Monitoring report form
(Version 05.1)

Complete this form in accordance with the Attachment "Instructions for filling out the monitoring report form" at the end of this form.

MONITORING REPORT		
Title of the project activity	Methane Emission Utilization for Power Generation from Ethanol wastewater treatment at PT. Indonesia Ethanol, Lampung province, Indonesia	
UNFCCC reference number of the project activity	4678	
Version number of the monitoring report	01	
Completion date of the monitoring report	28/03/2016	
Monitoring period number and duration of this monitoring period	Monitoring period number 1 Duration of this monitoring period (first and last days included): 01/10/2014 - 31/03/2015	
Project participant(s)	PT Indonesia Ethanol Industry PT Biogas Energy Indonesia ISCCP Investment Platform Limited Swedish Energy Agency	
Host Party	Republic of Indonesia	
Sectoral scope(s)	Sectoral scope 13: Waste handling and disposal.	
Selected methodology(ies)	Methodology: ACM0014 ver. 3.1 – Mitigation of greenhouse gas emissions from treatment of industrial wastewater	
Selected standardized baseline(s)	Not applicable	
Estimated amount of GHG emission reductions or net GHG removals by sinks for this monitoring period in the registered PDD	49,402CO_2e	
Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period	GHG emission reductions or net GHG removals by sinks reported up to 31 December 2012	GHG emission reductions or net GHG removals by sinks reported from 1 January 2013 onwards
	0	16,005

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

>>

The purpose of the project activity is to reduce the greenhouse gas emissions by the capturing and utilization of biogas produced from the wastewater treatment from the ethanol plant for Power generation. PT Indonesia Ethanol Industry (IEI) produces 40,000 tons per year cassava based ethanol, utilizing "fibre" technology, at its new plant (Greenfield project) located at Bandar Mataram District, Lampung Province, Indonesia. The cassava is sourced from farmers in the nearby region. It is estimated that the plant will discharge about 1,500 m3 of wastewater per day with an estimated average 85,000 mg/l COD (Chemical Oxygen Demand). The project activity proposes to install an in-ground anaerobic digester technology, CIGAR (Covered In-Ground Anaerobic Reactor), to capture biogas from the ethanol plant wastewater discharge. The technology consists of a uniquely designed lagoon process with mixers, baffles and a thick high density polyethylene (HDPE) cover, followed by a subsequent aerobic lagoon.

The project activity will also consist of utilizing the biogas via co-firing in a 1.8 MW co-generation facility, which would otherwise be fired by coal only. The electricity and heat generated by the coal and biogas will be utilized for meeting the on-site energy (electricity and heat) requirement of the ethanol facility.

This project was registered as a UNFCCC CDM Project (Reference No. 4678) on 8 August 2011 (http://cdm.unfccc.int/Projects/DB/ERM-CVS1302616499.11/view. The construction of the CDM project activity started on 21 May 2010 and was commissioned in June 2011.The IEI plant started continuous operation from February 2012.

This Monitoring Report covers the monitoring period of 1 October 2014 – 31 March 2015 (inclusive of both days).

The total emission reductions achieved in this monitoring period is 16,005 tCO2e

A.2. Location of project activity

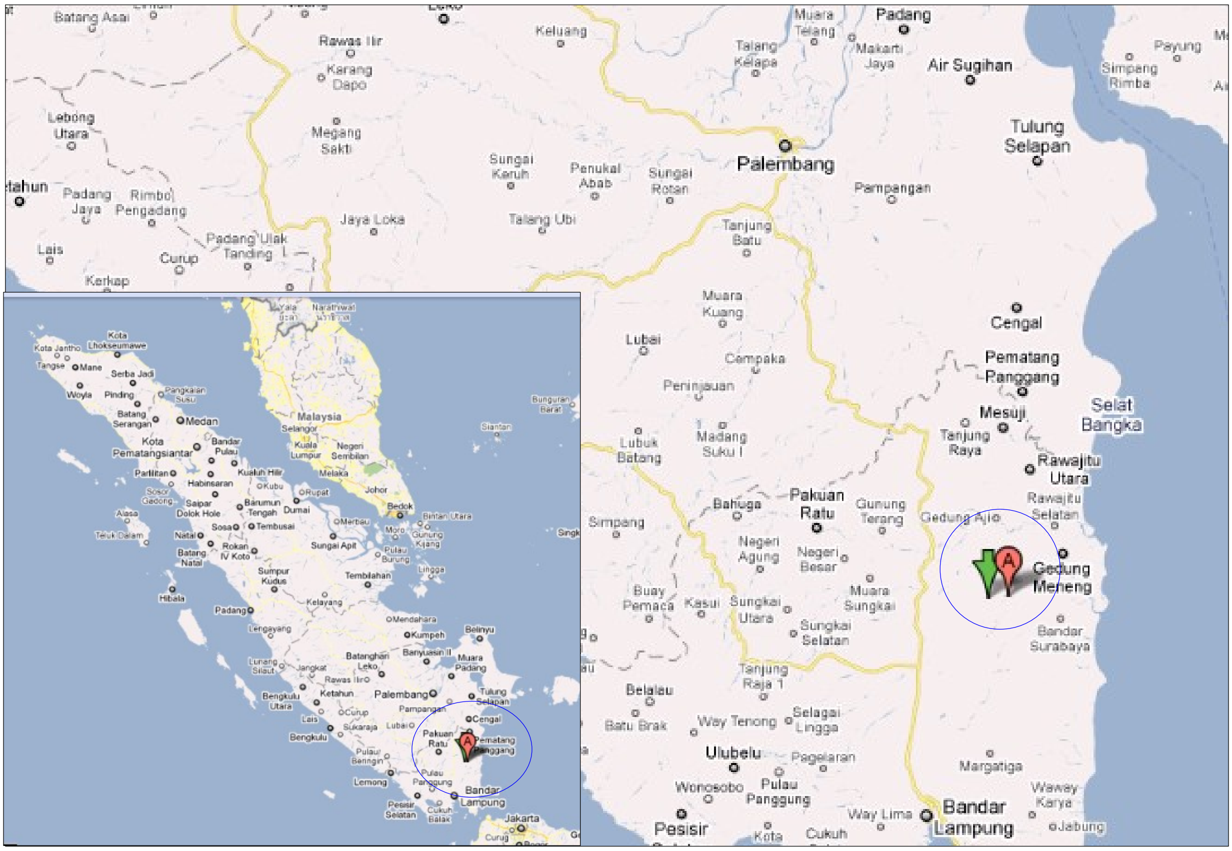
>>

The Project activity is located on the premises of Indonesia Ethanol's factory, located in the village of Sriwijaya Mataram, Bandar Mataram district, Lampung Tengah of Lampung Province in Sumatra, Indonesia.

The geographic coordinates are
Latitude: 4°46'10.98"S (S 4.769717)
Longitude: 105°27'46.62"E (E 105.46295)

The physical location of the Project is shown in Figure 1.

Figure 1 Physical location of the Project



A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate whether the Party involved wishes to be considered as project participant (yes/no)
Republic of Indonesia (host)	PT Indonesia Ethanol Industry	No
Republic of Indonesia (host)	PT Biogas Energy Indonesia	No
United Kingdom (annex 1)	ISCCP Investment Platform Limited	No
Sweden (annex 1)	Swedish Energy Agency	No

A.4. Reference of applied methodology and standardized baseline

>>

The Project applies the approved consolidated baseline and monitoring methodology ACM0014 "Mitigation of greenhouse gas emissions from treatment of industrial wastewater" (version 03.1).

The methodology also applies the following tools:

- Tool for the demonstration and assessment of additionality (version 05.2);
- Tool to determine project emissions from flaring gases containing methane (version 01);
- Tool to calculate the emission factor for an electricity system (version 02);
- Tool to calculate baseline, project and/or leakage emission from electricity consumption (version 01);
- Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (version 02).

For detail information regarding the methodology and tools, further reference is available at UNFCCC methodology website http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

A.5. Crediting period of project activity

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Crediting Period of the project activity is 01 February 2012 – 31 January 2022 (10 years fixed) including first and last days.

A.6. Contact information of responsible persons/entities

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Mr. Jay Mariyappan
Managing Director
Project Participant
ISCCP Investment Platform Ltd
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Singapore
Tel. +65 6732 8897
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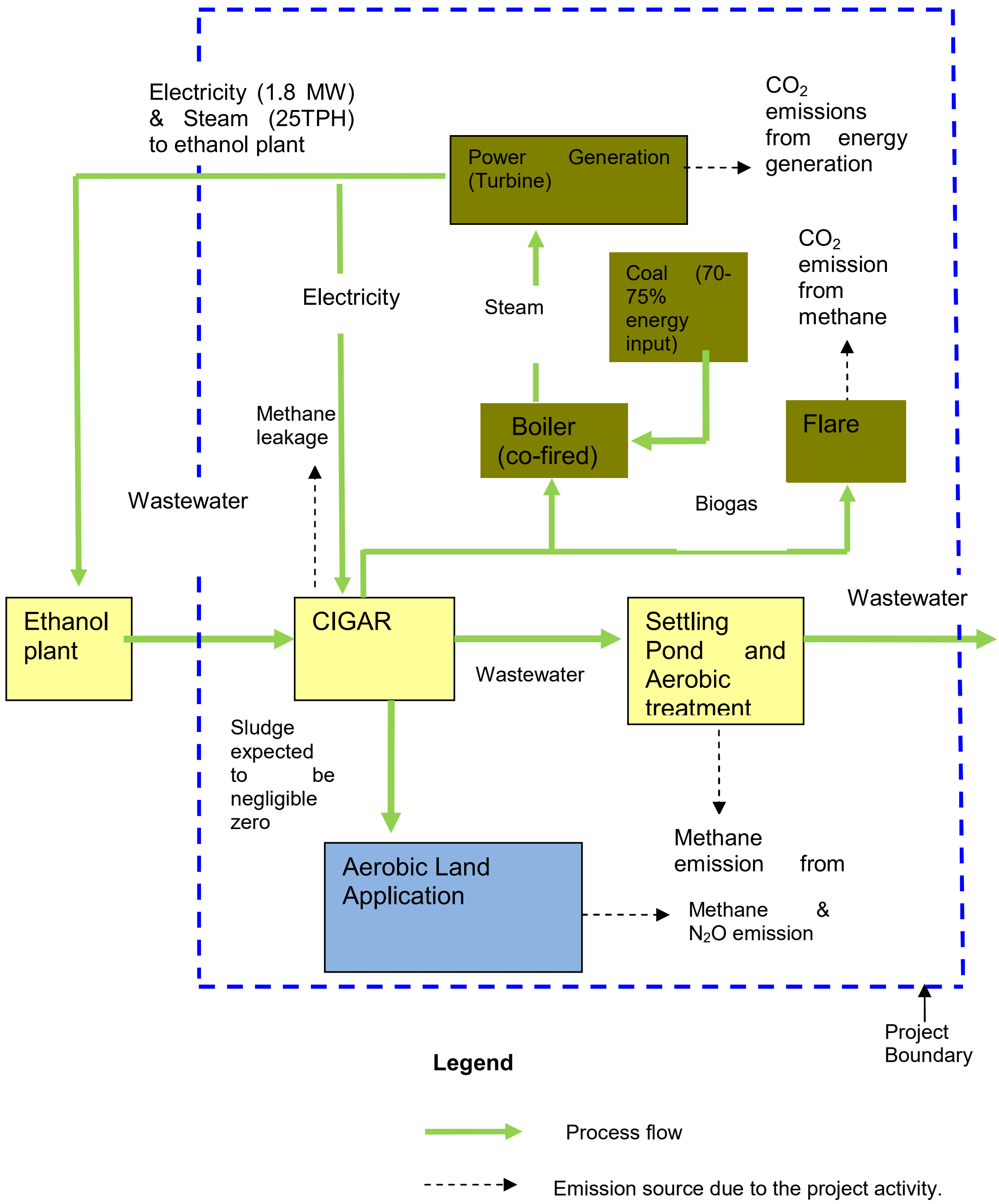
SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

>>

The project activity installed an in-ground anaerobic digester technology, CIGAR (Covered In-Ground Anaerobic Reactor), to capture biogas from the ethanol plant wastewater discharge. The technology consists of a uniquely designed lagoon process with mixers, baffles and a thick high density polyethylene (HDPE) cover. The CIGAR is capable of processing 1500 – 1700 m3/day waste with COD concentration up to 85,000 mg/l COD. The Biogas produced is used to co-fire a superheated steam boiler with coal to generate steam. A back pressure steam turbine utilizes the steam to generate electricity.

Figure 2: Schematic diagram of the project boundary



The specification of the co-generation unit is provided in the table below:

Table 1: Specification for Power Generation Unit

Item	Data
Back Pressure Steam Turbine	
Rated Power	3 MW
Steam Flow	42 t/h
Steam Rate	14 kg/kwh
Steam Inlet Pressure	3.43 MPa
Steam Inlet Temperature	435°C
Steam Exhaust Pressure	0.785 MPa
Generator	
Rated Power	3 MW
Rated Voltage	6,300 KV

Rated Speed	3,000 r/m
Super Heated Steam Boiler	
Rated Capacity	25 t/h
Superheated steam temp	450 ^oC
Rated Working Pressure	3.8 MPa
Superheated Steam Temperature	450 ^oC
Boiler Efficiency	82% $\pm$ 2%
Commissioning date	14 Jan 2012

In a situation where there is surplus biogas due to cogeneration plant maintenance or any other factors, the biogas will be sent to flares. Summary of the technical specification of the flaring system is given in table 2 below:

Table 2: Specification of the flaring unit

Item	Data
Enclosed Flare	
Capacity (Nm3/h)(at 0^{o}C and 1 Atm)	400
Flare pressure MPa	0.02
Stack Size	OD : 1.5 m, H : 7.8m
Insulation	Ceramic fibre
Open Flare	
Capacity (Nm3/h)(at 0^{o}C and 1 Atm)	1,120
Flare pressure MPa	0.002
Stack Size	OD : 1.3 m, H : 7.1 m
Total Flare capacity (Nm3/h)(at 0oC and 1 Atm)	3,760
Commissioning date	18 Feb 2011

Special events that impacted on CDM data during this monitoring period can be seen in Annex 1.

B.2. Post-registration changes

B.2.1. Temporary deviations from registered monitoring plan, applied methodology or applied standardized baseline

>>
No temporary deviations from registered monitoring plan, applied methodology or applied standardized baseline for this monitoring period.

B.2.2. Corrections

>>

No corrections to project information or parameters fixed at validation for this monitoring period

B.2.3. Changes to start date of crediting period

>>
The start date of the crediting period was changed from 08 August 2011 to 01 February 2012.

B.2.4. Inclusion of a monitoring plan to the registered PDD that was not included at registration

>>
There have been no changes to the project design of the project activity submitted or approved during this monitoring period with this monitoring report.

B.2.5. Permanent changes from registered monitoring plan, applied methodology or applied standardized baseline

>>

There have been no permanent changes from registered monitoring plan, applied methodology or applied standardized baseline submitted or approved during this monitoring period with this monitoring report.

B.2.6. Changes to project design of registered project activity

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There have been no changes to the project design of the project activity submitted or approved during this monitoring period with this monitoring report.

B.2.7. Types of changes specific to afforestation or reforestation project activity

>>

Not Applicable

SECTION C. Description of monitoring system

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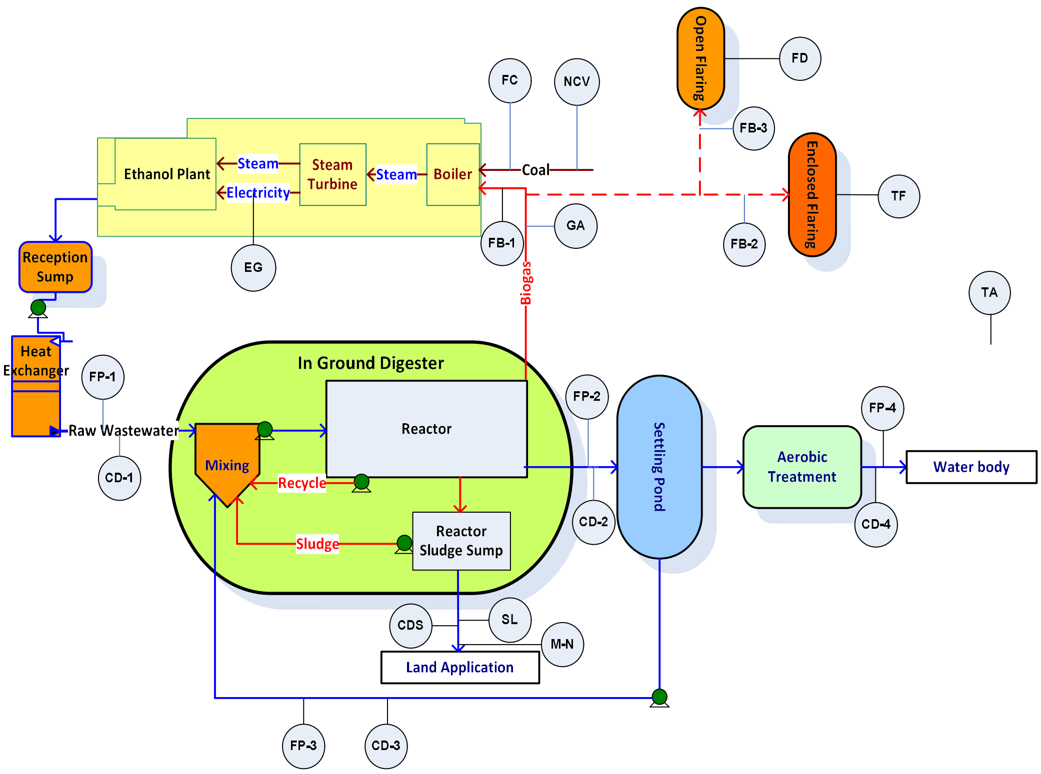
In order to guarantee the quality of the data and data collection system, a detailed monitoring manual has been developed and implemented. This detailed monitoring manual (available for verification by the DOE) is based on requirements set out in the PDD and monitoring plan. A schematic of the monitoring system is shown below:

Figure 2 Location of the CDM measurement devices



Notation	Remark
NCV	Net Calorific Value of Coal and Biogas
FC	Amount of Coal
EG	Electricity Generated from Steam Turbine
FP-1	Quantity of the wastewater outlet from factory
FP-2	Quantity of the wastewater outlet from In Ground Digester
FP-3	Quantity of the waste water recycle from settling pond to Mixing tank
FP-4	Quantity of the wastewater discharged to water body
CD-1	Chemical Oxygen Demand of the wastewater outlet from factory
CD-2	Chemical Oxygen Demand of the wastewater outlet from In Ground Digester
CD-3	Chemical Oxygen Demand of the waste water recycle from settling pond to Mixing tank
CD-4	Chemical Oxygen Demand of the wastewater discharged to water body
SL	Quantity of the sludge applied to the land
CDS	Chemical Oxygen Demand of the sludge applied to the land
M-N	Mass Fraction of Nitrogen in the sludge applied to the land
FB-1	Amount of inlet biogas to the boiler
FB-2	Amount of inlet biogas to the enclosed flare
FB-3	Amount of inlet biogas to the open flare
GA	Fraction of the methane in biogas
TF	Temperature of Flare in the enclosed flare
FD	Flame detection in the open flare
TA	Temperature of the ambient

Parameters to be monitored
The variables to be monitored were all listed and described in Section D.2

Management structure for the implementation of monitoring plan
A specific CDM department has been established by the project owner and a CDM manager appointed to oversee that activities are carried out according to the monitoring plan. The organizational structure for the CDM department is shown below in Figure 6.

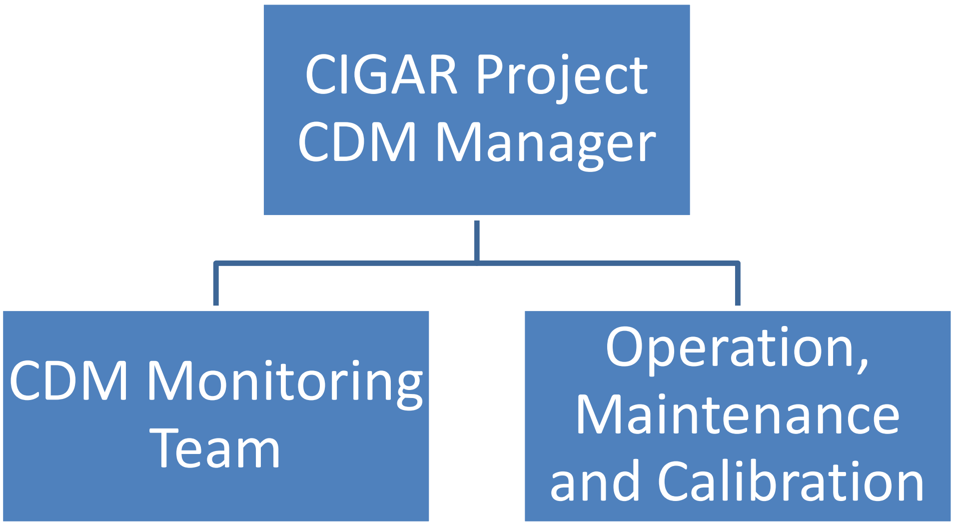


Figure 6. Organizational Structure of CDM Department

Responsibility and CDM management: A CDM manager has been appointed with responsibility for monitoring all project related activities and organising training. To ensure competency for all positions, employees selected have technical school background and are trained in wastewater operation, monitoring and health and safety.

All calculations are checked and signed off by the CDM manager who will also be responsible for preparing and checking documents required for verification.

A CDM monitoring team (reporting to the CDM manager) will have day to day responsibilities for checking instrumentation, record keeping, data handling and data processing, filing, reporting, organising repair and maintenance of monitoring equipment and ensuring the monitoring plan is adhered to as indicated in the approved PDD. The monitoring staff will receive technical training and refresher training as well as safety training to minimise exposure to workplace hazards.

BEI is responsible for ensuring that the activities are carried out in accordance with the monitoring plan. To ensure this BEI will work closely with the team of PT. Indonesia Ethanol Industry. A management level link will be established to ensure effective co-operation between CIGAR operation staff and CDM monitoring staff.

All relevant information, notes of meetings, data files, maintenance records, defect reports, hard copy and computerised records of monitoring are kept at a designated location and arranged in an orderly and transparent manner to facilitate audit as and when required.

Responsibilities, procedures, methods, equipment types and specifications are described in detail in a site-specific CDM monitoring manual. The copy of Monitoring Manual will be given to the DOE upon request.

Data collection and management

1. Measurement Management
   There are 2 types of measurement which is on-line measurement and manual measurement. Online measurement will be applied for waste water flow, biogas flow, methane concentration; electricity generated and enclosed flare temperature. Manual measurement will be applied for Chemical Oxygen Demand (COD), amount of coal, NCV of Coal and biogas and amount of sludge. The COD of wastewater and NCV of coal and biogas will be tested based on national or international standard in laboratory.

2. On-line monitoring
   On-line parameters required to determine GHG emissions and emission reductions will be monitored from a central control point which will record meter readings at a pre-determined interval as specified in the CDM monitoring manual. Manual data will be measured on regular basis and input to central control point. These data will be used to continuously update total emission reductions as long as the generating plant is in operation.

3. Manual data recording system

The CDM Manager will implement a manual data recording system to act as a back-up for the on-line monitoring system. This will involve completion of a log sheet that records flow meter and electricity meter readings. Spot readings of other values (methane concentration, flare temperature) will also be recorded periodically and at the times when flow meter readings are taken.

4. Regulatory requirements related to CIGAR project
   Although the methodology only requires recording at the renewal of the crediting period, the information related to all relevant policies and circumstances will be collected and recorded annually. Information will be kept during crediting period and two years after.

5. Data archiving
   The on-line monitoring system will automatically and periodically (eg. weekly) archive data in a safe manner. Electronic documents will be saved for backup, with written documents and back-ups safely kept. Calibration data should be saved electronically. All information related to monitoring such as meeting minutes, data documents, maintenance records, accident reports, hard copies as well as computer records, should be kept in order at designated locations to ensure examination process transparent and highly effective. These data will be stored until 2 years after the end of the crediting period.

Maintenance and calibration of meters
All meters are purchased and maintained as specified in the CDM monitoring manual according to manufacturer specifications. All key meters will be subject to a quality control regime that will include regular maintenance and calibration. Calibrations are carried out by the manufacturer or a suitably qualified external company. The gas analyzer is calibrated internally using the standard gas. The coal belt scale is also calibrated internally using the calibrated weighbridge. A record will be maintained showing the location and unique identification number of each meter, the calibration status of that meter (when last calibrated, when next due for calibration) and who performs the calibration service. Calibration certificates will be retained for all meters until two years after the end of the crediting period.

Treatment of missing or corrupted data
When data in the on-line system are corrupted or missing whilst the plant is operating (as shown, for example, by electricity output) the missing data can be estimated by taking the lower value of the parameter one hour before the error and one hour after the system restart. If there is evidence that neither of these values is representative, use the average value of the parameter from the previous 24 hours.

The error will be recorded in the log sheet and the occurrence of the error will be investigated and rectified as soon as possible. If the on-line system is compromised for more than 24 hours, data will be manually recorded. Manually recorded data table will be backup data for methane destruction amount and other key parameters. Any deficiencies in methane flow monitoring data will be rectified by calculation from power generation data.

Non essential data
The on-line monitoring system will also monitor “non-essential” data. Such data is termed non-essential because it is not directly listed in the CDM Monitoring Methodology, but it will constitute a means of corroborating the on-line system. Non-essential data is including mechanical equipment operation data and also alarm of process failure.

Document Control
The CDM Manager will implement a document control system that ensures that the current versions of necessary documents are available at the point of use.

Preparation of monitoring report
A monitoring report will be prepared by CDM department at periodic intervals (at least once per year). The monitoring report will serve as basis for verification by a DOE. The content of the monitoring report should include as minimum information concerning the project activity, monitoring data, calculation of emission reductions and records on maintenance and calibration of monitoring meters.

Audit function and management review
The CDM Manager will arrange for an independent internal audit of the management system periodically and at least once per year. The auditor will not be involved in the daily operation of the CIGAR and if necessary, may be sourced from a third party. The auditor will assess the implementation of the monitoring procedure and the preparation of the monitoring report. Audit findings, and steps taken to address findings will be

recorded and reviewed in a Management Review meeting (convened at least annually) at which time the effectiveness of these procedures will be reviewed and necessary changes implemented.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante or at renewal of crediting period

(Copy this table for each piece of data and parameter)

Data/parameter:	$COD_{out,x}$
Unit	tonne COD / year
Description	COD of the effluent in the period x
Source of data	Design features of the baseline open lagoon system
Value(s) applied)	689
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission calculation
Additional comments	-

Data/parameter:	$COD_{in,x}$
Unit	tonne COD / year
Description	Design COD inflow to the baseline anaerobic lagoon in period x
Source of data	Design features of the baseline open lagoon system
Value(s) applied)	30,600
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission calculation
Additional comments	-

Data/parameter:	B_o
Unit	tCH4/tCOD
Description	Maximum methane producing capacity, expressing the maximum amount of CH4 that can be produced from a given quantity of chemical oxygen demand
Source of data	2006 IPCC Guidelines
Value(s) applied)	0.21
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline & Project Emission calculation
Additional comments	-

Data/parameter:	f_d
Unit	%
Description	Factor expressing the influence of the depth of the lagoon on methane generation
Source of data	ACM0014 version 03.1

Value(s) applied)	70
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline & Project Emission calculation
Additional comments	Applicable to the methane conversion factor method

Data/parameter:	*D*
Unit	m
Description	Average depth of the lagoon or sludge pit
Source of data	Design specification of the baseline open lagoon system
Value(s) applied)	6
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission calculation
Additional comments	-

Data/parameter:	$EF_{grid,y}$
Unit	tCO_2/MWh
Description	Grid Emission factor in year *y*
Source of data	Tool to calculate the emission factor for an electricity system
Value(s) applied)	0.716
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission calculation
Additional comments	-

Data/parameter:	$\eta_{EL,captive}$
Unit	%
Description	Efficiency of the fossil fuel fired captive (cogeneration) power plant
Source of data	Calculated based on the technical specifications of the captive cogeneration plant
Value(s) applied)	83%
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission calculation
Additional comments	-

Data/parameter:	$EF_{BL.EL,captive}$
Unit	tCO_2/MWh
Description	Emission factor of electricity generated by the captive power plant that would have been used in the absence of the project activity
Source of data	ACM0014 version 03.1

Value(s) applied)	0.390
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission calculation
Additional comments	-

Data/parameter:	$EF_{CO2,FF,captive}$
Unit	tCO_2/GJ
Description	CO_2 emission factor of the fossil fuel type used in the captive power plant
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2
Value(s) applied)	0.0895
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission calculation
Additional comments	-

Data/parameter:	$FL_{biogas,digest}$
Unit	m^3 biogas leaked / m^3 biogas produced
Description	Fraction of biogas that leaks from the digester
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5
Value(s) applied)	0.05
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission calculation
Additional comments	-

Data/parameter:	GWP_{CH4}
Unit	tCO_2e/tCH_4
Description	Global Warming Potential of Methane
Source of data	IPCC changed GWP from 21 to 25 according to decision 4/CMP7 and para 66, EB 69
Value(s) applied)	25 for second commitment period starting from January 1st, 2013.
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission & Project Emission calculation
Additional comments	Shall be updated according to any future COP/MOP decisions

Data/parameter:	A
Unit	ha
Description	Surface of the lagoon
Source of data	Design specification of the baseline open lagoon system

Value(s) applied)	2.1936
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline Emission calculation
Additional comments	-

D.2. Data and parameters monitored

(Copy this table for each piece of data and parameter)

Data / Parameter:	$F_{PJ,digm}$
Unit:	m^3/month
Description:	Quantity of wastewater that is treated in the anaerobic digester in the project activity in month *m*
Measured/ Calculated / Default:	Measured from FT 608 inlet flow meter and FT 670 inlet from settling pond
Source of data:	Flow meters from the reception tank and from the settling pond
Value(s) of monitored parameter:	120,550 m^3 (see monthly table below)
Monitoring equipment:	1. FP-1/ FT-608 Accuracy : +/- 0.3% Brand / Type: Krohne / Optiflux 4000 Serial Number : A1093149 Calibration Frequency : 3 Yearly Date of Calibration: 19 Sept 2013 Validity: 19 Sept 2016 2. FP-3/ FT-670 Accuracy : +/- 0.3% Brand / Type: Krohne / Optiflux 4000 Serial Number : S1025692 Calibration Frequency : 3 Yearly Date of Calibration: 19 Sept 2013 Validity: 19 Sept 2016
Measuring/ Reading/ Recording frequency:	Continuously, but aggregated monthly for calculations
Calculation method (if applicable):	-
QA/QC procedures:	Flow meters undergo maintenance/calibration in line with the manufacturer's recommendations

Month	$F_{PJ,dig,m}$	
	FP-1	FP-3
Oct-14	33,716	856
Nov-14	26,238	26
Dec-14	51,704	615
Jan-15	1,460	244
Feb-15	1,002	23
Mar-15	4,271	397
Total	118,390	2,160

Purpose of data:	Project Emission calculation
Additional comment:	-

Data / Parameter:	$w_{COD,dig,m}$
Unit:	t COD/m^3
Description:	Average chemical oxygen demand in the wastewater that is treated in the anaerobic digester in the project activity
Measured/ Calculated / Default:	Measured in mg/L and calculated to tCOD/m^3
Source of data:	External laboratory analysis results
Value(s) of monitored parameter:	see table below
Monitoring equipment:	N/A
Measuring/ Reading/ Recording frequency:	Weekly, averaged monthly.
Calculation method (if applicable):	-
QA/QC procedures:	The COD parameter is analysed according to the national or international standard
Purpose of data:	Project Emission Calculation
Additional comment:	-

Month	CD-1	CD-3
Oct-14	0.02754	0.00168
Nov-14	0.04076	0.00193
Dec-14	0.04703	0.00163
Jan-15	0.04979	0.00078
Feb-15	0.09773	0.00049
Mar-15	0	0.00036
Average	0.0526	0.0011

Data / Parameter:	$T_{2,m}$
Unit:	K
Description:	Average temperature at the project site in month *m*
Measured/ Calculated / Default:	Measured
Source of data:	Regional weather statistics of Lampung as provided by Department of Climatology & Geophysics

Value(s) of monitored parameter:	<table><tr><th>Month</th><th>Average temperature (C)</th><th>Average temperature (K)</th></tr><tr><td>Oct-14</td><td>28.2</td><td>301.36</td></tr><tr><td>Nov-14</td><td>27.2</td><td>300.36</td></tr><tr><td>Dec-14</td><td>26.6</td><td>299.76</td></tr><tr><td>Jan-15</td><td>26.2</td><td>299.36</td></tr><tr><td>Feb-15</td><td>26.6</td><td>299.76</td></tr><tr><td>Mar-15</td><td>27.2</td><td>300.36</td></tr></table>
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	Continuously, aggregated in monthly average values
Calculation method (if applicable):	-
QA/QC procedures:	-
Purpose of data:	Project Emission calculation
Additional comment:	Measurement in degrees Celcius converted to degrees Kelvin. Applicable for methane conversion factor method.

Data / Parameter:	$FC_{Coal,y}$
Unit:	Tonne/year
Description:	Quantity of coal utilised for electricity generation in year *y*
Measured/ Calculated / Default:	Measured
Source of data:	Continuous measurement by the check weigher
Value(s) of monitored parameter:	7789.8 tonnes
Monitoring equipment:	Brand / Type: Hassler / SBS Accuracy : +/- 0.5% Serial Number : VHRS 2501 Calibration Frequency : Annually Date of Calibration:, 6 Jun 2014 Validity: 6 Jun 2015
Measuring/ Reading/ Recording frequency:	Continuously
Calculation method (if applicable):	NA
QA/QC procedures:	Load cell undergo maintenance/calibration in line with manufacturer's recommendations. This measured quantity will be cross checked with stock change
Purpose of data:	Project Emission calculation

Additional comment:	Calibration is done by comparing the weight of coal measured by calibrated weighbridge and by the belt scale.

Data / Parameter:	$NCV_{Coal,y}$
Unit:	kj/kg
Description:	Weighted average of net calorific value of coal in year *y*
Measured/ Calculated / Default:	Measured
Source of data:	External laboratory analysis results
Value(s) of monitored parameter:	see table below
Monitoring equipment:	
Measuring/ Reading/ Recording frequency:	Every shipment, analysed monthly
Calculation method (if applicable):	-
QA/QC procedures:	The measurement of NCV parameter is in accordance to national or international standards
Purpose of data:	Project emission calculation
Additional comment:	The NCV values are multiplied by 4.184 to obtain NCV values in kJ/kg. * NCV values of Jan-15 and Feb-15 are taken from the average values of previous 3 months since although there was coal consumption in Jan-15 and Feb-15, there have been no coal shipment to the plant

Value(s) of monitored parameter:

Month	**$NCV_{coal,y}$**
Oct-14	18882
Nov-14	18928
Dec-14	18920
Jan-15	18910*
Feb-15	18920*
Mar-15	0
Average	18911

Data / Parameter:	EG_y
Unit:	MWh/year
Description:	Total electricity generated in year *y* from steam turbine (from coal and biogas)
Measured/ Calculated / Default:	Measured
Source of data:	Measurement by electricity meter

Value(s) of monitored parameter:	3554.91 MWh
Monitoring equipment:	Brand / Type: Actaris / SL7000 Accuracy : +/- 0.5% Serial Number : 37118788 Calibration Frequency : 5 Yearly Date of Calibration: 12 May 2012 Validity: 12 May 2017
Measuring/ Reading/ Recording frequency:	Continuously, aggregated monthly
Calculation method (if applicable):	-
QA/QC procedures:	Electricity meter is calibrated as per the recommendation from the grid code of the National Electricity Company.
Purpose of data:	Project Emission calculation
Additional comment:	The recommended calibration frequency given by the National Electricity Company stated in the grid code is 5 yearly.

Data / Parameter:	$EG_{pj,y}$
Unit:	MWh/ year
Description:	Net quantity of electricity generated in year y with biogas from the new anaerobic digester
Measured/ Calculated / Default:	Calculated using volume of biogas, NCV biogas, volume of coal, NCV coal and total electricity generation measured by the electricity meter
Source of data:	Total energy generated from biogas/ (total energy generated from biogas and coal) * total electricity generation (from coal and biogas)
Value(s) of monitored parameter:	1,142 MWh
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	Continuously, aggregated monthly
Calculation method (if applicable):	The total electricity from coal and biogas is measured by an electricity meter. The quantity of electricity generated from biogas is calculated based on the share of biogas in the fuel mix going to the boiler.
QA/QC procedures:	Electricity meter is calibrated as per the recommendation from the grid code of the National Electricity Company.
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	$HG_{biogas,y}$
Unit:	TJ/year
Description:	Energy content of biogas used in the boiler

Measured/ Calculated / Default:	Calculated
Source of data:	Calculated as from volume of biogas transferred to the boiler * NCV biogas
Value(s) of monitored parameter:	see table below
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	The gas usage is measured daily, calculation is done monthly
Calculation method (if applicable):	The energy content of biogas used in the boiler is calculated on the basis of NCV of biogas and the quantity of biogas utilized in the boiler
QA/QC procedures:	-
Purpose of data:	Project emission calculation
Additional comment:	-

Month	$HGbiogas_{,y}$
Oct-14	16.37
Nov-14	25.62
Dec-14	27.04
Jan-15	0.75
Feb-15	0.01
Mar-15	0.00
Total	**69.79**

Data / Parameter:	$HG_{Coal,y}$
Unit:	TJ/year
Description:	Energy content of coal used in the boiler
Measured/ Calculated / Default:	Calculated
Source of data:	Quantity of coal usage * weighted average NCV coal
Value(s) of monitored parameter:	

Month	$HG_{coal,y}$
Oct-14	46.09
Nov-14	44.42
Dec-14	47.39
Jan-15	1.13
Feb-15	8.28
Mar-15	0.00
Total	**147.31**

Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	The coal usage is measured daily. Calculation is done monthly
Calculation method (if applicable):	The energy content of coal used in the boiler is calculated on the basis of NCV of coal and the quantity of coal utilized in the boiler.
QA/QC procedures:	-
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	$NCV_{Biogas,\ y}$
Unit:	KJ/Kg
Description:	Weighted average of net calorific value of biogas in year *y*
Measured/ Calculated / Default:	Measured
Source of data:	External laboratory analysis result
Value(s) of monitored parameter:	see table below
Monitoring equipment:	
Measuring/ Reading/ Recording frequency:	3 monthly, weighted average value is calculated.
Calculation method (if applicable):	-
QA/QC procedures:	The calorific value of biogas is fairly constant and is determined through sample testing by an external laboratory. The measurement follows national or international standards.
Purpose of data:	Project emission calculation.
Additional comment:	-

Month	**$NCV_{biogas,y(kj/kg)}$**
Oct-14	27,999.44
Nov-14	27,999.44
Dec-14	27,999.44
Jan-15	28,885.32
Feb-15	28,885.32
Mar-15	28,885.32
Average	28,008.73

Data / Parameter:	$F_{PJ,effl,dig,m}$
Unit:	m^3/month
Description:	Quantity of effluent from the digester in month *m*

Measured/ Calculated / Default:	Measured from FT 660
Source of data:	Continuously monitored online with flowmeter
Value(s) of monitored parameter:	<table><tr><th>Month</th><th>FP-2</th></tr><tr><td>Oct-14</td><td>20,399</td></tr><tr><td>Nov-14</td><td>18,842</td></tr><tr><td>Dec-14</td><td>38,341</td></tr><tr><td>Jan-15</td><td>6,426</td></tr><tr><td>Feb-15</td><td>739</td></tr><tr><td>Mar-15</td><td>654</td></tr><tr><td>Total</td><td>85,402</td></tr></table>
Monitoring equipment:	FP-2/ FT-660 Accuracy : +/- 0.3% Brand / Type: Krohne / Optiflux 4000 Serial Number : A1062795 Calibration Frequency : 3 Yearly Date of Calibration:19 Sept 2013 Validity: 19 Sept 2016
Measuring/ Reading/ Recording frequency:	Continuously, but aggregated monthly for calculations
Calculation method (if applicable):	-
QA/QC procedures:	Flow meter undergoes maintenance/ calibration in line with the manufacturer's recommendation.
Purpose of data:	Project emission calculation
Additional comment:	Annual values are derived from monthly measures (m)

Data / Parameter:	$F_{PJ,effl,lag,m}$
Unit:	m^3
Description:	Quantity of effluent from open lagoon or dewatering facility in which the effluent from digester is treated
Measured/ Calculated / Default:	Measured
Source of data:	Continuously monitored online with flow meter

Value(s) of monitored parameter:	<table><tr><th>Month</th><th>FP-4</th></tr><tr><td>Oct-14</td><td>77</td></tr><tr><td>Nov-14</td><td>7,562</td></tr><tr><td>Dec-14</td><td>15,049</td></tr><tr><td>Jan-15</td><td>1,095</td></tr><tr><td>Feb-15</td><td>0</td></tr><tr><td>Mar-15</td><td>0</td></tr><tr><td>Total</td><td>23,783</td></tr></table>
Monitoring equipment:	FP-4/ FT-Discharge Accuracy : +/- 0.3% Brand / Type: Krohne / Optiflux 4000 Serial Number : S1025695Calibration Frequency : 3 Yearly Date of Calibration: 13 Dec 2010, 19 Sept 2013 Validity: 13 Dec 2013, 19 Sept 2016
Measuring/ Reading/ Recording frequency:	Continuously, Continuously, but aggregated monthly for calculations
Calculation method (if applicable):	-
QA/QC procedures:	Flow meter undergoes maintenance/ calibration in line with the manufacturer's recommendation
Purpose of data:	Project Emission calculation
Additional comment:	Annual values are derived from monthly measures (m)

Data / Parameter:	$w_{COD,effl,dig,m}$
Unit:	T COD / m^3
Description:	Average chemical oxygen demand in the effluent from the digester
Measured/ Calculated / Default:	Measured in mg/L and calculated to t COD /m^3
Source of data:	External laboratory analysis result
Value(s) of monitored parameter:	<table><tr><th>Month</th><th>CD-2</th></tr><tr><td>Oct-14</td><td>0.00491</td></tr><tr><td>Nov-14</td><td>0.00194</td></tr><tr><td>Dec-14</td><td>0.00145</td></tr><tr><td>Jan-15</td><td>0.00091</td></tr><tr><td>Feb-15</td><td>0.00066</td></tr><tr><td>Mar-15</td><td>0.00047</td></tr><tr><td>Average</td><td>0.00172</td></tr></table>

Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	Weekly, calculate average monthly and annual values
Calculation method (if applicable):	-
QA/QC procedures:	Measure COD parameter according to the national or international standard.
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	$w_{COD,effl,lag,m}$
Unit:	T COD / m^3
Description:	Average chemical oxygen demand in the effluent from the lagoon
Measured/ Calculated / Default:	Measured in mg/L and calculated to t COD /m^3
Source of data:	External laboratory analysis result
Value(s) of monitored parameter:	see table below
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	Weekly, calculate average monthly and annual values
Calculation method (if applicable):	-
QA/QC procedures:	Measure COD parameter according to the national or international standard.
Purpose of data:	Project emission calculation
Additional comment:	-

Month	CD-4
Oct-14	0.00074
Nov-14	0.00028
Dec-14	0.00027
Jan-15	0.00017
Feb-15	0.00011
Mar-15	0
Average	0.00031

Data / Parameter:	$F_{biogas,y}$
Unit:	Nm^3
Description:	Amount of biogas collected in the outlet of the new digester in year *y*
Measured/ Calculated / Default:	Measured and calculated
Source of data:	Continuously monitored with online flow meter

Value(s) of monitored parameter:	3,573,640 Nm^3 (see table below)

	$F_{biogas,y}$		
Month	FB-1 (Boiler)	FB-2 (EF)	FB-3 (OF)
Oct-14	815,519	223	370
Nov-14	1,276,555	87	32,247
Dec-14	1,347,404	95	8,773
Jan-15	36,201	48,068	690
Feb-15	261	4,728	2,083
Mar-15	0	241	96
Total	3,475,939	53,442	44,259

Monitoring equipment:	FB-1 Accuracy : +/- 1% Brand / Type: Endress & Hauser/ Proline T-mass Serial Number : DA081B02000 Calibration Frequency : 3 Yearly Date of Calibration: 22 May 2013 Validity: 22 May 2016 FB-2 Accuracy : +/- 1% Brand / Type: Endress & Hauser/ Proline T-mass Serial Number : DA081C02000 Calibration Frequency : 3 Yearly Date of Calibration: 22 May 2013 Validity: 22 May 2016 FB-3 Accuracy : +/- 1% Brand / Type: Endress & Hauser/ Proline T-mass Serial Number : DA081D02000 Calibration Frequency : 3 Yearly Date of Calibration: 22 May 2013 Validity: 22 May 2016
Measuring/ Reading/ Recording frequency:	Continuously, FB-1 recorded hourly, FB-2 and FB-3 recorded minutely
Calculation method (if applicable):	-
QA/QC procedures:	Flow meter undergoes maintenance/ calibration in line with the manufacturer's recommendation
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	$w_{CH4,biogas,y}$
Unit:	Kg CH_4 / m^3
Description:	Concentration of methane in the biogas in the outlet of the digester
Measured/ Calculated / Default:	Measured
Source of data:	Continuous measurement with on-line gas analyzer

Value(s) of monitored parameter:	<table><tr><th>Month</th><th>W CH4 KgCH4/m3</th></tr><tr><td>Oct-14</td><td>0.4034</td></tr><tr><td>Nov-14</td><td>0.4301*</td></tr><tr><td>Dec-14</td><td>0.4301*</td></tr><tr><td>Jan-15</td><td>0.4301*</td></tr><tr><td>Feb-15</td><td>0.4301*</td></tr><tr><td>Mar-15</td><td>0.4301*</td></tr></table>
Monitoring equipment:	Brand / Type: Siemens Analytics/ Ultramat 23 Accuracy : +/- 2% Serial Number : N1-A9-369 Calibration Frequency : Monthly Date of Calibration: Available to DOE on separate files Validity: Available to DOE on separate files
Measuring/ Reading/ Recording frequency:	Continuously
Calculation method (if applicable):	-
QA/QC procedures:	The gas analyzer is calibrated monthly using standard gas
Purpose of data:	Project emission calculation
Additional comment:	* Methane (CH4) concentration data is not available from 26 Oct 2014 to 31 Mar 2015 cause by Gas Condenser Unit which cools down the biogas before going to the Gas Analyzer is broken. To be conservative 60% methane (as spec) applied on the period where the missing methane data occurred.

Data / Parameter:	$FV_{RG,h}$
Unit:	m^3
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour,*h*
Measured/ Calculated / Default:	Measured continuously and recorded every minute
Source of data:	Flow rate of residual gas in monitored continuously via on-line flowmeter
Value(s) of monitored parameter:	Open Flare : 50,589 m3 Enclosed Flare: 30,470 m3 The minutely data can be seen in the monthly CDM spreadsheets

Monitoring equipment:	FB-2 (Enclosed Flare) Accuracy : +/- 1% Brand / Type: Endress & Hauser/ Proline T-mass Serial Number : DA081C02000 Calibration Frequency : 3 Yearly Date of Calibration: 22 May 2013 Validity: 22 May 2016 FB-3 (Open Flare) Accuracy : +/- 1% Brand / Type: Endress & Hauser/ Proline T-mass Serial Number : DA081D02000 Calibration Frequency : 3 Yearly Date of Calibration: 22 May 2013 Validity: 22 May 2016
Measuring/ Reading/ Recording frequency:	Continuously, recorded minutely
Calculation method (if applicable):	--
QA/QC procedures:	The same basis should be applied dry for this measurement and the measurement of volumetric fraction of all components in the residual gas (fvi,h) when the residual gas exceeds 60°C
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	T_{flare}
Unit:	°C
Description:	Temperature of exhaust gas in the flare
Measured/ Calculated / Default:	Measured
Source of data:	Continuous reading from the flare thermocouple
Value(s) of monitored parameter:	Refer to CDM spreadsheet
Monitoring equipment:	Brand / Type: TC type N Accuracy : +/- 2% Serial Number : 21959M/3A, 42493M/1A Calibration Frequency : Annually 42493M/1A Date of Calibration: 27 Aug 2014 Validity: 27 Aug 2015
Measuring/ Reading/ Recording frequency:	Continuously
Calculation method (if applicable):	-
QA/QC procedures:	Thermocouple should be replaced or calibrated annually
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	*Flame Detector*
Unit:	On/Off
Description:	Flame detection unit
Measured/ Calculated / Default:	Measured on-line
Source of data:	The flame detector is connected to the PLC unit to monitor the flame.
Value(s) of monitored parameter:	-
Monitoring equipment:	
Measuring/ Reading/ Recording frequency:	Measured continuously, recorded every minute
Calculation method (if applicable):	-
QA/QC procedures:	The detector will be replaced according to the manufacturer specifications.
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	$COD_{sludge,LA,y}$
Unit:	tCOD/yr
Description:	Chemical Oxygen Demand (COD) of the sludge applied to the land after the dewatering process in year y
Measured/ Calculated / Default:	Measured
Source of data:	A representative sample of sludge will be analysed for COD according to appropriate national or international standards by external laboratory
Value(s) of monitored parameter:	0
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	The COD of sludge will be measured whenever the sludge is removed from CIGAR and applied to land after dewatering
Calculation method (if applicable):	-
QA/QC procedures:	The COD parameter is measured according to the national or international standards
Purpose of data:	Project Emission calculation
Additional comment:	During this monitoring period, no sludge removal is done.

Data / Parameter:	$S_{LA,y}$
Unit:	Tonne/year
Description:	Amount of sludge applied to land in year y
Measured/ Calculated / Default:	Measured by a flow meter
Source of data:	The sludge removal is recorded in the logbook

Value(s) of monitored parameter:	0
Monitoring equipment:	FT- 656 Accuracy : +/- 0.3% Brand / Type: Krohne / Optiflux 4000 Serial Number : S1025697 Calibration Frequency : 3 Yearly Date of Calibration: 14 Dec 2010, Validity: 14 Dec 2013,
Measuring/ Reading/ Recording frequency:	The quantity of sludge will be measured by flowing it through a flow meter whenever the sludge is removed from CIGAR and applied to land after dewatering
Calculation method (if applicable):	-
QA/QC procedures:	-
Purpose of data:	Project Emission calculation
Additional comment:	During this monitoring period, no sludge removal is done

Data / Parameter:	$w_{N,sludge,y}$
Unit:	T N/ t sludge
Description:	Mass fraction of nitrogen in the sludge applied to land in year y
Measured/ Calculated / Default:	Measured
Source of data:	A representative sample of sludge will be analysed for the nitrogen fraction according to the appropriate national or international standards.
Value(s) of monitored parameter:	0
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	This parameter will be measured whenever the sludge is removed from the CIGAR and applied to land after dewatering
Calculation method (if applicable):	-
QA/QC procedures:	The parameter is measured according to the national or international standards.
Purpose of data:	Project Emission calculation
Additional comment:	During this monitoring period, no sludge removal is done

D.3. Implementation of sampling plan

>>
Not applicable

SECTION E. Calculation of emission reductions or GHG removals by sinks

E.1. Calculation of baseline emissions or baseline net GHG removals by sinks

>>
According to ACM0014 (version 03.1), baseline emissions and project emissions are determined as follows:

(1) Baseline Emissions

$$BE_Y = BE_{CH_4,y} + BE_{EL,y} + BE_{HG,y}$$

Where:

BE_Y	=	Baseline emissions in year *y* (tCO2e / yr)
$BE_{CH_4,y}$	=	Methane emissions from anaerobic treatment of the wastewater in open lagoons (scenario 1) or the anaerobic treatment of sludge in sludge pits (scenario 2) in the absence of the project activity in year *y* (tCO2e / yr)
$BE_{EL,y}$	=	CO2 emissions associated with electricity generation that is displaced by the project activity and / or electricity consumption in the absence of the project activity in year *y* (tCO2 / yr)
$BE_{HG,y}$	=	CO2 emissions associated with fossil fuel combustion for heating equipment that is displaced by the project in year *y* (tCO2 / yr)

Scenario 1 is chosen for this project activity.

Methane emission from anaerobic treatment of the wastewater in open lagoon

$$BE_{CH_4,y} = GWP_{CH_4} \times MCF_{BL,y} \times B_o \times COD_{BL,y}$$

Where:

$BE_{CH_4,y}$	=	Methane emissions from anaerobic treatment of the wastewater in open lagoons in the absence of the project activity in year *y* (tCO2e / yr)
GWP_{CH_4}	=	Global Warming Potential of methane valid for the commitment period (tCO2e/tCH4)
$MCF_{BL,y}$	=	Average baseline methane conversion factor (fraction) in year *y*, representing the fraction of $B_o \times COD_{PJ,y}$ that would be degraded to CH_4 in the absence of project activity
B_o	=	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand (tCH4/tCOD)
$COD_{BL,y}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in year *y* (tCOD/yr)

Determination of $COD_{BL,y}$

As per ACM0014 if there is effluent from the lagoons in the baseline, the baseline chemical oxygen demand ($COD_{BL,y}$) should be adjusted by an effluent adjustment factor which relates the COD supplied to the lagoon with the COD in the effluent, as follows:

$$COD_{BL,y} = AD_{BL} \times COD_{PJ,y}$$

Where:

$COD_{BL,y}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in year *y* (tCOD/yr)
AD_{BL}	=	Effluent adjustment factor expression the percentage of COD that is degraded in open lagoons in the absence of the project activity
$COD_{PJ,y}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in year *y* (tCOD/yr)

As the project is implemented at a Greenfield facility, AD_{BL} is determined as follows:

$$AD_{BL} = 1 - \frac{COD_{out,x}}{COD_{in,x}}$$

Where:

AD_{BL}	=	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in year *y* (tCOD/yr)
$COD_{out,x}$	=	Design COD outflow from the baseline anaerobic lagoon in the period x (t COD)
$COD_{in,x}$	=	Design COD inflow to the baseline anaerobic lagoon in the period x (t COD)

x = Representative historical reference period (at least one year)

$COD_{PJ,y}$ is determined as follows:

$$COD_{PJ,y} = \sum_{m=1}^{12} F_{PJ,dig,m} \times w_{COD,dig,m}$$

Where:

$COD_{PJ,y}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in year *y* (tCOD/yr)
$F_{PJ,dig,m}$	=	Quantity of wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (m³ / month)
$w_{COD,dig,m}$	=	Average chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (t COD / m³)
m	=	Months of year *y* of the crediting period

Determination of $MCF_{BL,y}$

$MCF_{BL,y}$ is calculated as follows:

$$MCF_{BL,y} = f_d \times f_{T,y} \times 0.89$$

$MCF_{BL,y}$	=	Average baseline methane conversion factor (fraction) in year *y*, representing the fraction of ($COD_{PJ,y}$ x Bo) that would be degraded to CH4 in the absence of the project activity
f_d	=	Factor expressing the influence of the depth of the lagoon or sludge pit on methane Generation .In the case of the project activity as the baseline scenario anaerobic lagoon has a depth greater than 5m the value applied is 70%.
$f_{T,y}$	=	Factor expressing the influence of the temperature on the methane generation in year *y*
0.89	=	Conservativeness factor as per ACM0014 version 03.1

Determination of $f_{T,y}$

The amount of organic matter available for degradation to methane ($COD_{available,m}$) is assumed to be equal to the amount of organic matter directed to the open lagoon , less any effluent, plus the COD that may have remained in the lagoon from previous months, as follows:

$$COD_{available,m} = COD_{BL,m} + (1 - f_{T,m}) \times COD_{available,m-1}$$ with

$$COD_{BL,m} = AD_{BL} \times COD_{PJ,m}$$ and

$$COD_{PJ,m} = F_{PJ,dig,m} \times w_{COD,dig,m}$$

$COD_{available,m}$	=	Quantity of chemical oxygen demand available for degradation in the open lagoon or sludge pit in month *m* (t COD / month)
$COD_{BL,m}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in month *m* (t COD/month)
$f_{T,m}$	=	Factor expressing the influence of the temperature on the methane generation in month *m*
AD_{BL}	=	Effluent adjustment factor expressing the percentage of COD that is degraded in open lagoons in the absence of the project activity
$COD_{PJ,m}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (t COD / month)
$F_{PJ,dig,m}$	=	Quantity of wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (m³ / month)

$w_{COD,dig,m}$	=	Average chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (t COD / m³)
m	=	Months of year *y* of the crediting period

The monthly factor to account for the influence of the temperature on methane generation is calculated based on the following "van't Hoff – Arrhenius" approach:

$$f_{T,m} = \begin{cases} 0 & if\ T_{2,m} < 283K \\ \exp\left(\frac{E \times (T_{2,m} - T_1)}{R \times T_1 \times T_{2,m}}\right) & if\ 283K < T_{2,m} < 303K \\ 1 & if\ T_{2,m} > 303K \end{cases}$$

Where:

$f_{T,m}$	=	Factor expressing the influence of the temperature on the methane generation in month *m*
E	=	Activation energy constant (15,175 cal / mol) as per ACM0014 version 03.1
$T_{2,m}$	=	Average temperature at the project site in month *m* (K)
T_1	=	303.16 K (273.16 K + 30 K)
R	=	Ideal gas constant (1.987 cal / K mol) as per ACM0014 version 03.1
m	=	Months of year *y* of the crediting period

Based on the monthly values $f_{T,m}$ the annual value $f_{T,y}$ is calculated as follows:

$$f_{T,y} = \frac{\sum_{m=1}^{12} f_{T,m} \times COD_{available,m}}{\sum_{m=1}^{12} COD_{BL,m}}$$

$f_{T,y}$	=	Factor expressing the influence of the temperature on the methane generation in year *y*
$f_{T,m}$	=	Factor expressing the influence of the temperature on the methane generation in month *m*
$COD_{available,m}$	=	Quantity of chemical oxygen demand available for degradation in the open lagoon or sludge pit in month *m* (t COD/month)
$COD_{BL,m}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in month *m* (t COD/month)
m	=	Months of year *y* of the crediting period

AD_{BL}		
	$COD_{out,x}(t)$	$COD_{in,x}(t)$
	Design COD outflow from the baseline anaerobic lagoon in the period x	Design COD inflow to the baseline anaerobic lagoon in the period x (t COD)
x=year	688.5	30,600
Equation:	**AD_{BL} = 1 - ($COD_{out,x}$ / $COD_{in,x}$)**	
AD_{BL}		**0.9775**

Calculations:

$$COD_{PJ,m} = F_{PJ,dig,m} \times w_{COD,dig,m}$$

$$COD_{BL,m} = AD_{BL} \times COD_{PJ,m}$$

$$COD_{available,m} = COD_{BL,m} + (1 - f_{T,m}) \times COD_{available,m-1}$$

$$f_{T,m} = \begin{cases} 0 & if\ T_{2,m} < 283K \\ \exp\left(\dfrac{E \times (T_{2,m} - T_1)}{R \times T_1 \times T_{2,m}}\right) & if\ 283K < T_{2,m} < 303K \\ 1 & if\ T_{2,m} > 303K \end{cases}$$

Table A-1 Calculation of factor expressing the influence of the temperature ($T_{2,m}$) on the methane generation.

Month	Quantity of chemical oxygen demand that is treated in the anaerobic digester in the project activity (t COD / m)	Effluent adjustment factor expression the percentage of COD that is degraded in open lagoons in the absence of the project activity	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in month m (t COD / month)	Quantity of chemical oxygen demand available for degradation in the open lagoon in month m (t COD / month)	Factor expressing the influence of the temperature on the methane generation	Average temperature (C)	Average temperature (K)	Quantity of chemical oxygen demand available for degradation in the open lagoon in month m-1 (t COD / month)	$f_{T,m}$ * $COD_{available,m}$
m	**$COD_{PJ,m}$**	**AD_{BL}**	**$COD_{BL,m}$**	**$COD_{available,m}$**	**$f_{T,m}$**	**$T_{2,m}$**	**$T_{2,m}$**	**$COD_{available,m-1}$**	
Oct-14	930	0.9775	909	1,131	0.86	28.2	301.36	1,587	973
Nov-14	1,070	0.9775	1,045	1,282	0.79	27.2	300.36	1,131	1,014
Dec-14	2,433	0.9775	2,378	2,697	0.75	26.6	299.76	1,282	2,026
Jan-15	73	0.9775	71	809	0.73	26.2	299.36	2,697	588
Feb-15	98	0.9775	96	297	0.75	26.6	299.76	809	223
Mar-15	0	0.9775	0	62	0.79	27.2	300.36	297	49
$COD_{PJ,y}$	**4,603**								

$\Sigma f_{T,m}$ x $COD_{available,m}$	**4,873**
$\Sigma COD_{BL,m}$	**4,499**
$f_{T,y}$	**1.0830**

$$COD_{PJ,y} = \sum_{m=1}^{12} F_{PJ,dig,m} \times w_{COD,dig,m}$$

$$f_{T,y} = \frac{\sum_{m=1}^{12} f_{T,m} \times COD_{available,m}}{\sum_{m=1}^{12} COD_{BL,m}}$$

Methane emissions from anaerobic treatment of the wastewater in open lagoons in open lagoons (BE_{CH4})				
Parameter	**Description**	**Value**	**Unit**	**Source**
AD_{BL}	Effluent adjustment factor expression the percentage of COD that is degraded in open lagoons in the absence of the project activity	0.9775	-	Calculation, refer to fT,y worksheet
$COD_{PJ,y}$	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in year y	4,603	tCOD	
$COD_{BL,y} = AD_{BL} \times COD_{PJ,y}$	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in year y	4,499	tCOD	Calculation
-	Conservativeness factor	0.89	-	ACM0014 version 03.1
f_d	Factor expressing the influence of the depth of the lagoon on methane generation	70%	-	ACM0014 version 03.1; Depth > 5m
$f_{T,y}$	Factor expressing the influence of the temperature	1.083	-	Calculation, refer to fT,y worksheet
$MCF_{BL,y} = f_d \times f_{T,y} \times 0.89$	Average baseline methane conversion factor (fraction) in year y, representing the fraction of (CODPJ,y x Bo) that would be degraded to CH4 in the absence of the project activity	0.6747	fraction	Calculation
GWP_{CH4}	Global Warming Potential of methane	25	tCO_2e/tCH_4	IPCC 2006
B_O	Maximum methane producing capacity	0.25	$tCH_4/tCOD$	IPCC 2006
Equation:	$BE_{CH4,y} = GWP_{CH4} \times MCF_{BL,y} \times B_0 \times COD_{BL,y}$	**18,974**	tCO_2e	Calculation

Baseline emissions from generation and/or consumption of electricity

$$BE_{EL,y} = \left(EC_{BL,y} + EG_{PJ,y}\right) \times EF_{BL,EL,y}$$

Where:

$BE_{EL,y}$	=	CO2 emissions associated with electricity generation that is displaced by the project activity and / or electricity consumption in the absence of the project activity in year *y* (tCO2 / yr)
EC_{BL}	=	Annual quantity of electricity that would be consumed in the absence of the project activity for the treatment of the wastewater (MWh / yr)
$EG_{PJ,y}$	=	Net quantity of electricity generated in year *y* with biogas from the new anaerobic biodigester (MWh / yr)
$EF_{BL,EL,y}$	=	Baseline emission factor for electricity generated and / or consumed in the absence of the project activity in year *y* (tCO2 / MWh)

The determination of $EF_{BL,EL,y}$ depends on the baseline scenario and the configuration at the project site. The scenario for electricity generation applicable to the Project is E1 hence as per ACM0014 version 03.1 the lower emission factor between the grid emission factor and the emission factor of the captive power plant should be used as a conservative simplification, as follows:

$$EF_{BL,EL,y} = MIN\left(EF_{grid,y} ; EF_{BL,EL,captive}\right)$$

$EF_{BL,EL,y}$	=	Baseline emission factor for electricity generated and / or consumed in the absence of the project activity in year *y* (tCO2 / MWh)
$EF_{grid,y}$	=	Grid emission factor in year *y* (tCO2 / MWh)
$EF_{BL,EL,captive}$	=	Emission Factor of captive power plant (tCO2 / MWh)

The emission factor of the captive power plant $\left(EF_{BL,EL,captive}\right)$ will be determined using one of the following options:

- In case diesel generators are used during emergency purpose: the default emission factor for a diesel generator with a capacity of more than 200 kW for small-scale project activities (0.8 tCO_2/MWh, see AMS I-D.1 in the simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories);
- Calculate $EF_{BL,EL,captive}$ as follows:

$$EF_{BL,EL,captive} = \frac{EF_{CO2,FF,captive}}{{}_{EL,captive}} \times 3.6$$

where:

$EF_{BL,EL,captive}$ = Emission factor of electricity generated by the captive power plant that would have been used in the absence of the project activity (tCO_2/MWh)
$EF_{CO2,FF,captive}$ = CO_2 emission factor of the fossil fuel type used in the captive power plant (tCO_2 /GJ)
$\eta_{EL,captive}$ = Efficiency of electricity generation of the fossil fuel fired captive power plant
3.6 = Unit conversion factor from GJ to MWh

For ex-ante emission the captive cogeneration power plant efficiency of 83% has been used. This is based on the technical specification of the boiler and the steam turbine that will be used in the project activity. The captive power plant efficiency will be calculated using the technical specification of the equipment installed data during the first verification.

Grid emission factor ($EF_{grid,y}$) is calculated as the combined margin (CM) using the method and procedure provided in the "Tool to calculate the emission factor for an electricity system[1] ".

As suggested in the tool the weighting of build margin and operating margin in combined margin is assumed as 50%

Item	Unit	EF
$EF_{OM,average,y}$	tCO_{2e}/MWh	0.873
$EF_{BM,y}$	tCO_{2e}/MWh	0.559
EF_y	tCO_{2e}/MWh	0.716

The combined margin emission factor of the Sumatera grid is 0.716 tCO2/MWh

Using the technical specifications of installed boiler and turbine, the co-gen power efficiency is found to be 83% and the Emission Factor for captive power plant is 0.390 tCO_2/MWh. Since it is lower than the grid emission factor, the EF captive power is used for the calculation of baseline emission from generation and/or consumption of electricity.

[1] The spreadsheet for calculating the grid emission factor has been submitted to the DOE.

CO2 emissions associated with electricity generation that is displaced by the project activity and / or electricity consumption ($BE_{EL,y}$)				
$EC_{BL,y}$	Annual quantity of electricity that would be consumed in the absence of the project activity for the treatment of the wastewater	0	MWh	It is assumed zero to be conservative.
$EG_{PJ,y}$	Net quantity of electricity generated with biogas from the new anaerobic biodigester	225	MWh	Calculation, refer to Biogas worksheet
$EF_{BL,EL,y}$	Baseline emission factor for electricity generated and / or consumed	0.716	tCO_2e/MWh	
Equation:	$BE_{EL,y} = (EC_{BL,y} + EG_{PJ,y}) \times EF_{BL,EL,y}$	160	tCO_2e	Calculation

$$BE_Y = BE_{CH_4,y} + BE_{EL,y} + BE_{HG,y}$$

Baseline Emission is 19,134 tCO_2e

E.2. Calculation of project emissions or actual net GHG removals by sinks

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$$PE_y = PE_{CH_4,effluent,y} + PE_{CH_4,digest,y} + PE_{flare,y} + PE_{sludge,LA,y} + PE_{EC,y} + PE_{FC,y}$$

PE_y	=	Project emissions in year *y* (tCO2e / yr)
$PE_{CH_4,effluent,y}$	=	Project emissions from treatment of wastewater effluent from the anaerobic digester in year *y* (tCO2e / yr)
$PE_{CH_4,digest,y}$	=	Project emissions from physical leakage of methane from the anaerobic digester in year *y* (tCO2e / yr)
$PE_{flare,y}$	=	Project emissions from flaring of biogas generated in the anaerobic digester in year *y* (tCO2e / yr)
$PE_{sludge,LA,y}$	=	Project emissions from land application of sludge in year *y* (tCO2e / yr)
$PE_{EC,y}$	=	Project emissions from electricity consumption in year *y* (tCO2e / yr)
$PE_{FC,y}$	=	Project emissions from fossil fuel consumption in year *y* (tCO2e / yr)

$PE_{FC,y}$ is excluded as the project activity does not consume fossil fuel. As the baseline emission due to electricity generation/consumption is based on net quantity of electricity generated in year *y* with biogas from the new anaerobic digester i.e. after excluding the electricity consumed by project activity $PE_{EC,y}$ is assumed to be zero.

(i) Project methane emissions from effluent from the digester

The methane emissions from treatment of the effluent from the digester are estimated as follows:

$$PE_{CH_4,effluent,y} = GWP_{CH_4} \times MCF_{PJ,y} \times B_o \times \left(COD_{PJ,effl,dig,y} - COD_{PJ,effl,lag,y}\right)$$ with

$$COD_{PJ,effl,dig,y} = \sum_{m=1}^{12} F_{PJ,effl,dig,m} \times w_{COD,effl,dig,m}$$ and

$$COD_{PJ,effl,lag,y} = \sum_{m=1}^{12} F_{PJ,effl,lag,m} \times w_{COD,effl,lag,m}$$

Where:

$PE_{CH_4,effluent,y}$	=	Project emissions from treatment of wastewater effluent from the anaerobic digester in year *y* (tCO2e / yr)
GWP_{CH_4}	=	Global Warming Potential of methane valid for the commitment period (tCO2e / tCH4)
$MCF_{PJ,y}$	=	Project methane conversion factor (fraction) in year *y*, representing the fraction of ($COD_{PJ,effluent,y} \times B_o$) that degrades to CH4
B_o	=	Maximum methane producing capacity, expressing the maximum amount of CH4 that can be produced from a given quantity of chemical oxygen demand (tCH4 / tCOD)
$COD_{PJ,effl,dig,y}$	=	Quantity of chemical oxygen demand in the effluent from the digester in year *y* (tCOD / yr)
$COD_{PJ,effl,lag,y}$	=	Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering facility in which the effluent from the digester is treated in year *y* (tCOD / yr)
$F_{PJ,effl,dig.m}$	=	Quantity of effluent from the digester in month *m* (m³ / month)
$w_{COD,effl,dig,m}$	=	Average chemical oxygen demand in the effluent from the digester in month *m* (t COD / m³)
$F_{PJ,effl,lag,m}$	=	Quantity of effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month *m* (m³ / month)
$w_{COD,effl,lag,m}$	=	Average chemical oxygen demand in the effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month *m* (t COD / m³)

Determination of $MCF_{PJ,y}$

The quantity of methane generated from COD disposed to the open lagoon or in dewatering facility is calculated as follows:

$$MCF_{PJ,y} = f_d \times f_{PJ,T,y}$$

Where:

$MCF_{PJ,y}$	=	Project methane conversion factor (fraction) in year *y*, representing the fraction of ($COD_{PJ,effluent,y} \times B_o$) that degrades to CH4
f_d	=	Factor expressing the influence of the depth of the lagoon or dewatering facility on methane generation. In the case of the project activity as the baseline scenario anaerobic lagoon has a depth greater than 5m the value applied is 70%.
$f_{PJ,T,y}$	=	Factor expression the influence of the temperature on the methane generation under the project activity in year *y*

Determination of $f_{PJ,T,y}$

The factor $f_{PJ,T,y}$ is calculated, as under baseline emissions, with the help of a monthly stock change model which aims at assessing how much COD degrades in each month, as follows:

$$COD_{PJ,available,m} = \left(COD_{PJ,effl,dig,m} - COD_{PJ,effl,lag,m}\right) + \left(1 - f_{T,m}\right) \times COD_{PJ,available,m-1}$$ with

$$COD_{PJ,effl,dig,m} = F_{PJ,effl,dig,m} \times w_{COD,effl,dig,m}$$ and

$$COD_{PJ,effl,lag,m} = F_{PJ,effl,lag,m} \times w_{COD,effl,lag,m}$$

Where:

$COD_{PJ,available,m}$	=	Quantity of chemical oxygen demand available for degradation in the open lagoon or dewatering facility under the project activity in month *m* (t COD / month)
$COD_{PJ,effl,dig,m}$	=	Quantity of chemical oxygen demand in the effluent from the digester in month *m* (tCOD / month)
$COD_{PJ,effl,lag,m}$	=	Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering facility in which the effluent from the digester is treated in month *m* (tCOD / month)
$F_{PJ,effl,dig,m}$	=	Quantity of effluent from the digester in month *m* (m³ / month)
$w_{COD,effl,dig,m}$	=	Average chemical oxygen demand in the effluent from the digester in month *m* (t COD / m³)
$F_{PJ,effl,lag,m}$	=	Quantity of effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month *m* (m³ / month)
$w_{COD,effl,lag,m}$	=	Average chemical oxygen demand in the effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month *m* (t COD / m³)
$f_{T,m}$	=	Factor expressing the influence of the temperature on the methane generation in month *m*
M	=	Months of year *y* of the crediting period

Based on the monthly values $f_{T,m}$ the annual value $f_{T,PJ,y}$ is calculated as follows:

$$f_{PJ,T,y} = \left(\frac{\sum_{m=1}^{12} f_{T,m} \times COD_{PJ,available,m}}{\sum_{m=1}^{12} \left(COD_{PJ,effl,dig,m} - COD_{PJ,effl,lag,m}\right)} \right)$$

Where:

$f_{PJ,T,y}$	=	Factor expressing the influence of the temperature on the methane generation under the project activity in year *y*
$f_{T,m}$	=	Factor expressing the influence of the temperature on the methane generation in month *m*
$COD_{PJ,available,m}$	=	Quantity of chemical oxygen demand available for degradation in the open lagoon or dewatering facility under the project activity in month *m* (t COD / month)
$COD_{PJ,effl,dig,m}$	=	Quantity of chemical oxygen demand in the effluent from the digester in month *m* (tCOD / month)
$COD_{PJ,effl,lag,m}$	=	Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering facility in which the effluent from the digester is treated in month *m* (tCOD / month)
M	=	Months of year *y* of the crediting period

Month	Quantity of wastewater or sludge that is treated in the anaerobic digester (m3/month)		Quantity of effluent from the digester (m3/month)	Quantity of effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated (m3/month)	Average chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions (tCOD/m3)		Average chemical oxygen demand in the effluent from the digester (tCOD/m3)	Average chemical oxygen demand in the effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated (tCOD/m3)
	$F_{PJ,dig,m}$		$F_{PJ,effl,dig,m}$	$F_{PJ,effl,lag,m}$	$\omega_{COD,dig,m}$		$\omega_{COD,effl,dig,m}$	$\omega_{COD,effl,lag,m}$
	FP-1	FP-3	FP-2	FP-4	CD-1	CD-3	CD-2	CD-4
Oct-14	33,716	856	20,399	77	0.02754	0.00168	0.00491	0.00074
Nov-14	26,238	26	18,842	7,562	0.04076	0.00193	0.00194	0.00028
Dec-14	51,704	615	38,341	15,049	0.04703	0.00163	0.00145	0.00027
Jan-15	1,460	244	6,426	1,095	0.04979	0.00078	0.00091	0.00017
Feb-15	1,002	23	739	0	0.09773	0.00049	0.00066	0.00011
Mar-15	4,271	397	654	0	0	0.00036	0.00047	0
Total/Average	118,390	2,160	85,402	23,783	0.0526	0.0011	0.00172	0.00031

Table A-2 Calculation of factor expressing the influence of the temperature ($T_{2,m}$) on the methane generation in year y ($f_{PJ,T,y}$; project scenario)

$COD_{PJ,effl,dig,y}$		$COD_{PJ,effl,lag,y}$							
Month	Quantity of chemical oxygen demand in the effluent from the digester in year y (tCOD/m)	Quantity of chemical oxygen demand in the effluent of the open lagoon in which the effluent from the digester is treated in year y (tCOD/m)	$COD_{PJ,effl,dig,m}$ - $COD_{PJ,effl,lag,m}$ (tCOD/month)	Quantity of chemical oxygen demand available for degradation in the open lagoon under the project activity in month m (tCOD/month)	Factor expressing the influence of the temperature on the methane generation	Average temperature (C)	Average temperature (K)	Quantity of chemical oxygen demand available for degradation in the open lagoon under the project activity in month m-1 (tCOD/month)	$f_{T,m}$* $COD_{PJ,available,m}$ (tCOD/month)
	$COD_{PJ,effl,dig,m}$	**$COD_{PJ,effl,lag,m}$**		**$COD_{PJ,available,m}$**	**$f_{T,m}$**	**$T_{2,m}$**	**$T_{2,m}$**	**$COD_{PJ,available,m-1}$**	
Oct-14	100.1601	0.056758	100.1033	168.1349	0.86	28.2	301.36	487.0000	144.6473
Nov-14	36.5533	2.117304	34.4360	69.6273	0.79	27.2	300.36	168.1349	55.0540
Dec-14	55.5944	4.063338	51.5311	68.8362	0.75	26.6	299.76	69.6273	51.7277
Jan-15	5.8480	0.186116	5.6619	24.5017	0.73	26.2	299.36	68.8362	17.7958
Feb-15	0.4877	0	0.4877	6.5774	0.75	26.6	299.76	24.5017	4.9426
Mar-15	0.3074	0	0.3074	1.6840	0.79	27.2	300.36	6.5774	1.3316
	199	**6**							

$\Sigma f_{T,m}$ x $COD_{PJ,available,m}$	**275**
Σ ($COD_{PJ,effl,dig,y}$ - $COD_{PJ,effl,lag,y}$)	**193**
$f_{PJ,T,y}$	**1.4310**

Parameter	Description	Value	Unit	Source
Project emissions from treatment of wastewater effluent from the anaerobic digester ($PE_{CH4,effluent,y}$)				
GWP_{CH4}	Global Warming Potential of methane	25	tCO_2e/tCH_4	IPCC 2006
B_O	Maximum methane producing capacity	0.21	$tCH_4/tCOD$	IPCC 2006
$COD_{PJ,effl,dig,y}$	Quantity of chemical oxygen demand in the effluent from the digester	199	tCOD	Data monitoring and calculation
$COD_{PJ,effl,lag,y}$	Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering facility in which the effluent from the digester is treated	6	tCOD	
Equation:	$(COD_{PJ,effl,dig,y} - COD_{PJ,effl,lag,y})$	193	tCOD	calculation
f_d	Factor expressing the influence of the depth of the lagoon on methane generation	70%	-	ACM0014 version 03.1; Depth > 5m
$f_{PJ,T,y}$	Factor expression the influence of the temperature on the methane generation under the project activity	1.4310	-	calculation, refer to fPJ,T,y worksheet.
$MCF_{PJ,y}$	Average baseline methane conversion factor (fraction) in year y, representing the fraction of ($COD_{PJ,effl,y}$ x B_o) that would be degraded to CH4. **($MCF_{BL,y}$ = fd × fPJ,T,y)**	1.0017	fraction	calculation
Equation:	$PE_{CH4,effluent,y} = GWPCH_4 \times MCF_{PJ,y} \times BO \times (COD_{PJ,effl,dig,y} - COD_{PJ,effl,lag,y})$	1,013	tCO2e	Calculation

The project emission from treatment of wastewater effluent from anaerobic digester is 1,013 tCO_2e.

(ii) Project emissions related to physical leakage from the digester

The proposed Project activity includes the construction of a new anaerobic digester. The emissions directly associated with the operation of digesters involve the physical leakage of methane from the digester system, although this is unlikely. Methane emissions from the new digester are calculated as follows:

$$PE_{CH_4,digest,y} = F_{biogas,y} \times FL_{biogas,digest} \times w_{CH_4,biogas,y} \times GWP_{CH_4} \times 0.001$$

Where:

$PE_{CH_4,digest,y}$ = Project emissions from physical leakage of methane from the anaerobic digester (tCO2e / yr)

$F_{biogas,y}$ = Amount of biogas collected in the outlet of the new digester in year *y* (m3/ yr).For ex-ante calculation the expected biogas production of 9818,182 m3/year has been assumed.

$FL_{biogas,digest}$ = Fraction of biogas that leaks from the digester (m³ biogas leaked / m³ biogas produced)

$w_{CH_4,biogas,y}$ = Concentration of methane in the biogas in the outlet of the new digester (kg CH4 / m³) based on fraction of methane in biogas and the density of methane at normal conditions of 0.7168 kg/m3.

GWP_{CH_4} = Global Warming Potential of methane valid for the commitment period (tCO2e / tCH4)

Project emissions from physical leakage of methane from the anaerobic digester ($PE_{CH4,digest,y}$)				
$F_{biogas,y}$	Amount of biogas collected in the outlet of the new digester in year y	3,573,640	m^3/yr	FSR (= $V_{CH4,y}$ / 0.6; applied 60% methane contents; round off to the 10,000)
$FL_{biogas,digest}$	Fraction of biogas that leaks from the digester	0.05	m^3/m^3	ACM0014 Version03
$w_{CH4,biogas,y}$	Concentration of methane in the biogas in the outlet of the new digester	0.425	kg/m^3	= $\rho_{CH4,293K}$ / 0.6 = (applied 60% methane contents)
GWP_{CH4}	Global Warming Potential of methane	25	tCO_2e/tCH_4	IPCC 2006
Equation:	$PE_{CH4,digest,y} = F_{biogas,y} \times FL_{biogas,digest} \times w_{CH4,biogas,y} \times GWP_{CH4} \times 0.001$	1,900	tCO2e	Calculation

The project emission from physical leakage of methane from anaerobic digester based on ACM0014 version 03.1 is 1,900 tCO_2e.

iii) Methane emissions from flaring

The Project will install a flare in order to burn biogas when the boiler is not available because of failure or malfunction. According to ACM0014 version 03.1, methane released as a result of incomplete combustion in the flare is calculated based on the “Tool to determine project emissions from flaring gases containing methane”.

Project emissions from flaring of the residual gas stream are calculated based on the flare efficiency and the mass flow rate of methane in the residual gas stream that is flared. The flare efficiency depends on both the actual efficiency of combustion in the flare and the time that the flare is operating. For enclosed flares, either of the following two options can be used to determine the flare efficiency:

(a). To use a 90% default value. Continuous monitoring of compliance with manufacturer's specification of flare (temperature, flow rate of residual gas at the inlet of the flare) must be performed. If in a specific hour any of the parameters are out of the limit of manufacturer's specifications, a 50% default value for the flare efficiency should be used for the calculations for this specific hour.
(b). Continuous monitoring of the methane destruction efficiency of the flare (flare efficiency).

This project proposes to use a 90% default value as the enclosed flare efficiency.

In case of open flares, the flare efficiency cannot be measured in a reliable manner (i.e. external air will be mixed and will dilute the remaining methane) and a default value of 50% is to be used provided that it can be demonstrated that the flare is operational (e.g. through a flame detection system reporting electronically on continuous basis)). If the flare is not operational the default value to be adopted for flare efficiency is 0%.

The project proposes to use a 50% default value as the open flare efficiency.

Methodological "Tool to determine project emissions from flaring gases containing methane" defines the steps to determine project emission from the flaring of biogas.

Determination of methane mass flow rate in the residual gas on a dry basis

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH_4,RG,h} \times \rho_{CH_4,n}$$

Variable	Description	SI Unit
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in hour *h*	kg/h
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h*	m³/ h
$fv_{CH_4,RG,h}$	Volumetric fraction of methane in the residual gas on dry basis in hour *h*	-
$\rho_{CH_4,n}$	Density of methane at normal conditions (0.716)	kg/m^3

Determination of the hourly flare efficiency

As per the "Tool to determine project emissions from flaring gases containing methane" in case of **enclosed flares and use of the default value** for the flare efficiency, the flare efficiency in the hour *h* ($h_{flare,h}$) is:

- 0% if the temperature in the exhaust gas of the flare (T_{flare}) is below 500 °C for more than 20 minutes during the hour *h.*
- 50%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour *h,* but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour *h*.

- 90%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour *h* and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h*.

This project assume in ex-ante calculation that project activity meet the requirement to use a default value of 90% for enclosed flare and 50% for open flare.

Calculation of annual project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions from each hour *h*, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour *h* ($\eta_{flare,h}$), as follows:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH_4}}{1000}$$

Variable	Description	SI Unit
$PE_{flare,y}$	Project emissions from flaring of the residual gas stream in year *y*	tCO2e
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour *h*	kg/h
$\eta_{flare,h}$	Flare efficiency in the hour *h*	-
GWP_{CH_4}	Global Warming Potential of methane valid for the commitment period	tCO2e/tCH4

Under normal operation, all recovered biogas is supplied to a boiler to generate steam. As the biogas can be stored in the in-ground digester the biogas is expected to be flared for four days during the one week Ramadan holidays and one hour per week for flare maintenance. Therefore, the ex-ante calculation provided in section B.6.3., project emissions resulted from flaring as mentioned above have been considered. Equations provided thus far are used for ex-post calculation of emission reductions.

Project emissions from flaring of biogas generated in the anaerobic digester ($PE_{flare,y}$) [enclosed flare]				
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in year y	50,589	m3/y	monitoring data
$fv_{CH4,RG,h}$	Volumetric fraction of methane in the residual gas on dry basis in hour h	0.594	-	monitoring data
$\rho_{CH4,n}$	Density of methane at normal condition	0.716	kg/m3	Flaring Tool
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour h	21,452		

$\eta_{flare,h}$	Flare efficiency in hour h	0.90	-	
GWP_{CH4}	Global Warming Potential of methane valid for the commitment period	25	tCO2e/tCH4	
Equation:	$PE_{flare,y} = TM_{RG,h} \times (1 - \eta_{flare,h}) \times GWP_{CH4} \times 0.001$	54	tCO_2e	
Project emissions from flaring of biogas generated in the anaerobic digester ($PE_{flare,y}$) [Open flare]				
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in year y	30,470	m3/y	monitoring data
$fv_{CH4,RG,h}$	Volumetric fraction of methane in the residual gas on dry basis in hour h	0.594	-	monitoring data
$\rho_{CH4,n}$	Density of methane at normal condition	0.716	kg/m3	Flaring Tool
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour h	12,921		
$\eta_{flare,h}$	Flare efficiency in hour h	0.50	-	
GWP_{CH4}	Global Warming Potential of methane valid for the commitment period	25	tCO2e/tCH4	
Equation:	$PE_{flare,y} = TM_{RG,h} \times (1 - \eta_{flare,h}) \times GWP_{CH4} \times 0.001$	162	tCO_2e	
Total PE from flaring		216	tCO_2e	

Project emissions from flaring of biogas generated in the anaerobic digester is 216 tCO_2e.

(iv) Project emissions from land application of sludge

This step is applicable if under the project activity sludge is applied on lands. Negligible amount of sludge is expected to be accumulated in the digester which will be extracted occasionally during the life of the project. Therefore the project emissions from land application of sludge are expected to be negligible. Hence for the ex-ante emission reduction calculations it is conservatively assumed that 15 tonne of sludge will be applied to land every year. The project will be monitored to ensure that any sludge removed from the digester is measured and will follow Equation 31 in the ACM14 version 03.1 methodology.

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

$$PE_{sludge,LA,y} = COD_{sludge,LA,y} \times Bo \times MCF_{sludge,LA,y} \times GWP_{CH4} + S_{LA,y} \times w_{N,sludge,y} \times EF_{N2O,LA,sludge} \times GWP_{N2O}$$

Where:

$PE_{sludge,LA,y}$	=	Project emissions from land application of sludge in year *y* (tCO2e/yr)
$COD_{sludge,LA,y}$	=	Chemical oxygen demand (COD) of the sludge applied to land after the dewatering process in year *y* (tCOD/yr)
$MCF_{sludge,LA,y}$	=	Methane conversion factor for the application of sludge to lands
GWP_{CH4}	=	Global Warming Potential of methane valid for the applicable commitment period (tCO2e/tCH4)

$S_{LA,y}$	Amount of sludge applied to land in year *y* (t/yr)
$w_{N,sludge,y}$	Mass fraction of nitrogen in the sludge applied to land in year *y* (t N/t sludge)
$EF_{N2O,LA,sludge}$	N2O emission factor for nitrogen from sludge applied to land (t N2O/t N)
GWP_{N2O}	Global Warming Potential of nitrous dioxide (tCO2e/tN2O)

Since there is no land application for sludge within the monitoring period, the project emission is 0.

Total Project Emission is 3,129 tCO_2e.

E.3. Calculation of leakage

>>
According to ACM0014 version 03.1, is not necessary to consider leakage.

Summary of calculation of emission reductions or net GHG removals by sinks

Item	Baseline emissions or baseline net GHG removals by sinks (t CO_2e)	Project emissions or actual net GHG removals by sinks (t CO_2e)	Leakage (t CO_2e)	GHG emission reductions or net GHG removals by sinks (t CO_2e) achieved in the monitoring period		
				Up to 31/12/2012	From 01/01/2013	Total amount
Total	19,134	3,129	0	0	16,005	16,005

E.4. Comparison of actual emission reductions or net GHG removals by sinks with estimates in registered PDD

Item	Values estimated in ex ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO_2e)	49,402	16,005

E.5. Remarks on difference from estimated value in registered PDD

>>

The actual CER generation in this monitoring period is lower than the value estimated in the PDD.

Annex 1. Special Event Log

Special Event Log
PT BIOGAS ENERGY INDONESIA

Year	DATE	DESCRIPTION
2014	26 – 31 Oct 1 – 30 Nov 1 – 31 Dec	CH_4 Analyzer is not working CH_4 Analyzer is not working CH_4 Analyzer is not working
2015	3 Jan 5 – 31 Jan 1 – 8 Feb 15 – 28 Feb 1 – 23 Mar 24 – 31 Mar 1 Jan – 31Mar	Ethanol plant not processing Ethanol plant not processing Ethanol plant not processing Ethanol plant not processing Ethanol plant not processing Ethanol plant not processing Methane analyzer is not working

Annex 2. Monitoring Equipment List

Parameter	Measurement Device	Tag Number	Brand (serial number)	Calib. Report I Date	Next Calibration Sheduled	Remarks
$F_{PJ,dig,m}$	Flow meter	FT-608	Krohne Optiplux 4000 (S/N A1093149)	19-Sep-13	19-Sep-16	Wastewater flow into Digester
$F_{PJ,eff,dig,m}$	Flow meter	FT-660	Krohne Optiflux 4000 (S/N A1062795)	19-Sep-13	19-Sep-16	Quantity of effluent from the digester
$F_{PJ,eff,dig,m}$	Flow meter	FT-670	Krohne Optiflux 4000 (S/N S1025692)	19-Sep-13	19-Sep-16	Quantity of the waste water recycle from settling pond to Mixing tank
$F_{PJ,eff,lag,m}$	Flow meter	FT-Discharge	Krohne Optiflux 4000 (S/N S1025695)	19-Sep-13	19-Sep-16	Quantity effluent to water body
$FC_{coal,y}$	Belt Scale		Hasler SBS (S/N VHRS 2501)	6-Jun-14	6-Jun-15	Quantity of coal utilized for Elec. Generation
EG_y	Electricity Meter		Itron ACE SL 7000 (S/N : 37118788)	12-May-12	12-May-17	IndoEthanol Plant Electricity Meter

Parameter	Measurement Device	Tag Number	Brand (serial number)	Calib. Report IV Date	Next Calibration Sheduled	Remarks
F biogas, y	Flow meter	FT-1	Endress+Hausser (S/N DA081B0200)	22-May-13	22-May-16	Biogas Utilized in Boiler
		FT-2	Endress+Hausser (S/N DA081C0200)	22-May-13	22-May-16	Biogas to Enclosed Flare
		FT-3	Endress+Hausser (S/N DA081D0200)	22-May-13	22-May-16	Biogas to Open Flare
W CH4, biogas, y	Gas analyzer	GA	Siemens Ultramat 23 (S/N 7MB2337-4DR00-1CR1)	Monthly Internal calibration 06/09/14, 05/10/14		Methane concentration
T flare	Thermocouples	TF	TC mineral insulated thermocoule type N, 6 mm dia x 415 mm long (S/N: 42493M/1A)	27-Aug-14	27-Aug-15	Enclosed flare temperature
S_{LA}, y	Flow meter	FT-656	Khrone Optiflux 4000 (S/N: S1025697)	14-Dec-2010	14-Dec-2013	Amount of sludge applied to land in year y

Appendix 1. Contact information of project participants and responsible persons/entities

Project participant and/or responsible person/ entity	☒ Project participant ☒ Responsible person/ entity for completing the CDM-MR-FORM
Organization name	ISCCP Investment Platform Ltd
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Document information

Version	*Date*	*Description*
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01	28 May 2010	EB 54, Annex 34. Initial adoption.

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