Revision to approved baseline methodology AM0013

"Forced methane extraction from organic waste-water treatment plants for grid-connected electricity supply and/or heat production"

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 and 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. 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" and NM0085 "Vinasse Anaerobic Treatment Project" 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 recovery project activities involving industrial 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 residence time of the sludge in the open lagoons should be at least one year; and
    - The temperature of the sludge in the open lagoons is always higher than 15°C.
- 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 and/or for the production of heat.
- 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/version 2 ("Forced methane extraction for grid-connected electricity supply and/or heat production").

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 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.

Leakage

No leakage is associated with the project activity.

Baseline

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.

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:

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

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. Taking into account the uncertainty of this estimate, project participants should use a value of 0.21 kg CH_4/kg COD [1] as a conservative assumption for B_o.

The IPCC guidelines do not provide a single default factor for MCF, but provide a value of 0.9 for MCF in Africa, Asia and Latin America & Caribbean[2]. In order to reflect the uncertainty of this key parameter and for the purpose of providing conservative estimates of emission reductions, a conservativeness factor must be applied to the default value, assuming an uncertainty range of 50-100% and in accordance with table 2 below. The MCF default value to be adopted for projects in these area will be then 0.738.

For North America, Australia and New Zealand, the IPCC factor is 0.7. With the same assessment of conservativeness the MCF default value for projects in this area will be 0.574.

Where project participants use own estimates for MCF, for example based on measurements undertaken, they should justify these values, estimate the uncertainty range associated with these estimates and apply the corresponding conservativeness factors in Table 2.

[1] Lowest value provided by IPCC Good Practice guidance, Page 5.19
[2] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Table 6-8.

Table 2. Conservativeness factors [3]

Estimated uncertainty range (%)	Assigned uncertainty band (%)	Conservativeness factor where lower values are more conservative
Less than or equal to 10	7	0.98
Greater than 10 and less than or equal to 30	20	0.94
Greater than 30 and less than or equal to 50	40	0.89
Greater than 50 and less than or equal to 100	75	0.82
Greater than 100	150	0.73

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

Electricity baseline emissions
The electricity baseline emissions are determined:
Option 1) From a weighted average emission factor of the grid mix and electricity generated from project activity and exported to the electricity grid under consideration, or
Option 2) Following the procedure for combined margin calculation contained in the ACM 0002. The procedure is included in Annex I.

Option 1)
This option is applicable if the capacity of the power plant built as part of the project activity is lower than 15 MW.
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.
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:

$$\underset{(t\,CO_2)}{CO_2\text{ emissions}} = \underset{(10^3\text{ toe})}{\text{Fuel Consumption}} \times \underset{\substack{(TJ/10^3\text{ toe})\\ 41.868^{4}}}{\text{Net calorific value}} \times \underset{(t\,C/TJ)}{\text{Carbon emission factor}} \times \text{Fraction of C oxidised} \times \underset{\substack{(t\,CO_2/t\,C)\\ 44/12}}{\text{Mass conversion factor}}$$

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:

$$\underset{(t\,CO_2/MWh)}{CO_2\text{ emission factor}} = \underset{(t\,C/TJ)}{\text{C emission factor}} \times \text{Fraction of C oxidised} \times \underset{(kg\,CO_2/t\,C)}{\text{Mass conversion factor}} \times \underset{(TJ/kWh)}{\text{Energy conversion factor}} \div \text{Efficiency}$$

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

[3] The general guidance for the procedure is included in document FCCC/SBSTA/2003/10/Add.2, pages 11-27
[4] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook, table 1-1.

Fossil fuel combustion emissions

The emissions associated with fossil fuel combustion in the industrial process heating equipment are determined considering the volume of biogas combusted, the energy content of the biogas and the carbon content of the displaced fossil fuel. The industrial process heating emissions treated by this methodology are not the total emissions produced in the Base Case. Rather, they are only the emissions associated with that portion of Base Case fossil fuel that is displaced by the Project Case biogas.

Baseline emissions from the portion of fossil fuel displaced by biogas used in heating equipment (tCO_2/yr)	=	Volume of biogas combusted in the heating equipment (Nm^3)	x	Energy content of biogas (TJ/N m^3)	x	Carbon content of the fossil fuel (t C/TJ)	x	Mass conversion factor (t CO_2/t C) 44/12

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, physical leakage from the digester system and emissions related with the consumption of electricity in the digester auxiliary equipment.

1) 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 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)

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

2) Methane emissions from biodigesters
The emissions directly associated with the digesters involve:

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.

3) CO_2 emissions associated with the digester auxiliary equipment
Emissions directly associated with the digester auxiliary equipment (referred to as parasitic loads or parasitics) that involve any consumption by the digester auxiliary equipment of grid-supplied electricity. If the digester parasitics are powered by site-generated electricity derived from the combustion of biogas, parasitic-related emissions are considered to be zero.

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.

Project emissions (tCO_2/yr)	=	Emissions from open lagoons (t CO_2e/yr)	+	Physical leakage from biodigester (t CO_2e/yr)	+	Emissions from electric consumption by auxiliary equipment (t CO_2e/yr)

Emission reductions:

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 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 lowest figure between $ER\_CH_{4exante}$ and $ER\_CH_{4expost}$ is to be adopted for emissions reduction determination.

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[5].

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, 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;
- Labour cost;
- Operation and Maintenance cost;
- Administration cost;
- Fuel cost;
- Capital cost and interest;
- Revenue from electricity sales.

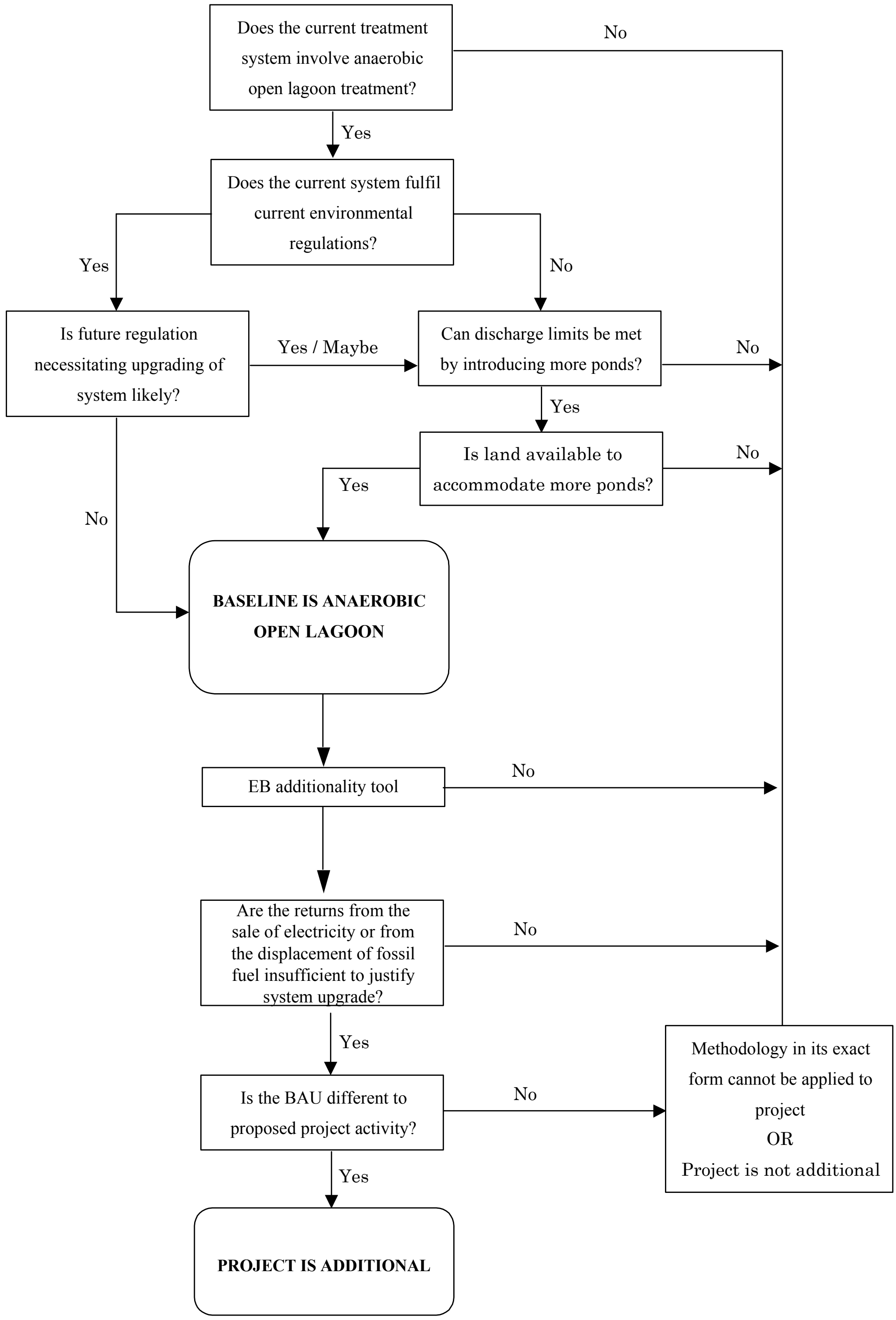
Data sources used should be identified in the CDM-PDD, and can include either project-specific or typical industry values. Where project-specific data are used, this should not deviate from the range of accepted industry values. Should a deviation be identified, this should be justified so as to ensure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

[5] 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.



Annex I. Baseline Methodology.

Option 2 for combined margin calculation. Procedure contained in ACM 0002[6]

Project Boundary

The **spatial extent** of the project boundary includes the project site and all power plants connected physically to the electricity system that the CDM project power plant is connected to.

For the purpose of determining the build margin (BM) and operating margin (OM) emission factor, as described below, a (regional) **project electricity system** is defined by the spatial extent of the power plants that can be dispatched without significant transmission constraints. Similarly, a **connected electricity system,** e.g. national or international, is defined as a (regional) electricity system that is connected by transmission lines to the project electricity system and in which power plants can be dispatched without significant transmission constraints. In determining the project electricity system, project participants should justify their assumptions.

Electricity transfers from connected electricity systems to the project electricity system are defined as **electricity imports** and electricity transfers to connected electricity systems are defined as **electricity exports**.

For the purpose of determining the Build Margin (BM) emission factor, as described below, the spatial extent is limited to the project electricity system, except where recent or likely future additions to transmission capacity enable significant increases in imported electricity. In such cases, the transmission capacity may be considered a build margin source, with the emission factor determined as for the OM imports below.

For the purpose of determining the Operating Margin (OM) emission factor, as described below, use one of the following options to determine the CO_2 emission factor(s) for net electricity imports ($COEF_{i,j,imports}$) from a connected electricity system within the same host country(ies):

(a) 0 tCO_2/MWh, or
(b) the emission factor(s) of the specific power plant(s) from which electricity is imported, if and only if the specific plants are clearly known, or
(c) the average emission rate of the exporting grid, if and only if net imports do not exceed 20% of total generation in the project electricity system, or
(d) the emission factor of the exporting grid, determined as described in steps 1,2 and 3 below, if net imports exceed 20% of the total generation in the project electricity system.

For imports from connected electricity system located in another country, the emission factor is 0 tons CO_2 per MWh.

Electricity exports should not be subtracted from electricity generation data used for calculating and monitoring the baseline emission rate.

[6] This annex refers to the approved consolidated baseline and monitoring methodology ACM0002 “Consolidated methodology for grid-connected electricity generation from renewable sources”, without the references to geothermal plants. Please refer to <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

Emission factor

A baseline emission factor (EF_y) is calculated as a combined margin (*CM*), consisting of the combination of operating margin (*OM*) and build margin (*BM*) factors according to the following three steps. Calculations for this combined margin must be based on data from an official source (where available)[7] and made publicly available.

STEP 1. Calculate the Operating Margin emission factor(s) ($EF_{OM,y}$) based on one of the four following methods:

(a) Simple OM, or
(b) Simple adjusted OM, or
(c) Dispatch Data Analysis OM, or
(d) Average OM.

Each method is described below.

Dispatch data analysis should be the first methodological choice. Where this option is not selected project participants shall justify why and may use the simple OM, the simple adjusted OM or the average emission rate method taking into account the provisions outlined hereafter.

The Simple OM method (a) can only be used where low-cost/must run resources[8] constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term normals for hydroelectricity production.

The average emission rate method (d) can only be used

- where low-cost/must run resources constitute more than 50% of total grid generation and detailed data to apply option (b) is not available, and
- where detailed data to apply option (c) above is unavailable.

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[7] Plant emission factors used for the calculation of operating and build margin emission factors should be obtained in the following priority:

1. *acquired directly* from the dispatch center or power producers, if available; or
2. *calculated*, if data on fuel type, fuel emission factor, fuel input and power output can be obtained for each plant; if confidential data available from the relevant host Party authority are used the calculation carried out by the project participants shall be verified by the DOE and the CDM-PDD may only show the resultant carbon emission factor and the corresponding list of plants.
3. *calculated*, as above, but using estimates such as
   - default IPCC values from the *IPCC 1996 Revised Guidelines* and the *IPCC Good Practice Guidance* for net calorific values and carbon emission factors for fuels instead of plant-specific values (note that the *IPCC Good Practice Guidance* includes some updates from the *IPCC 1996 Revised Guidelines*);
   - technology provider's name plate power plant efficiency or the anticipated energy efficiency documented in official sources (instead of calculating it from fuel consumption and power output). This is likely to be a conservative estimate, because under actual operating conditions plants usually have lower efficiencies and higher emissions than name plate performance would imply;
   - conservative estimates of power plant efficiencies, based on expert judgments on the basis of the plant's technology, size and commissioning date; or
4. *calculated,* for the simple OM and the average OM, using aggregated generation and fuel consumption data, in cases where more disaggregated data is not available.

[8] Low operating cost and must run resources typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation. If coal is obviously used as must-run, it should also be included in this list, i.e. excluded from the set of plants.

(a) *Simple OM.* The Simple OM emission factor ($EF_{OM,simple,y}$) is calculated as the generation-weighted average emissions per electricity unit (tCO_2/MWh) of all generating sources serving the system, not including low-operating cost and must-run power plants:

$$EF_{OM,simple,y} = \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_{j} GEN_{j,y}} \quad \textbf{(1)}$$

where

$F_{i,j,y}$ is the amount of fuel *i* (in a mass or volume unit) consumed by relevant power sources *j* in year(s) *y*,

j refers to the power sources delivering electricity to the grid, not including low-operating cost and must-run power plants, and including imports[9] to the grid,

$COEF_{i,j\,y}$ is the CO_2 emission coefficient of fuel *i* (tCO_2 / mass or volume unit of the fuel), taking into account the carbon content of the fuels used by relevant power sources j and the percent oxidation of the fuel in year(s) y, and

$GEN_{j,y}$ is the electricity (MWh) delivered to the grid by source *j*.

The CO_2 emission coefficient $COEF_i$ is obtained as

$$COEF_i = NCV_i \cdot EF_{CO2,i} \cdot OXID_i \quad \textbf{(2)}$$

where:

NCV_i is the net calorific value (energy content) per mass or volume unit of a fuel *i*,

$OXID_i$ is the oxidation factor of the fuel (see page 1.29 in the 1996 Revised IPCC Guidelines for default values),

$EF_{CO2,i}$ is the CO_2 emission factor per unit of energy of the fuel *i*.

Where available, local values of NCV_i and $EF_{CO2,i}$ should be used. If no such values are available, country-specific values (see e.g. IPCC Good Practice Guidance) are preferable to IPCC world-wide default values.

The Simple OM emission factor can be calculated using either of the two following data vintages for years(s) *y*:

- A 3-year average, based on the most recent statistics available at the time of PDD submission, or
- The year in which project generation occurs, if $EF_{OM,y}$ is updated based on ex post monitoring.

(b) *Simple Adjusted OM.* This emission factor ($EF_{OM,simple\ adjusted,y}$) is a variation on the previous method, where the power sources (including imports) are separated in low-cost/must-run power sources (*k*) and other power sources (*j*):

$$EF_{OM,simple\ adjusted,y} = \left(1-\lambda_y\right) \cdot \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_{j} GEN_{j,y}} + \lambda_y \cdot \frac{\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}}{\sum_{k} GEN_{k,y}} \quad \textbf{(3)}$$

[9] As described above, an import from a connected electricity system should be considered as one power source *j*.

where $F_{i,k,y}$, $COEF_{i,k}$ and GEN_k are analogous to the variables described for the simple OM method above for plants k; the years(s) y can reflect either of the two vintages noted for simple OM above, and

$$\lambda_y\ (\%) = \frac{\text{Number of hours per year for which low-cost/must-run sources are on the margin}}{\text{8760 hours per year}} \quad \textbf{(4)}$$

where lambda (λ_y) should be calculated as follows (see figure below):

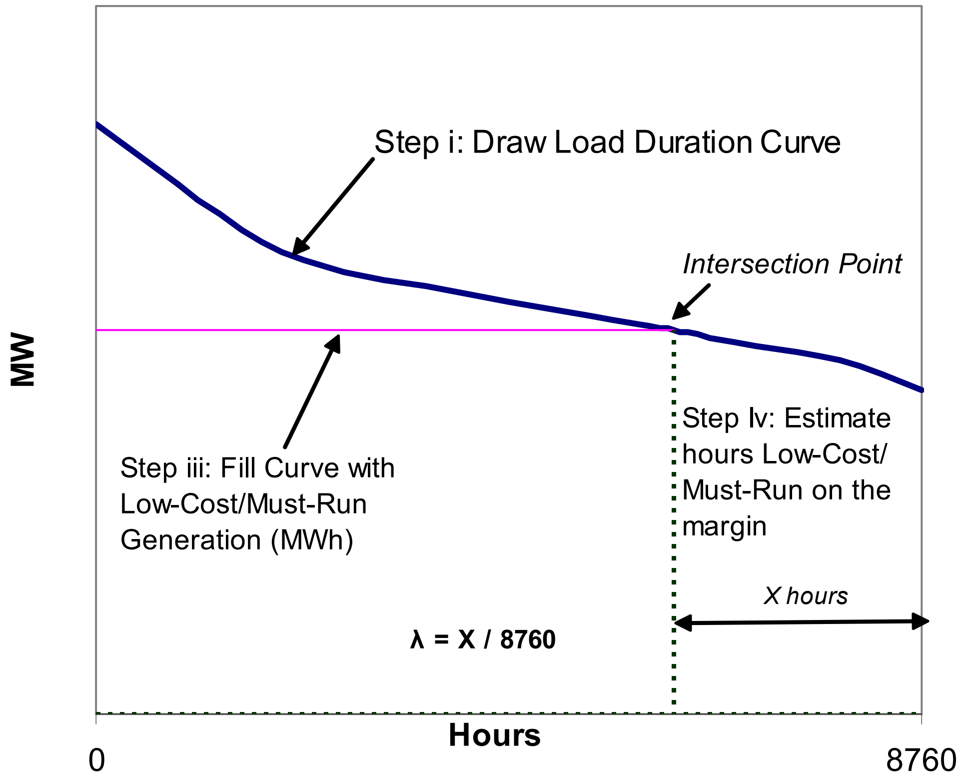
Step i) Plot a Load Duration Curve. Collect chronological load data (typically in MW) for each hour of a year, and sort load data from highest to lowest MW level. Plot MW against 8760 hours in the year, in descending order.

Step ii) Organize Data by Generating Sources. Collect data for, and calculate total annual generation (in MWh) from low-cost/must-run resources (i.e. $\sum_k GEN_{k,y}$).

Step iii) Fill Load Duration Curve. Plot a horizontal line across load duration curve such that the area under the curve (MW times hours) equals the total generation (in MWh) from low-cost/must-run resources (i.e. $\sum_k GEN_{k,y}$).

Step iv) Determine the "Number of hours per year for which low-cost/must-run sources are on the margin". First, locate the intersection of the horizontal line plotted in step (iii) and the load duration curve plotted in step (i). The number of hours (out of the total of 8760 hours) to the right of the intersection is the number of hours for which low-cost/must-run sources are on the margin. If the lines do not intersect, then one may conclude that low-cost/must-run sources do not appear on the margin and λ_y is equal to zero. Lambda (λ_y) is the calculated number of hours divided by 8760.

Figure 1: Illustration of Lambda Calculation for Simple Adjusted OM Method



Note: Step (ii) is not shown in the figure, it deals with organizing data by source.

(c) *Dispatch Data Analysis OM.* The Dispatch Data OM emission factor ($EF_{OM,Dispatch\ Data,y}$) is summarized as follows:

$$EF_{OM,Dispatch\ Data,y} = \frac{E_{OM,y}}{EG_y} \quad \textbf{(5)}$$

where EG_y is the generation of the project (in MWh) in year y, and $E_{OM,y}$ are the emissions (tCO_2) associated with the operating margin calculated as

$$E_{OM,y} = \sum_h EG_h \cdot EF_{DD,h} \quad \textbf{(6)}$$

where EG_h is the generation of the project (in MWh) in each hour h and $EF_{DD,h}$ is the hourly generation-weighted average emissions per electricity unit (tCO_2/MWh) of the set of power plants (n) in the top 10% of grid system dispatch order during hour h:

$$EF_{DD,h} = \frac{\sum_{i,n} F_{i,n,h} \cdot COEF_{i,n}}{\sum_n GEN_{n,h}} \quad \textbf{(7)}$$

where *F*, *COEF* and *GEN* are analogous to the variables described for the simple OM method above, but calculated on an hourly basis for the set of plants (*n*) falling within the top 10% of the system dispatch. To determine the set of plants (*n*), obtain from a national dispatch center: a) the grid system dispatch order of operation for each power plant of the system; and b) the amount of power (MWh) that is dispatched from all plants in the system during each hour that the project activity is operating (GEN_h). At each hour *h*, stack each plant's generation (GEN_h) using the merit order. The set of plants (n) consists of those plants at the top of the stack (i.e., having the least merit), whose combined generation ($\sum GEN_h$) comprises 10% of total generation from all plants during that hour (including imports to the extent they are dispatched).

(d) *Average OM*. The average Operating Margin (OM) emission factor ($EF_{OM,average,y}$) is calculated as the average emission rate of all power plants, using equation (1) above, but including low-operating cost and must-run power plants. Either of the two data vintages described for the simple OM (a) may be used.

STEP 2. Calculate the Build Margin emission factor ($EF_{BM,y}$) as the generation-weighted average emission factor (tCO_2/MWh) of a sample of power plants *m*, as follows:

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_{m} GEN_{m,y}} \quad \textbf{(8)}$$

where $F_{i,m,y}$, $COEF_{i,m}$ and $GEN_{m,y}$ are analogous to the variables described for the simple OM method above for plants *m*.

Project participants shall choose between one of the following two options:

Option 1. Calculate the Build Margin emission factor $EF_{BM,y}$ *ex ante* based on the most recent information available on plants already built for sample group *m* at the time of PDD submission. The sample group *m* consists of either

- the five power plants that have been built most recently, or
- the power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Project participants should use from these two options that sample group that comprises the larger annual generation.

Option 2. For the first crediting period, the Build Margin emission factor $EF_{BM,y}$ must be updated annually *ex post* for the year in which actual project generation and associated emissions reductions occur. For subsequent crediting periods, $EF_{BM,y}$ should be calculated *ex-ante*, as described in option 1 above. The sample group *m* consists of either

- the five power plants that have been built most recently, or
- the power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Project participants should use from these two options that sample group that comprises the larger annual generation.

Power plant capacity additions registered as CDM project activities should be excluded from the sample group *m*.

STEP 3. Calculate the baseline emission factor EF_y as the weighted average of the Operating Margin emission factor ($EF_{OM,y}$) and the Build Margin emission factor ($EF_{BM,y}$):

$$EF_y = w_{OM} \cdot EF_{OM,y} + w_{BM} \cdot EF_{BM,y} \qquad \textbf{(9)}$$

where the weights w_{OM} and w_{BM}, by default, are 50% (i.e., $w_{OM} = w_{BM} = 0.5$), and $EF_{OM,y}$ and $EF_{BM,y}$ are calculated as described in Steps 1 and 2 above and are expressed in tCO_2/MWh. Alternative weights can be used, as long as $w_{OM} + w_{BM} = 1$, and appropriate evidence justifying the alternative weights is presented. These justifying elements are to be assessed by the Executive Board.[10]

The weighted average applied by project participants should be fixed for a crediting period and may be revised at the renewal of the crediting period.

[10] More analysis on other possible weightings may be necessary and this methodology could be revised based on this analysis. There might be a need to propose different weightings for different situations.

Revision to approved monitoring methodology AM0013

"Forced methane extraction for grid-connected electricity supply and/or heat production "

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 and 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.. 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" and NM0085 "Vinasse Anaerobic Treatment Project" on http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

Applicability

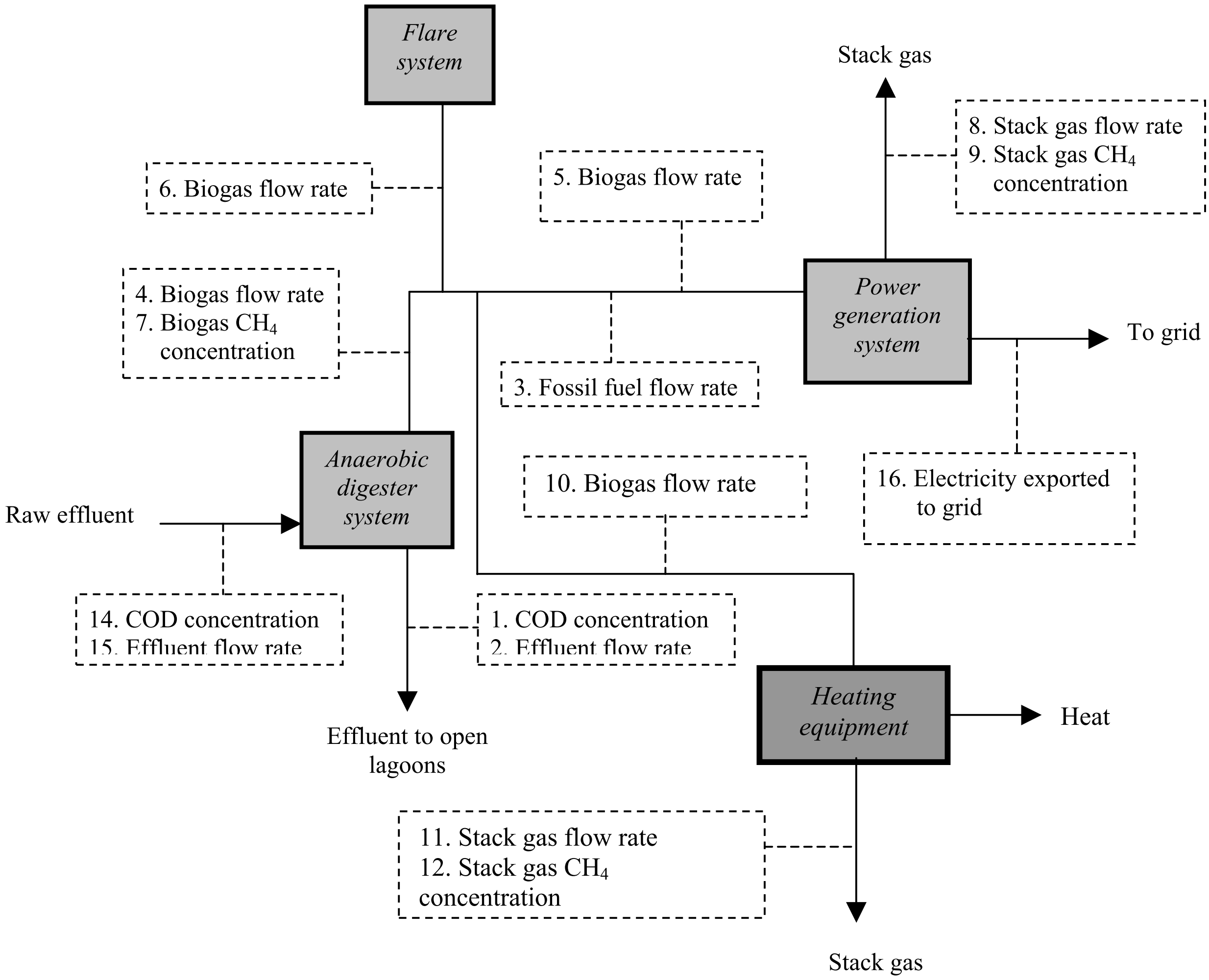
The methodology is applicable to methane recovery project activities involving organic wastewater treatment plants with the following applicability conditions:

- The existing waste water treatment system is an open lagoon system with an 'active' anaerobic condition, which is characterized as follows:
  - The depth of the open lagoon system is at least 1 m;
  - The residence time of the sludge in the open lagoons should be at least one year; and
  - The temperature of the sludge in the open lagoons is always higher than 15°C.
- 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 and/or for the production of heat;
- 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/version 2 ("Forced methane extraction from organic waste-water treatment plants for grid-connected electricity supply and/or heat production").

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 14 and 15 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 16 in the graph and subsequent tables);
3. Weighted grid emission factor (Option1) or Combined margin emission factor (Option 2). If Option 2 is selected monitoring procedures contained in ACM 0002 will apply. See Annex II.
4. Heat production to estimate CO_2 emissions from displaced fossil fuel.

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 flow rate and CH_4 content of biogas from digester (Data 4 and 7);
3. Biogas into the electricity generator and CH_4 content stack (Data 5, 6, 8 and 9).
   The amount of CH_4 destructed in the gas engine is obtained by monitoring the flow rate of the

biogas entering the gas engine[11] 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[12];

4. 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[13];
5. Fugitive emissions from biogas at the digester outlet, at the inlet of the electricity generator and-or the heating equipment, CH_4 content (Data 4, 5, 6 and 10).
   The amount of fugitive CH_4 is to be obtained by monitoring the biogas flow rate at the digester outlet, the flare inlet, the gas engine inlet and the heating equipment inlet. The biogas leakage rate can be estimated by subtracting the gas engine inlet, the heating equipment inlet and flare inlet flow rates from the digester outlet flow rate[14];
6. CH_4 content at the electricity generator outlet and at the heating equipment outlet (Data 9 and 12).
   The amount of CH_4 entering the gas engine and the heating equipment will be monitored so that a comparison can be made with the emission reduction amount calculated *ex ante*.
7. Biogas into the heating equipment and CH_4 content stack (Data 10 and 11).
   The amount of CH_4 destructed in the heat production is obtained by monitoring the flow rate and CH_4 content of the biogas entering the heating equipment[15] and subtracting the amount of methane

[11] 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.
[12] 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.
[13] Same method as for AM0004.
[14] 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, the heating equipment 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.
[15] See foot note 10.

escaping from the stack. Stack gas CH_4 is monitored through the stack gas flow rate and the CH_4 content[16];
8. Electricity consumed by digester parasitics (Data 13).

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.

[16] See foot note 11.

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 raw effluent	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 raw effluent/ 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 gas engine)	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 gas engine)	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	
10.	Activity level (fugitive CH_4)	Biogas flow rate at heating equipment 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
11.	Activity level (stack gas CH_4 heating equipment)	Stack gas flow rate	m^3/hr	m	continuously	100%	electronic	Minimum of two years after last issuance of CERs	
12.	Emission rate (stack gas CH_4 heating equipment)	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	
13.	Activity level (parasitics)	Electricity consumed by digester parasitics	MWh	m	monthly	100%	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
14.	Activity level (open lagoon)	COD concentration of effluent (at digester inlet)	$kgCOD/m^3$ raw effluent	m	at least monthly	–	electronic	Minimum of two years after last issuance of CERs	
15.	Activity level (open lagoon)	Flow rate of effluent (at digester inlet)	m^3 raw effluent/hr	m	continuously	100%	electronic	Minimum of two years after last issuance of CERs	
16.	Activity level (grid electricity)	Electricity supplied to grid	MWh	m	continuously	100%	electronic	Minimum of two years after last issuance of CERs	
17.	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	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
11.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
12.	Low	Yes	Sampling will be carried out adhering to internationally recognized procedures. This will be carried out at least quarterly.
13.	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.
14.	Low	Yes	Sampling will be carried out adhering to internationally recognized 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
15.	Low	Yes	Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
16.	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.
17.	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.

Annex II. Monitoring Methodology.

Option 2 for combined margin calculation. Procedure contained in ACM0002.

Monitoring Methodology

The methodology requires monitoring of the following:

- Electricity generation from the proposed project activity;
- Data needed to recalculate the operating margin emission factor, if needed, based on the choice of the method to determine the operating margin (OM), consistent with Annex I of AM 0013 and "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002);
- Data needed to recalculate the build margin emission factor, if needed, consistent with Annex I of AM0013 and "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002);

Project boundary

1) Consistent with Annex I of AM0013 and the "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002) the project boundary includes the following **emissions sources**:

For the baseline determination, project participants shall only account CO_2 emissions from electricity generation in fossil fuel fired power that is displaced due to the project activity.

2) The **spatial extent** of the project boundary includes the project site and all power plants connected physically to the electricity system that the CDM project power plant is connected to.

Baseline Emission Parameters

The 6th column indicates which monitoring elements are required depending on which method is used to determine the operating margin (OM) in step 1 of the "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002) "Simple OM" is defined in step 1a; "Simple Adjusted OM" in 1b; "Dispatch Data OM" in 1c; and "Average OM" in step 1d. Items required for "BM" are for the Build Margin defined in step 2. Note that for the "Simple OM", "Simple Adjusted OM" and the "Average OM" as well as the "BM, where project participants choose, consistent with "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002), a data vintage based on ex ante monitoring, at least EG_y shall be monitored, and all parameters will be required to recalculate the combined margin at any renewal of a crediting period, using steps 1-3 in the baseline methodology.

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	For which baseline method(s) must this element be included	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1. EG_y (EG_h if dispatch data OM is used)	Electricity quantity	Electricity supplied to the grid by the project	MWh	Directly measured	*Simple OM* *Simple Adjusted OM* *Dispatch Data OM* *Average OM* *BM*	hourly measure-ment and monthly recording	100%	electronic	During the crediting period and two years after	Electricity supplied by the project activity to the grid. Double check by receipt of sales.
2. EF_y	Emission factor	CO_2 emission factor of the grid	tCO_2 / MWh	c	*Simple OM* *Simple Adjusted OM* *Dispatch Data OM* *Average OM* *BM*	yearly	100%	electronic	During the crediting period and two years after	Calculated as a weighted sum of the OM and BM emission factors
3. $EF_{OM,y}$	Emission factor	CO_2 Operating Marin emission factor of the grid	tCO_2 / MWh	c	*Simple OM* *Simple Adjusted OM* *Dispatch Data OM* *Average OM*	yearly	100%	electronic	During the crediting period and two years after	Calculated as indicated in the relevant OM baseline method above

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	For which baseline method(s) must this element be included	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
4. $EF_{BM,y}$	Emission factor	CO_2 Build Margin emission factor of the grid	tCO_2 / MWh	c	BM	yearly	100%	electronic	During the crediting period and two years after	Calculated as $[\sum_i F_{i,y} * COEF_i] / [\sum_m GEN_{m,y}]$ over recently built power plants defined in the baseline methodology
5. $F_{i,y}$	Fuel quantity	Amount of each fossil fuel consumed by each power source / plant	Mass or volume	m	*Simple OM* *Simple Adjusted OM* *Dispatch Data OM* *Average OM* *BM*	yearly	100%	electronic	During the crediting period and two years after	Obtained from the power producers, dispatch centers or latest local statistics.
6. $COEF_i$	Emission factor coefficient	CO_2 emission coefficient of each fuel type i	tCO_2 / mass or volum e unit	m	*Simple OM* *Simple Adjusted OM* *Dispatch Data OM* *Average OM* *BM*	yearly	100%	electronic	During the crediting period and two years after	Plant or country-specific values to calculate COEF are preferred to IPCC default values.
7. $GEN_{j/k/n,,y}$	Electricity quantity	Electricity generation of each power source / plant j, k or n	MWh/ a	m	*Simple OM* *Simple Adjusted OM* *Dispatch Data OM* *Average OM* *BM*	yearly	100%	electronic	During the crediting period and two years after	Obtained from the power producers, dispatch centers or latest local statistics.
8.	Plant name	Identification of power source / plant for the OM	Text	e	*Simple OM* *Simple Adjusted OM* *Dispatch Data OM* *Average OM*	yearly	100% of set of plants	electronic	During the crediting period and two years after	Identification of plants (j, k, or n) to calculate Operating Margin emission factors

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	For which baseline method(s) must this element be included	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
9.	Plant name	Identification of power source / plant for the BM	Text	e	BM	yearly	100% of set of plants	electronic	During the crediting period and two years after	Identification of plants (m) to calculate Build Margin emission factors
10. λ_y	Parameter	Fraction of time during which low-cost/must-run sources are on the margin	Number	c	*Simple Adjusted OM*	yearly	100%	electronic	During the crediting period and two years after	Factor accounting for number of hours per year during which low-cost/must-run sources are on the margin
11.	Merit order	The merit order in which power plants are dispatched by documented evidence	Text	m	*Dispatch Data OM*	yearly	100%	paper for original documents, else electronic	During the crediting period and two years after	Required to stack the plants in the dispatch data analysis.
11a. $GEN_{j/k/ll,y}$ *IMPORTS*	Electricity quantity	Electricity imports to the project electricity system	kWh	c	*Simple OM* *Simple Adjusted OM* *Dispatch Data OM* *Average OM* *BM*	yearly	100%	electronic	During the crediting period and two years after	Obtained from the latest local statistics. If local statistics are not available, IEA statistics are used to determine imports.

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	For which baseline method(s) must this element be included	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
11b. $COEF_{i,j\ y}$ IMPORTS	Emission factor coefficient	CO_2 emission coefficient of fuels used in connected electricity systems (if imports occur)	tCO_2 / mass or volume unit	c	*Simple OM* *Simple Adjusted OM* *Dispatch Data OM* *Average OM* *BM*	yearly	100%	electronic	During the crediting period and two years after	Obtained from the latest local statistics. If local statistics are not available, IPCC default values are used to calculate.

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

All variables, except one related to off-site transportation, used to calculate project and baseline emissions are directly measured or are publicly available official data. To ensure the quality of the data, in particular those that are measured, the data are double-checked against commercial data. The quality control and quality assurance measures planned for the Project are outlined in the following table.

Data	Uncertainty Level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
1.	Low	Yes	These data will be directly used for calculation of emission reductions. Sales record to the grid and other records are used to ensure the consistency.
Others	Low	Yes	Default data (for emission factors) and IEA statistics (for energy data) are used to check the local data.

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