The amount of fugitive CH₄ is to be obtained by monitoring the biogas flow rate at the digester outlet, the flare inlet and the gas engine inlet. The biogas leakage rate can be estimated by subtracting the gas engine inlet and flare inlet flow rates from the digester outlet flow rate¹⁰;
5. CH₄ content at the electricity generator inlet and outlet (Data 7 and 9).
The amount of CH₄ entering the gas engine will be monitored so that a comparison can be made with the emission reduction amount calculated *ex ante*.

As per the accompanying baseline methodology, each of the three minor emission sources project (emissions associated with fossil fuel use, fugitive CH₄, and stack gas CH₄) is considered to be negligible. However, they will be monitored and an emission source will be included in the project emission calculations once it is considered significant – contributing more than 1% of the annual amount of CERs.

⁹ Same method as for AM0004.

¹⁰ As fugitive CH₄ is considered a minor source of emissions, the proposed monitoring methodology will only mandate the periodic measurement of CH₄ content at the digester outlet, and use the average annual value as the emission rate. Sampling of CH₄ content is carried out at either the gas engine inlet or digester outlet. The CH₄ content of the biogas is considered equivalent throughout the piping, as well as for the escaped biogas. If a plant with strong safety features is designed such that no leaks occur either in the instrumentation or piping (with all excess biogas not used for power generation being flared) fugitive CH₄ need not be monitored.

*Parameters to be monitored**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
1.	Activity level (open lagoon)	COD concentration of effluent (at digester outlet)	kgCOD/m ³ POME	m	at least monthly	100%	electronic	Minimum of two years after last issuance of CERs	
2.	Activity level (open lagoon)	Flow rate of effluent (at digester outlet)	m ³ POME/hr	m	continuously	100%	electronic	Minimum of two years after last issuance of CERs	
3.	Activity level (fossil fuel use)	Mass of fossil fuel used onsite	kg fuel	m	continuously (aggregate)	100%	electronic	Minimum of two years after last issuance of CERs	
4.	Activity level (fugitive CH ₄)	Biogas flow rate at digester outlet	m ³ /hr	m	continuously	100%	electronic	Minimum of two years after last issuance of CERs	
5.	Activity level (fugitive CH ₄)	Biogas flow rate at gas engine inlet	m ³ /hr	m	continuously	100%	electronic	Minimum of two years after last issuance of CERs	
6.	Activity level (fugitive CH ₄)	Biogas flow rate at flare inlet	m ³ /hr	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
7.	Emission rate (fugitive CH ₄)	Biogas CH ₄ content at digester outlet or gas engine inlet	%	m	Interval to satisfy statistical 95% confidence level. At least quarterly	–	electronic	Minimum of two years after last issuance of CERs	
8.	Activity level (stack gas CH ₄)	Stack gas flow rate	m ³ /hr	m	continuously	100%	electronic	Minimum of two years after last issuance of CERs	
9.	Emission rate (stack gas CH ₄)	Stack gas CH ₄ content	%	m	Interval to satisfy statistical 95% confidence level. At least quarterly	–	electronic	Minimum of two years after last issuance of CERs	

*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
10.	Activity level (open lagoon)	COD concentration of effluent (at digester inlet)	kgCOD/m ³ POME	m	at least monthly	–	electronic	Minimum of two years after last issuance of CERs	
11.	Activity level (open lagoon)	Flow rate of effluent (at digester inlet)	m ³ POME/hr	m	continuously	100%	electronic	Minimum of two years after last issuance of CERs	
12.	Activity level (grid electricity)	Electricity supplied to grid	MWh	m	continuously	100%	electronic	Minimum of two years after last issuance of CERs	
13.	Qualitative	Regulations and incentives relevant to effluent	--	--	annually	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.	Low	Yes	Sampling will be carried out adhering to internationally recognized procedures.
2.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
3.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards. Meter readings will be compared to fuel purchase receipts.
4.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
5.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
6.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
7.	Low	Yes	Sampling will be carried out adhering to internationally recognized procedures. This will be carried out at least quarterly.
8.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
9.	Low	Yes	Sampling will be carried out adhering to internationally recognized procedures. This will be carried out at least quarterly.
10.	Low	Yes	Sampling will be carried out adhering to internationally recognized procedures.
11.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
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.
13.	Low	--	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.