DRAFT - Approved baseline methodology AM00XX

"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 CH_4 generation;
- The methodology applies to forced CH_4 extraction project cases, as 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 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 AM00XX ("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 CH_4 allowed to dissipate into the atmosphere. By also utilizing the biogas to produce electricity for the grid, instead of flaring the CH_4, 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 CH_4 emissions from open lagoon wastewater treatment systems and the CO_2 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, CH_4 emissions from wastewater are calculated as follows:

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

where

COD	Is Chemical Oxygen Demand of effluent entering lagoons (measured)
B_o	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 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[1]. The IPCC guidelines do not provide a single default factor for MCF, but provide the following system MCF values, as shown below[2]:

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 CH_4 emissions are translated into CO_2 equivalent emissions by multiplying by its global warming potential (GWP) of 21[3].

Ex-post monitoring of the actual amount of CH_4 captured and fed to the electricity generator leads to an ex-post estimate of baseline methane emissions (= B_{expost}).

The conservative figure between B_{exante} and B_{expost} is adopted for ER determination.

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.

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[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 CH_4 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 CO_2 emissions of the grid can be calculated from fuel consumption data, as follows:

CO_2 emissions ($t\ CO_2$)	=	Fuel Consumption (10^3 toe)	x	Net calorific value ($TJ/10^3$ toe) 41.868[4]	x	Carbon emission factor (t C/TJ)	x	Fraction of C oxidised	x	Mass conversion factor ($t\ CO_2/t\ C$) 44/12

The grid CEF ($t\ CO_2/MWh$) is then calculated by dividing the CO_2 ($t\ CO_2$) 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:

CO_2 emission factor ($t\ CO_2/MWh$)	=	C emission factor (t C/TJ)	x	Fraction of C oxidised	x	Mass conversion factor ($kg\ CO_2/t\ C$)	x	Energy conversion factor (TJ/kWh)	÷	Efficiency

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. The calculation of these CH_4 emissions is carried out in the same way as for the baseline, using the same conversion factor:

CH_4 emissions (kg/yr)	=	COD at digester outlet (kg COD/yr)	x	B_o ($kg\ CH_4/kg\ COD$)	x	MCF

where

COD	Is Chemical Oxygen Demand of effluent entering lagoons (measured)
B_o	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 ponds[5].

The total project CH_4 emissions are translated into CO_2 equivalent emissions by multiplying by its global warming potential (GWP) of 21[6].

[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.
[6] The IPCC revised the GWP of CH_4 to 23 in its Third Assessment Report. Once this is formally adopted, this will be used in lieu of the current GWP.

There are several other minor sources of project emissions associated with fossil fuel use (if any), fugitive CH_4, and stack gas CH_4. 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:

Emission reductions (tCO_2/yr)		Baseline emissions from open lagoons (t CO_2e/yr)		Project emission from open lagoons (t CO_2e/yr)		Project emissions from minor sources (t CO_2e/yr)		Baseline emissions from grid electricity generation (tCO_2/yr)
	=		–		–		+	

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 CH_4 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 CH_4, 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;
- Administration cost;
- Fuel cost;
- Capital cost and interest;
- Revenue from electricity sales.

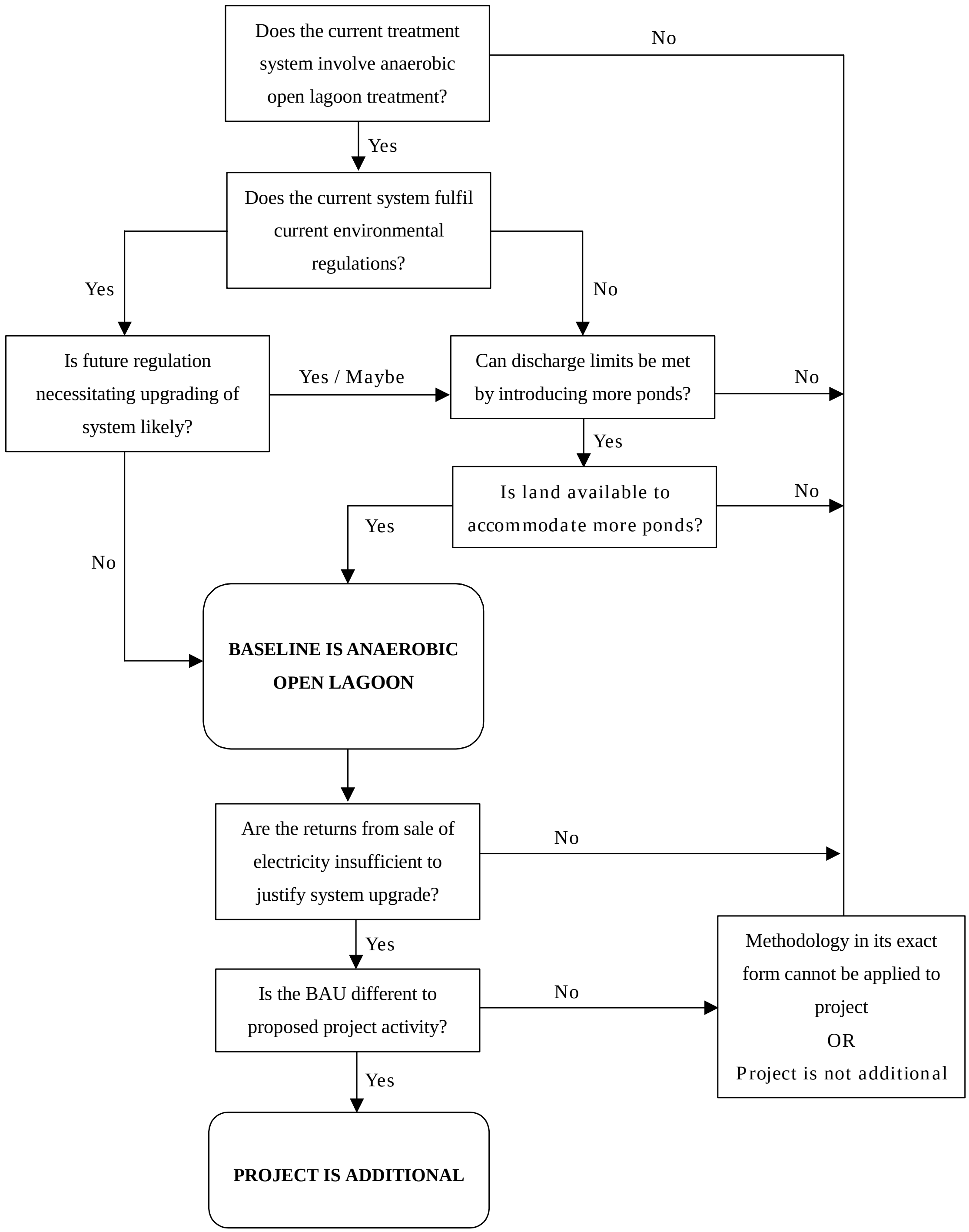
Data sources used should be identified in the CDM-PDD, and can include either project-specific or typical industry values. Where project-specific data are used, this should not deviate from the range of accepted industry values. Should a deviation be identified, this should be justified so as to ensure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



DRAFT- Approved monitoring methodology AM00XX

"Forced methane extraction 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

Applicability

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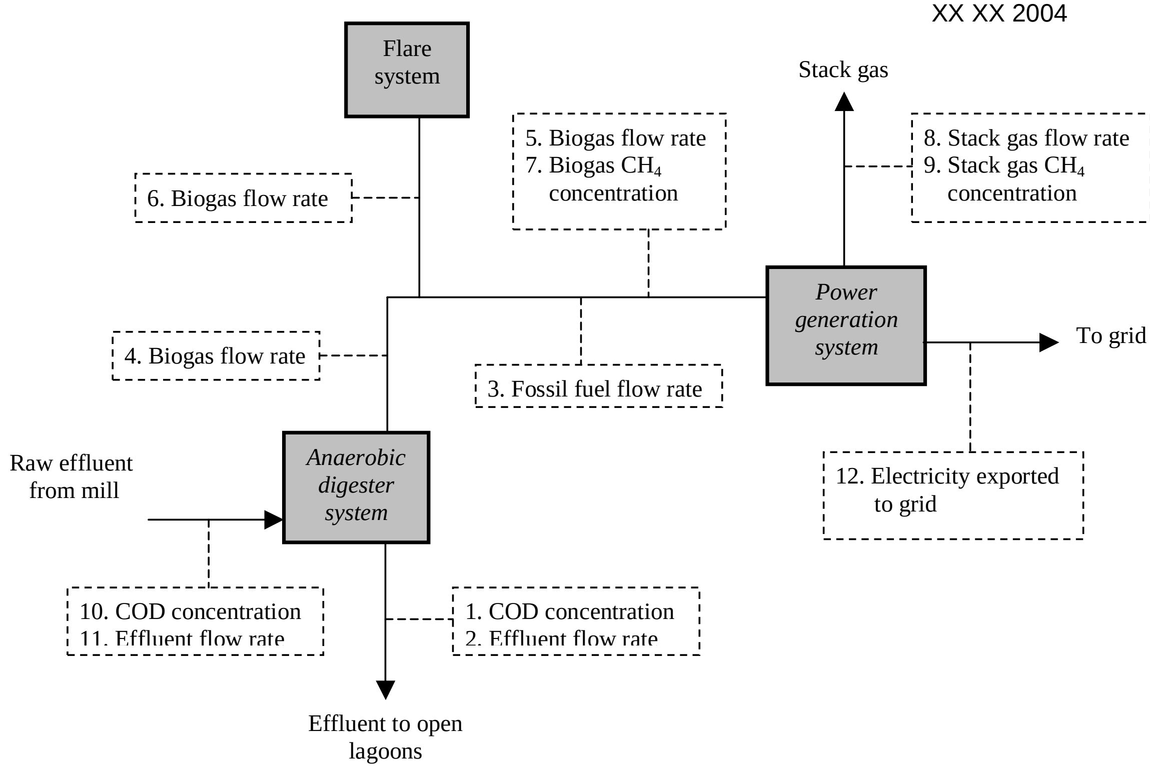
- The methodology applies to forced CH_4 extraction project cases, as there is a process change from open lagoon to accelerated CH_4 generation in a closed tank digester or similar technology. Therefore, depending only on the amount of captured methane emissions to establish baseline emissions will not be adequate as the project activity may extract more CH_4 than would be emitted in the baseline case;
- The 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 AM00XX ("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 CO_2 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 CH_4 emissions in the project case (Data 1 and 2 in the graph and subsequent tables);
2. Biogas into the electricity generator and CH_4 content stack (Data 5, 6, 7 and 8, 9).
   The amount of CH_4 destructed in the gas engine is obtained by monitoring the flow rate and CH_4 content of the biogas entering the gas engine[7] and subtracting the amount of methane escaping from the stack. Stack gas CH_4 is monitored through the stack gas flow rate and the CH_4 content[8];

[7] It is noted that the proposed methodology mandates only a quarterly sampling of the CH_4 content in biogas, although more frequent monitoring can be expected at the project-specific level. This is due to the simple correlation between CH_4 entering the gas engine and electricity output. 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.

[8] Here again, being only a minor source of emissions, periodic sampling of CH_4 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 factors[9];
4. Fugitive emissions from biogas at the digester outlet and at the inlet of the electricity generator, CH_4 content (Data 4, 5 and 6).
   The amount of fugitive CH_4 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 rate[10];
5. CH_4 content at the electricity generator inlet and outlet (Data 7 and 9).
   The amount of CH_4 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 CH_4, and stack gas CH_4) 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 CH_4 is considered a minor source of emissions, the proposed monitoring methodology will only mandate the periodic measurement of CH_4 content at the digester outlet, and use the average annual value as the emission rate. Sampling of CH_4 content is carried out at either the gas engine inlet or digester outlet. The CH_4 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 CH_4 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	continuous	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	continuous (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	continuous	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	continuous	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	continuous	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	continuous	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	continuous	100%	electronic	Minimum of two years after last issuance of CERs	
12.	Activity level (grid electricity)	Electricity supplied to grid	MWh	m	continuous	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.