Monitoring report form
(Version 03.1)

Monitoring report

Title of the project activity	Chao Khun Agro Biogas Energy Project
Reference number of the project activity	2138
Version number of the monitoring report	06
Completion date of the monitoring report	12/06/2013
Registration date of the project activity	09/03/2009
Monitoring period number and duration of this monitoring period	1st monitoring period; 09/03/2009 – 31/03/2011 (both dates are included)
Project participant(s)	• Thai Biogas Energy Company • Kingdom of Spain • Asian Development Bank, as trustee of the Asian Pacific Carbon Fund Swedish Energy Agency
Host Party(ies)	Thailand
Sectoral scope(s) and applied methodology(ies)	Sectoral scope 13: Waste handling and disposal Applied methodology: AM0022 Avoided Wastewater and On-site Energy Use Emissions in the Industrial Sector, Version 04
Estimated amount of GHG emission reductions or net anthropogenic GHG removals by sinks for this monitoring period in the registered PDD	99,369 tCO_2e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	101,220 tCO_2e
Actual GHG emission reduction or net anthropogenic GHG removals by sinks achieved during the period up to 31 December 2012 (if applicable)	101,220 tCO_2e
Actual GHG emission reduction or net anthropogenic GHG removals by sinks achieved during the period from 1 January 2013 onward (if applicable)	-

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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The Chao Khun Agro Biogas Energy Project was developed by Thai Biogas Energy Company is an industrial anaerobic wastewater treatment which treats wastewater from the cassava processing factory located in Saraburi, Thailand. The Cover In-Ground Anaerobic Reactor (CIGAR) has been installed as an anaerobic digester before the series of open lagoons. As the wastewater flow in to CIGAR, organic material is digested and resulting biogas. Then the generated biogas is captured and utilized. The capture biogas replaces the fossil fuel using for heat generation and surplus biogas is flared in open flaring system. The detail description of the main equipment is given in the section "B.1 Implementation status of the project description of the project activity".

The purposed of the project activity is to reduce the greenhouse gas emission from the anaerobic open lagoons wastewater treatment. The methane generated from anaerobic digesting was directly released to atmosphere and not utilized. Also the fossil fuel was used in heat generation and generated the greenhouse gas to atmosphere; however, the fossil fuel is replaced by biogas generated from new anaerobic wastewater treatment technology. Therefore, the project activity can reduce the greenhouse gas emission from direct methane emission and replacing the fossil fuel consumption from heat generation.

Since the project activity has been started from 16/12/2006, the relevant dates for the project activity are presented in the Table 1.

Table 1: The relevant date for the project activity

Status	Date
Commercial Operations Date (COD) of new wastewater treatment system	16/12/2006
Commercial Operations Date (COD) boiler and combustion system	16/12/2006
UNFCCC Registered date	09/03/2009

The total emission reduction during the first monitoring period (09/03/2009 – 31/03/2011 both dates are included) is 101,220 tCO_2e. The web-link has been provided below.
(http://cdm.unfccc.int/Projects/DB/DNV-CUK1218616482.16/view)

A.2. Location of project activity

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(a) Thailand
(b) Saraburi province
(c) Kaengkoi city / Songkorn district
(d) Physical location: Chao Khun Agro Products Project, 44 Moo 2, Songkorn, Kaengkoi, Saraburi, 18110, Thailand
(e) Geographical location: Latitude 14°35'59.28"N Longitude 101°00'41.30"E

The geographical map of the project activity has been showed in the Figure 1.

Figure 1: The geological map of project activity

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 if the Party involved wishes to be considered as project participant (Yes/No)
Kingdom of Thailand (Host)	Thai Biogas Energy Company	No
Spain	Kingdom of Spain	No
Sweden	• Asian Development Bank, as trustee of the Asian Pacific Carbon Fund • Swedish Energy Agency	No

The Asian Development Bank, as trustee of the Asian Pacific Carbon Fund, the Kingdom of Spain, and the Swedish Energy Agency has been involved as project participant as per MOC date 13/12/2010 and valid since 23/12/2010. On the other hand, the EcoSecurities Group Plc. has been removed from project participant since 06/10/2011. All detail can be found on the UNFCCC website as below; (http://cdm.unfccc.int/Projects/DB/DNV-CUK1218619436.44/view)

A.4. Reference of applied methodology

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(a) AM0022 “Avoided Wastewater and On-site Energy Use Emissions in the Industrial Sector” (Version 04)

(b) “Tool to determine project emissions from flaring gases containing methane”

The applied methodologies and tool refer to UNFCC website;
http://cdm.unfccc.int/methodologies/DB/BM4NZO7YAH9373G9P0UZHN6G1XM3IW/view.html

http://cdm.unfccc.int/Projects/DB/DNV-CUK1218619436.44/view

A.5. Crediting period of project activity

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Type of crediting period:	Fixed at 10 years
Starting date of the crediting period:	09/03/2009
Length of the crediting period:	09/03/2009 – 08/03/2019 (both dates are included)
The corresponding to this monitoring period:	09/03/2009 – 31/03/2011 (both dates are included)

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

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This section includes a description of the implementation and operation status of the project as of this monitoring period. The project activity has installed the main machines with specifications as shown in Figure 2 and fully been operated since 16/12/2006 as mentioned in section A.1.

Table 2: The specification of main machines installed in the project activity

Main machine	Type of equipment	Specification
New wastewater treatment reactor	CIGAR	41,000 m^3
Boiler	Steam boiler/Loos boiler	15,000 kg/hr, 13 bar, 195°C
Burner	Weishaupt WKGMS 70/2-A	Rating: min 1400 kW/max 10800 kW Supply pressure: min 15 mbar / max 500 mbar
Flare system	Open flare	Flow rate 2000 m^3/hr

The main equipment and the measurement point are provided in Figure 2.

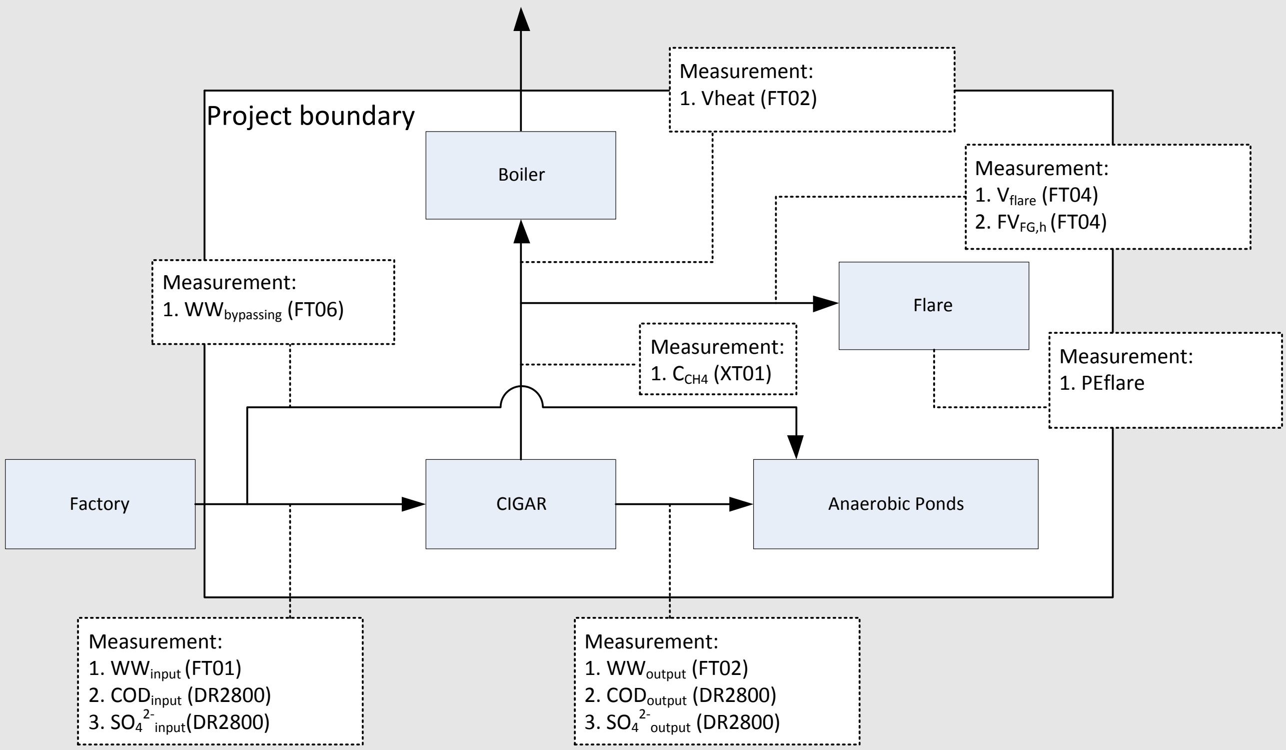

Figure 2: Process flow diagram and the measurement point

The position of measurement equipment is presented in the Figure 2. The FT01 are representative of the wastewater inlet flow meters (WW_{input}). FT02 is measured the wastewater outlet (WW_{outlet}) from the CIGAR. The wastewater bypassing the CIGAR is measured by FT06 (WW_{bypass}). Moreover, FT02 and FT04 are measured the biogas flow to boiler and flare respectively. The concentration of methane is measured by continuous gas analyser which represent as XT01. The concentration of COD_{input}, COD_{output}, $SO_4^{2-}{}_{input}$ and $SO_4^{2-}{}_{output}$ are measured by spectrophotometer DR2800.

The total downtimes for the project activity during this monitoring period are presented in Table 3; however, the detail of the downtimes has been provided in Annex I.

Table 3: The summary of downtimes during 09/03/2009 to 31/03/2011 (both dates included)

Period	Total downtimes (days)
09/03/2009- 08/03/2010	16
09/03/2010- 08/03/2011	97
09/03/2011-31/03/2011	0

During the monitoring period, downtimes of the project activity has been in total 113 days.

B.2. Post registration changes

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

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The monitoring plan in registered PDD states that the methane concentration of biogas (C_{CH4} and FV_{CH4}) should be measured continuously using gas analyser. In the project activity, the methane concentration of biogas (C_{CH4} and FV_{CH4}) has been continuously measured by a gas analyser and record in the midnight report except during the period from 02/04/2010 to 10/05/2010 (including both date), a total of 39 days where the methane concentration was not measured by continuous gas analyser.

For the baseline emission period from 02/04/2010 to 10/05/2010 (including both dates), the minimum of:

1) minimum value from continuous analyser (52.43%) during the vintage year two, and

2) lower bound of 95% confident interval from portable gas analyser (59.04%) during 02/04/2010 to 10/05/2010 (including both dates)

Then 52.43% is applied during 02/04/2010 to 10/05/2010 (including both dates) to be completely conservative.

For the project emission period from 02/04/2010 to 10/05/2010 (including both dates), the maximum of:

1) maximum value from continuous analyser (59.85%) during the vintage year two, and

2) upper bound of 95% confident interval from portable gas analyser (59.69%) during 02/04/2010 to 10/05/2010 (including both dates)

Then 59.85% is applied during 02/04/2010 to 10/05/2010 (including both dates) to be completely conservative.

Introducing the approaches above, it makes conservative emission reduction during this monitoring period as explanation below and this approaches only effects vintage year two (09/03/2010 – 08/03/2011).

Period	Average C_{CH4} (%)
09/03/2010 – 01/04/2010 (before malfunction period)	59.42
11/05/2010 – 08/03/2011 (after malfunction period)	58.36
09/03/2010 – 08/03/2011 (whole vintage year 2 period)	58.48
Minimum value of continuous gas analyser measurement in vintage year two (09/03/2010 – 08/03/2011) and it is applied from 02/04/2010 to 10/05/2010 for baseline emission calculation	52.43
Maximum value of continuous gas analyser measurement in vintage year two (09/03/2010 – 08/03/2011) and it is applied from 02/04/2010 to 10/05/2010 for project emission calculation	59.85

The table above shows average C_{CH4} value during 09/03/2010 to 10/04/2010, 11/05/2010 to 08/03/2011 and 09/03/2010 to 08/03/2011in comparison to the value applied (52.43%) for 02/04/2010 to 10/05/2010 (malfunction period of continuous gas analyser) to verify the baseline emission calculation and demonstrates it is the lowest value

and hence conservative. Moreover, the table above shows average C_{CH4} value 09/03/2010 to 10/04/2010, 11/05/2010 to 08/03/2011 and 09/03/2010 to 08/03/2011 in comparison to the value applied (59.85%) for 02/04/2010 to 10/05/201 (malfunction period of continuous gas analyser) for project emission calculation and demonstrates it is the highest value and hence conservative.

B.2.2. Corrections

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No the corrections of project activity during this monitoring period.

B.2.3. Permanent changes from registered monitoring plan or applied methodology

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No any permanent changes from registered monitoring plan.

B.2.4. Changes to project design of registered project activity

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No any changes to project design of registered project activity during this monitoring period.

B.2.5. Changes to start date of crediting period

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No any changes to start date of crediting period.

B.2.6. Types of changes specific to afforestation or reforestation project activity

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N/A

SECTION C. Description of monitoring system

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The monitoring diagram of the project activity

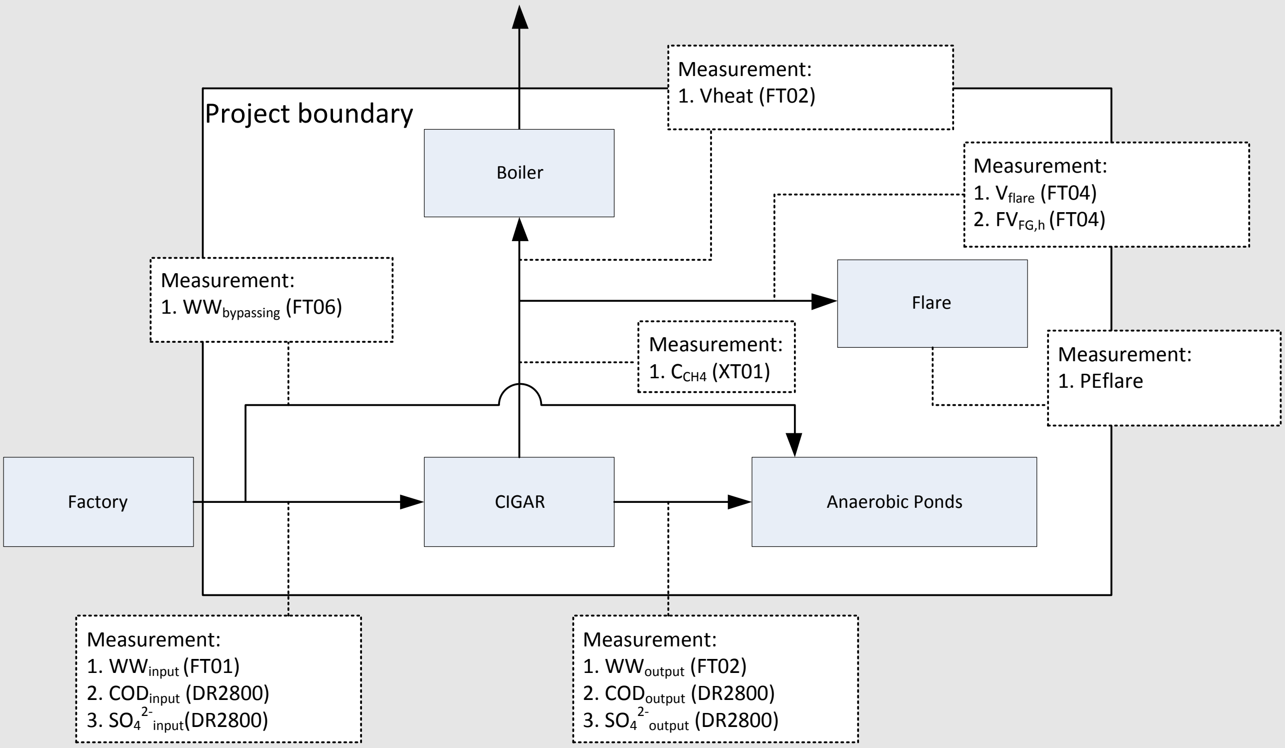

Figure 3: Presenting the monitored parameters locations in the project activity.

Organizational structure, roles and responsibilities

TBEC will be responsible for the on-site monitoring and implementation of the quality assurance and quality management system (ISO: 9001/2008) that is certified by June 2011 both ISO 9001/2008 and ISO 14001 /2004 , and compiling the CDM monitoring report for Verification. Its objectives are to achieve assured quality and consistency of the output. The standard prescribes formal documentation of procedures, performance measurements and records, which can be audited internally and externally. TBEC focus on statements of requirements, prevention and detection of problems, corrective actions, inspection and testing, and monitoring and review. TBEC is practical documents, emphasizing workplace acceptance. The operational and management structure that will be implemented to monitor emission reductions is described in the following diagram.

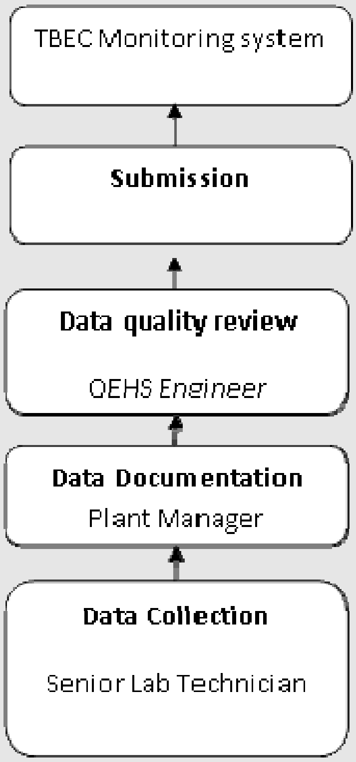

Figure 4: The CDM Organization structure

a. Shift Leader/Process Operator

TBEC will designate shift leader/process operator to fulfill the primary monitoring activities. The shift leader/Process operator will be responsible for checking SCADA midnight report, Electricity reports, and daily gas & liquid system daily check sheet on daily basis and share data with Senior Lab technician.

b. Senior Lab Technician

TBEC will designate Senior Lab Technician to fulfill the primary monitoring activities, mostly on wastewater analysis. Senior Lab Technician will be responsible for checking wastewater analysis report on daily basis and share with Shift leader. The Senior Lab technician is also responsible for collating all monitored data into the monitoring and verification workbook and submitting to the plant manager daily.

c. Plant Manager

Plant manager will be responsible for checking all monitoring data which they receive from the senior lab technician daily and ensure that the data continues to be recorded as per the monitoring requirements for each parameter. The Plant manager is responsible for sending the data on a weekly basis to QEHS Engineer.

d. QEHS Engineer

TBEC will designate a QEHS Engineer to administer the monitoring plan and ensure Quality Assurance and Quality Control Procedures are adherent. The QEHS Engineer will be responsible for internal integrating the Monitoring Plan to TBECs operation and maintenance procedures for the site. The QEHS Engineer will be responsible for training the Shift leader/Process operator and Senior lab technician in the correct procedures and to ensure that they understand the requirements of the monitoring plan.

Prior to operation of the project, the QEHS Engineer will ensure that all meters and monitoring equipment meet the required accuracy and manufacturing standards. During the project, they will ensure the ongoing maintenance and calibration of the all meters and monitoring equipment. Any equipment faults recorded by the Shift leader/Process operator and Senior lab technician will be followed up by the QEHS Engineer who will ensure that the equipment is repaired/ replaced as necessary.

The QEHS Engineer is responsible for compiling the quarterly report and submitting it to TBEC management. They will also participate in a yearly audit.

Periodically the QEHS undertake a cross check with the data report and the raw data.

e. CDM Project Manager

TBEC will designate a Senior Engineer/CDM Project Manager to oversee the preparation of the project annual Monitoring Report. They will review the monitored data provided quarterly by the Quality Control Officer and write the report for submission to the Designated Operational Entity (DOE). The Manager may also participate in and review the annual audit in co-ordination with the QHSE Engineer

All data required for verification and issuance will be kept for at least two years after the end of the crediting period or the last issuance of CERs of this project, whichever occurs later. Data will be archived electronically and data backup will be maintained. Paper data backup will also be available.

All equipment calibrated and maintained in accordance to the manufacturer's recommendations to ensure accuracy of measurements. Records of calibration certificates and maintenance retained as part of the CDM monitoring system.

Data collection procedures

The proposed monitoring plan for the Project activity should be implemented and followed by the Project developer on-site.
The monitoring plan is implemented based on the following criteria:

- Data Collection – the parameters should be measured according to the monitoring plan. The frequency of monitoring proposed should be followed based on the proposed monitoring schedule. The results of the monitoring should be recorded and a set of these data should be kept on-site for easier retrieval and reference for operational and maintenance purposes.

  The list of procedures is indicated below:
  • Procedure for Document control
  • Procedure for Clean Development Mechanism
  • Procedure for Quality Analysis
  • Procedure for Biogas operation process (Liquid & Gas phase)
  • Procedure for preventive maintenance
  • Procedure for Instrument calibration

- Reporting and documentation – All results and observations made during the monitoring should be reported and documented based on a standardized format. The collected data of the monitored parameters should be arranged, filed and documented for easy reference and better management. The retention/ archiving period for verification and CER issuance documents should be kept for at least 2 years after the end of the crediting period or the last issuance of CERs for this project activity whichever occurs later.
- The documents will be kept in both hard and soft copies (where available). For manual recording of monitoring data, the data sheets will be scanned/ keyed into computer in soft-copy for safe-keeping.
- Quality Assurance / Quality Control (QA/QC) – The QA/QC procedures should be carried out during each monitoring exercise to ensure best quality and reliable data are obtained. Manual recording will be recorded and verified by different personnel as a cross-checking measure. Observations during the monitoring exercise should be recorded and reported to the CDM manager immediately. The CDM manager should review the findings and update/improve the monitoring plan from periodically to suit the project's development.
- Communication, training and supervision – the monitoring plan should be communicated with relevant staff at all levels within the company (see the organization chart below). Relevant staff involved in the monitoring plan should be trained to implement the monitoring plan more effectively. Constant supervision and audits will be conducted to cross-check the results of the monitoring plan.
- Data protection, the data will be protected by creating the password and plant manager is authorize to access the data.

Emergency procedure

The plant maintains the data in both hard and soft copy formats. Also, the monthly report and soft copy format are sent and kept in the data room in head office. In general, the plant operates in line with the ISO9001 procedure.

However, no emergency occurred during the period under verification which could have given rise to emissions.

SECTION D. Data and parameters

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

Data/Parameter	EF_{CH4}
Unit	$kgCH_4$/kg COD
Description	Methane emission factor
Source of data	AM0022 ver.04
Value(s) applied	0.21
Purpose of data	Used for calculated both baseline emission and project emission calculation
Additional comment	The 2006 IPCC default of 0.25 kg CH_4/kg COD has been corrected to 0.21 kg CH_4/kg COD to account for uncertainties. This is also the value applied in AM0022 ver.04

Data/Parameter	GWP_{CH4}
Unit	Global Warming Potential of methane
Description	Methane emission factor
Source of data	AM0022 ver.04
Value(s) applied	21
Purpose of data	Used for calculated both baseline emission and project emission calculation
Additional comment	IPCC default, as set in the Kyoto Protocol

Data/Parameter	$M_{lagoon\_aerobic}$
Unit	kg COD/ha/day
Description	Amount of organic material degraded aerobically in the lagoon system
Source of data	AM0022 ver.04
Value(s) applied	254
Purpose of data	Used for calculated both baseline emission and project emission calculation
Additional comment	As provided by the Methodology and tested by the sensitivity analysis

Data/Parameter	R_{lagoon}
Unit	%
Description	Total organic material removal ratio of the lagoon
Source of data	Project developer
Value(s) applied	98.2
Purpose of data	Used for calculated both baseline emission and project emission calculation
Additional comment	Determined in accordance with AM0022 prior to the start of the project activity through on-site biochemical testing in the lagoon system

Data/Parameter	$R_{deposition}$
Unit	%
Description	Organic material deposition ratio of the lagoon
Source of data	Project developer
Value(s) applied	2.1
Purpose of data	Used for calculated both baseline emission and project emission calculation
Additional comment	In accordance with AM0022, testing was done prior to the start of the project activity which determined the rate of deposition

Data/Parameter	$NCV_{fuel,oil}$
Unit	TJ/dm^3
Description	Net calorific value of fuel oil
Source of data	IPCC 2006 and density from Engineer's Edge
Value(s) applied	39.996×10^{-6}
Purpose of data	Used for calculated both baseline emission
Additional comment	IPCC default value from Table 1.2 of Chapter 1 of Vol.2 used for the NCV of fuel oil expressed in TJ/t. This value is multiplied by the density value of 0.99Kg/l from Engineer's Edge (http://www.engineersedge.com/fluid_flow/fluid_data.htm)

Data/Parameter	$EF_{fuel\ oil}$
Unit	tCO_2/TJ
Description	Carbon emission factor of the fuel oil
Source of data	IPCC 2006
Value(s) applied	77.367
Purpose of data	Used for calculated both baseline
Additional comment	IPCC default value from Table 1.3 of Chapter 1 of Vol.2 gives an EF for residual fuel oil of 21.1kgcarbon/GJfueloil. Applying the coefficient 44 g of CO2 /12 g of Carbon gives 77.367 tCO_2/TJ

Data/Parameter	Grid CEF
Unit	tCO_2/MWh
Description	Carbon emission factor for the electricity displaced by the electricity generated
Source of data	Electricity Generating Authority of Thailand (EGAT)
Value(s) applied	0.524
Purpose of data	Used for calculated both baseline emission
Additional comment	The most recent available three years historical data from EGAT at the time of the start of validation was used to follow the methodological requirements which follows the calculations of ACM0002, version 06

Data/Parameter	Lagoon surface area
Unit	Ha
Description	Total lagoon area
Source of data	Project developer
Value(s) applied	1.105

Purpose of data	Used for calculated both baseline emission and project emission calculation
Additional comment	-

Data/Parameter	Flare efficiency
Unit	%
Description	Flare efficiency for open flare
Source of data	Tool to determine project emissions from flaring gases containing methane
Value(s) applied	50
Purpose of data	This is calculated according to the “Tool to determine project emissions from flaring gases containing methane” for open flares which consists of using a 50% default if a flame is detected for at least 20 min in the hour and ensuring that flare is operated properly
Additional comment	-

Data/Parameter	$R_{SO4}{}^{2-}$
Unit	kg/tonne (kgCOD/t$SO_4{}^{2-)}$
Description	Reduction factor for $SO_4{}^{2-}$ oxidative substance
Source of data	AM0022 ver.04
Value(s) applied	651
Purpose of data	Used for calculated both baseline emission and project emission calculation
Additional comment	AM0022 ver.04 states in p.32 under the section Determining losses of Chemical Oxygen Demand through chemical oxidation: “where the concentration of sulphate is observed to be 1 kg/m3 of waste water, 0.651 kg/m^3 of Chemical Oxygen Demand is removed through chemical reaction with the sulphate” hence the reduction factor is 0.651 kgCOD/t$SO_4{}^{2-}$ => 651 kgCOD/t$SO_4{}^{2-}$

D.2. Data and parameters monitored

Data/Parameter	WW_{input}
Unit	m^3
Description	Total wastewater flows entering system boundary
Measured/Calculated /Default	Measured
Source of data	Daily reports by SCADA
Value(s) of monitored parameter	see table below

Period	WW_{input} (m^3)
09/03/2009- 08/03/2010	704,362
09/03/2010- 08/03/2011	428,686
09/03/2011-31/03/2011	34,789

Monitoring equipment	Tag No: FT01 Manufacturer: ABB Type: COPA-XE Model: DE43F Serial No: 024436 Calibration frequency : every 2 years Accuracy class : +/- 0.50 % Date of last calibration and validity: Certificate Number / Date of calibration / Validity / Calibrator: L0808-162 / 22/08/2008 / 21/8/2010 / Miracle L1008-187 / 19/08/2010 / 18/08/2012 / Miracle
Measuring/Reading/ Recording frequency	To be measured continuously with a cumulative flow meter located at the incoming pipe to the CIGAR and reading recorded daily
Calculation method (if applicable)	-
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy
Purpose of data	Baseline emission calculation
Additional comment	During the period 09/03/2009 to 08/03/2010, the data had been missing for 2 days (29/08/2009 and 30/08/2009) because of malfunction meters. According to EB 70, Annex 02, appendix 1, page 43, paragraph 2, CDM project standard (version 02.1) the zero value is applied for these two days.

Certificate Number	Date of calibration	Validity	Calibrator
L0808-162	22/08/2008	21/8/2010	Miracle
L1008-187	19/08/2010	18/08/2012	Miracle

Data/Parameter	WW_{output}
Unit	m^3
Description	Total wastewater flows leaving treatment system
Measured/Calculated /Default	Measured
Source of data	Daily reports by SCADA
Value(s) of monitored parameter	(see table below)
Monitoring equipment	Tag No: FT05 Manufacturer: ABB Type: COPA-XE Model: DE43F Serial No: 019442 Calibration frequency : every 2 years Accuracy class : +/- 0.50 % Date of last calibration and validity: (see table below)
Measuring/Reading/ Recording frequency	To be measured continuously with a cumulative flow meter located at the pipe leaving the CIGAR and reading recorded daily

Period	WW_{output} (m^3)
09/03/2009- 08/03/2010	725,990
09/03/2010- 08/03/2011	431,943
09/03/2011- 31/03/2011	35,351

Certificate Number	Date of calibration	Validity	Calibrator
L0808-163	22/08/2008	21/08/2010	Miracle
L1008-188	19/08/2010	18/08/2012	Miracle

Calculation method (if applicable)	-
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy
Purpose of data	Project emissions calculations
Additional comment	During the period 09/03/2009 to 08/03/2010, the data had been missing for 22 days (31/08/2009 and 21/09/2009) because of malfunction meters. According to EB 70, Annex 02, appendix 1, page 43, paragraph 3, CDM project standard (version 02.1)the maximum value (3,818 m^3/day) of 1st vintage year period (09/03/2009 – 08/03/2010)is applied for these 22 days.

Data/Parameter	COD_{input}
Unit	kgCOD / m^3
Description	Total wastewater organic material concentration entering the project boundary
Measured/Calculated /Default	Measured
Source of data	Daily reports by Lab-technician
Value(s) of monitored parameter	see table below

Period	Measured COD_{input} (kg COD/m^3)	Adjusted COD_{input} (kg COD/m^3)
09/03/2009- 08/03/2010	23.25	21.80
09/03/2010- 08/03/2011	22.43	22.00
09/03/2011- 31/03/2011	26.56	26.46

Noted: the value in the table above is averaged from measured daily data and adjusted daily data according to conservative method. The adjusted COD_{input} is applied to baseline emissions calculation because it makes lower baseline emission than taking the measured COD_{input}. The adjustment method is described in additional comment below.

Monitoring equipment	Tag No: N/A Manufacturer: Hach Type: DR2800 Serial No. : 1156884 Calibration frequency : once a year Accuracy class : +/- 1.5 nm Date of last calibration and validity:

Certificate Number	Date of calibration	Validity	Calibrator
C06080189	09/10/2008	08/10/2009	SPC Calibration Center
C06090191	05/10/2009	04/10/2010	SPC Calibration Center
C06100204	04/10/2010	03/10/2011	SPC Calibration Center

Measuring/Reading/ Recording frequency	Daily sampling of the untreated wastewater influent and tested on site at the TBEC laboratory using Hach meter following international COD standard method 5220 D. Daily samples have been taken and used to calculated average monthly and annually values.
Calculation method (if applicable)	-
QA/QC procedures	Weekly samples are sent to an accredited analytical laboratory for cross checking with on-site data to assure accuracy.
Purpose of data	Baseline emissions calculations

Additional comment	The COD_{input} has been adjusted according to COD external laboratory result cross check. The COD_{input} from internal laboratory has been compared with the result from external laboratory in the same sample. The difference between internal lab and external lab result is averaged. Then, the daily COD_{input} are adjusted. Then lower value of COD_{input} is taken for baseline emission calculation.

Data/Parameter	COD_{output}
Unit	kgCOD / m^3
Description	Total wastewater organic material concentration leaving the treatment facility
Measured/Calculated /Default	Measured
Source of data	Daily reports by Lab-technician
Value(s) of monitored parameter	see table and note below
Monitoring equipment	Tag No: N/A Manufacturer: Hach Type: DR2800 Serial No. : 1156884 Calibration frequency : once a year Accuracy class : +/- 1.5 nm Date of last calibration and validity: (see table below)
Measuring/Reading/ Recording frequency	Daily sampling of the untreated wastewater influent and tested on site at the TBEC laboratory using Hach meter following international COD standard method 5220 D. Daily samples have been taken and used to calculate average monthly and annual values
Calculation method (if applicable)	-
QA/QC procedures	Weekly samples are sent to an accredited analytical laboratory for cross checking with on-site data to assure accuracy.
Purpose of data	Project emissions calculations
Additional comment	The COD_{output} has been adjusted according to COD external laboratory result cross check. The COD_{output} from internal laboratory has been compared with the result from external laboratory in the same sample. The difference between internal lab and external lab result is averaged. Then, the daily COD_{output} are adjusted. Then higher value of COD_{output} is taken for project emission calculation.

Value(s) of monitored parameter:

Period	Measured COD_{output} (kg COD/m^3)	Adjusted COD_{output} (kg COD/m^3)
09/03/2009- 08/03/2010	6.01	6.50
09/03/2010- 08/03/2011	5.13	5.31
09/03/2011- 31/03/2011	6.01	6.01

Noted: the value in the table above is averaged from measured daily data and adjusted daily data according to conservative method. The adjusted COD_{output} is applied to baseline emission calculation because it makes higher project emissions than taking the measured COD_{output}. The adjustment method is described in additional comment below.

Monitoring equipment – date of last calibration and validity:

Certificate Number	Date of calibration	Validity	Calibrator
C06080189	09/10/2008	08/10/2009	SPC Calibration Center
C06090191	05/10/2009	04/10/2010	SPC Calibration Center
C06100204	04/10/2010	03/10/2011	SPC Calibration Center

Data/Parameter	V_{heat}
Unit	Nm^3
Description	Total volume of biogas sent to facility heaters
Measured/Calculated /Default	Measured
Source of data	Midnight reports by SCADA
Value(s) of monitored parameter	<table><tr><th>Period</th><th>V_{heat} (Nm^3)</th></tr><tr><td>09/03/2009- 08/03/2010</td><td>5,665,686</td></tr><tr><td>09/03/2010- 08/03/2011</td><td>3,445,231</td></tr><tr><td>09/03/2011- 31/03/2011</td><td>195,611</td></tr></table>
Monitoring equipment	Tag No: FT02 Manufacturer: ABB Type : Sensy flow IG-EX Serial No. : 27751279 Calibration frequency : every 3 years Accuracy class : +/- 0.95 % Date of last calibration and validity: <table><tr><th>Certificate Number</th><th>Date of calibration</th><th>Validity</th><th>Calibrator</th></tr><tr><td>1612 DKD-K-05701 2008-07</td><td>29/07/2008</td><td>28/07/2011</td><td>ABB</td></tr></table>
Measuring/Reading/ Recording frequency	Volume in Nm^3 is measured continuously by a flow meter and reading recorded hourly by SCADA system into baseline emission calculation and daily report print out from recorder.
Calculation method (if applicable)	-
QA/QC procedures	Biogas meters should be subject to a regular maintenance and testing regime to ensure accuracy
Purpose of data	Baseline emissions calculations
Additional comment	-

Data/Parameter	V_{flare} (also $FV_{FG,h}$)
Unit	Nm^3
Description	Total biogas sent to flare
Measured/Calculated /Default	Measured
Source of data	Midnight reports by SCADA
Value(s) of monitored parameter	<table><tr><th>Period</th><th>V_{flare} (Nm^3)</th></tr><tr><td>09/03/2009- 08/03/2010</td><td>611,122</td></tr><tr><td>09/03/2010- 08/03/2011</td><td>496,752</td></tr><tr><td>09/03/2011- 31/03/2011</td><td>74,731</td></tr></table>

Monitoring equipment	Tag No: FT04 Manufacturer: ABB Type/Model: Sensy flow IG-EX Serial No. : 27751278 Calibration frequency : every 3 years Accuracy class : +/- 0.95 % Date of last calibration and validity: Manufacturer: ABB Tag No: FT04 Type/Model: Sensy flow IG-EX Serial No. : 26750814 Calibration frequency : every 3 years Accuracy class : +/- 0.95 %

Certificate Number	Serial Number	Date of calibration	Validity	Calibrator
469020	27751278	27/10/2006	26/10/2009	ABB
240236990	26750814	24/06/2009	22/06/2012	ABB
240278981	27751278	14/10/2009	13/10/2012	ABB

The flow meter S/N 27751278 was sent to calibration on 28/08/2009 and was reinstalled on 02/11/2009, hence it was uninstalled during 28/08/2009-02/11/2009. During this period the meter S/N 26750814 was installed.

Measuring/Reading/ Recording frequency	Volume in Nm^3 is measured continuously by a flow meter and reading recorded hourly by SCADA system into project emission calculation and daily report print out from recorder.
Calculation method (if applicable)	-
QA/QC procedures	Biogas flow meters will be subjected to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Project emissions calculations
Additional comment	This parameter is equivalent to the variable FVFG,h (volumetric flow rate of the residual gas in dry basis at normal conditions) as described in the "Tool to determine project emissions from flaring gases containing methane".

Data/Parameter	$C_{SO4}{}^{2-}{}_{in}$
Unit	Tonnes/m^3
Description	Amount of chemical oxidizing agents entering system boundary
Measured/Calculated /Default	Measured
Source of data	Daily analyzed by Lab-technical
Value(s) of monitored parameter	

Period	$C_{SO4}{}^{2}{}_{-in}$ (tonnes/m^3)
09/03/2009- 08/03/2010	0.0001200
09/03/2010- 08/03/2011	0.0001700
09/03/2011- 31/03/2011	0.0001448

Monitoring equipment	Tag No: N/A Manufacturer: Hach Type: DR2800 Serial No. : 1156884 Calibration frequency : once a year Accuracy class : +/- 1.5 nm Date of last calibration and validity:
Measuring/Reading/ Recording frequency	Samples are collected daily, mixed, and concentration measured weekly. For emission reduction calculations the most recent value from testing is kept until a new test result is received from the lab
Calculation method (if applicable)	-
QA/QC procedures	-
Purpose of data	Baseline emissions calculations
Additional comment	-

Certificate Number	Date of calibration	Validity	Calibrator
C06080189	09/10/2008	08/10/2009	SPC Calibration Center
C06090191	05/10/2009	04/10/2010	SPC Calibration Center
C06100204	04/10/2010	03/10/2011	SPC Calibration Center

Data/Parameter	$C_{SO4}{}^{2-}{}_{out}$
Unit	Tonnes/m^3
Description	Amount of chemical oxidizing agents out of the digester
Measured/Calculated /Default	Measured
Source of data	Daily analyzed by Lab-technical
Value(s) of monitored parameter	
Monitoring equipment	Manufacturer: Hach Tag No: N/A Type/Model: DR2800 Serial No. : 1156884 Calibration frequency : once a year Accuracy class : +/- 1.5 nm Date of last calibration and validity:
Measuring/Reading/ Recording frequency	Samples are collected daily, mixed, and concentration measured weekly. For emission reduction calculations the most recent value from testing is kept until a new test result is received from the lab

Period	$C_{SO4}{}^{2-}{}_{out}$ (tonnes/m^3)
09/03/2009- 08/03/2010	0.0000347
09/03/2010- 08/03/2011	0.0000360
09/03/2011- 31/03/2011	0.0000343

Certificate Number	Date of calibration	Validity	Calibrator
C06080189	09/10/2008	08/10/2009	SPC Calibration Center
C06090191	05/10/2009	04/10/2010	SPC Calibration Center
C06100204	04/10/2010	03/10/201	SPC Calibration Center

Calculation method (if applicable)	-
QA/QC procedures	-
Purpose of data	Project emissions calculations
Additional comment	-

Data/Parameter	$WW_{bypassing}$
Unit	m^3
Description	Total flow of wastewater directly to the current water treatment system, and bypassing the new wastewater treatment facility.
Measured/Calculated /Default	Measured
Source of data	Daily reports by SCADA
Value(s) of monitored parameter	see table below
Monitoring equipment	Tag No: FT06 Manufacturer: Endress Houser Serial No: A401442000 Calibration frequency: every 2 years Accuracy class: ±0.5% Manufacturer: ABB Serial No: 6710090063 Calibration frequency: every 2 years Accuracy class: ±0.5% Manufacturer: ABB Serial No: 000420831/Y004 Calibration frequency: every 2 years Accuracy class: ±0.5% see calibration table below
Measuring/Reading/ Recording frequency	Measured continuously and data recorded hourly. After commissioning of the project activity, all wastewater flows from the factory into the CIGAR. In the event that wastewater bypasses the CIGAR and flows directly into the lagoons, this wastewater volume is measured with a flow meter
Calculation method (if applicable)	-
QA/QC procedures	Regular maintenance and calibration of the flow meter
Purpose of data	-
Additional comment	-

Value(s) of monitored parameter:

Period	$WW_{bypassing}$ (m^3)
09/03/2009- 08/03/2010	0
09/03/2010- 08/03/2011	0
09/03/2011- 31/03/2011	0

Monitoring equipment:

Serial No.	Calibration number	Calibration date	Validity date	Installed date	Un-installed date
A4014420000	40035296-1909710	16/04/2008	15/04/2010	05/02/2009	01/04/2
6710090063	10/2/2/207153	15/03/2010	14/03/2012	01/04/2010	08/09/2
000420831/Y0004	L1009-028	07/09/2010	06/09/2012	08/09/2010	08/04/2

Data/Parameter	Biogas loss from pipeline
Unit	%
Description	Loss of biogas from pipeline
Measured/Calculated /Default	Pressure test report
Source of data	The test report from their party.
Value(s) of monitored parameter	<table><tr><th>Period</th><th>Biogas loss from pipeline (%)</th></tr><tr><td>09/03/2009- 08/03/2010</td><td>0</td></tr><tr><td>09/03/2010- 08/03/2011</td><td>0</td></tr><tr><td>09/03/2011- 31/03/2011</td><td>0</td></tr></table>
Monitoring equipment	<table><tr><th>Report Number</th><th>Testing date</th><th>Validity</th><th>Tester</th></tr><tr><td>Pressure test 2008</td><td>27/08/2008</td><td>26/08/2009</td><td>CK Thai</td></tr><tr><td>Pressure test 2009</td><td>24/08/2009</td><td>23/08/2010.</td><td>CK Thai</td></tr><tr><td>Pressure test 2010</td><td>24/08/2010</td><td>23/08/2011.</td><td>CK Thai</td></tr></table>
Measuring/Reading/ Recording frequency	Annually
Calculation method (if applicable)	-
QA/QC procedures	The standard method for testing has followed by Department of Energy's liquefied petroleum gas piping. And equipped with storage tanks and gas in the liquefied petroleum gas.
Purpose of data	Project emissions calculations
Additional comment	-

Data/Parameter	NCV_{biogas}
Unit	J/Nm^3
Description	Biogas calorific value
Measured/Calculated /Default	Measured
Source of data	NCV test report

Value(s) of monitored parameter	The actual value from the test report. **Table A:** Period / NCV_{biogas} (BTU/ft^3) 09/03/2009- 08/03/2010: 511 09/03/2010- 08/03/2011: 541 09/03/2011- 31/03/2011: 541 **Table B:** Period / NCV_{biogas} (J/Nm^3) / NCV_{biogas} (TJ/Nm^3) 09/03/2009- 08/03/2010: 19,039,326 / 1.90393E-05 09/03/2010- 08/03/2011: 20,157,094 / 2.01571E-05 09/03/2011- 31/03/2011: 20,157,094 / 2.01571E-05 Note: Each test result is carried out annually. In 2011 the test was not done within the period, the result in 2010 is considered. Moreover, the unit TJ/Nm^3 is used for calculation of $E_{CO2\ heat}$ in ER sheet calculation sheet. However, the unit J/Nm^3 presented in the table above is following the presenting unit in AM0022 and registered PDD.
Monitoring equipment	Testing report Report Number / Testing date / Validity / Third party COA-L6-0906-01279 / 27/06/2009 / 26/06/2010 / PTT COA-L6-1007-00987 / 23/07/2010 / 22/07/2011 / PTT
Measuring/Reading/ Recording frequency	To be measured annually
Calculation method (if applicable)	-
QA/QC procedures	-
Purpose of data	Baseline emission calculation
Additional comment	In original report, the NCV_{biogas} present in Btu/ft^3. Then, it is converted to J/Nm^3 for MR and TJ/Nm^3 for ER sheet. The conversion factor is referred to an engineering text book “Transport process and unit operation 3nd edition” page 851 and 852. (1055.06 J/BTU and 35.313 ft^3/m^3)

Period	NCV_{biogas} (BTU/ft^3)
09/03/2009- 08/03/2010	511
09/03/2010- 08/03/2011	541
09/03/2011- 31/03/2011	541

Period	NCV_{biogas} (J/Nm^3)	NCV_{biogas} (TJ/Nm^3)
09/03/2009- 08/03/2010	19,039,326	1.90393E-05
09/03/2010- 08/03/2011	20,157,094	2.01571E-05
09/03/2011- 31/03/2011	20,157,094	2.01571E-05

Report Number	Testing date	Validity	Third party
COA-L6-0906-01279	27/06/2009	26/06/2010	PTT
COA-L6-1007-00987	23/07/2010	22/07/2011	PTT

Data/Parameter	PE_{flare}
Unit	tCO_2
Description	Project emissions from flaring of the residual gas stream.
Measured/Calculated /Default	Calculated
Source of data	Daily report
Value(s) of monitored parameter	(see table below)
Monitoring equipment	-
Measuring/Reading/ Recording frequency	-

Period	PE_{flare} (tCO_2)
09/03/2009- 08/03/2010	2,656
09/03/2010- 08/03/2011	2,140
09/03/2011- 31/03/2011	318

Calculation method (if applicable)	Following the “Tool to determine project emissions from flaring gases containing methane” step 1, step 5 and step 7 as descripted in section E.2. $FM_{RG,h} = \rho_{RGn,h} \cdot FV_{RG,h}$ $TM_{RG,h} = FV_{RG,h} \cdot fv_{CH4,RG,h} \cdot \rho_{CH4,n}$ $PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \cdot (1-\eta_{flare,h}) \cdot \frac{GWP_{CH4}}{1000}$
QA/QC procedures	-
Purpose of data	Project emissions calculations
Additional comment	To determine project emission from flaring gases containing methane according to the Tool, the efficiency of flare is conditionally considered depending on the type of flare. In this project, the open flare is installed and the default value 50% is to be used provided through a flame detection system reporting on electronically numeric value indicating on/off continuous basis to demonstrate that the flare is operational. Also the flare efficiency is depended on the minute of flare (a) 0% if the flame is not detected for more than 20 minutes during the hour and (b) 50% if the flare is detected for more than 20 minutes during the hour. In this project, the report of minutes of flare is automatically counted the hour that the flare is detected for more than 20 minutes other while it is not reported in daily report.

Data/Parameter	F
Unit	dm^3
Description	Fossil fuel volume equivalent to generate the same amount of heat generated from the biogas collected in the anaerobic treatment facility.
Measured/Calculated /Default	Calculated
Source of data	ER workbook
Value(s) of monitored parameter	<table><tr><th>Period</th><th>F (dm^3)</th><th>F (Nm^3)</th></tr><tr><td>09/03/2009- 08/03/2010</td><td>2,697,040</td><td>269,704</td></tr><tr><td>09/03/2010- 08/03/2011</td><td>1,736,320</td><td>173,632</td></tr><tr><td>09/03/2011- 31/03/2011</td><td>98,580</td><td>9,858</td></tr></table> Noted: the unit Nm^3 is used for calculation of $E_{CO2\ heat}$ in ER sheet calculation sheet. However, the unit dm^3 presented in the table above is following the presenting unit in AM0022 and registered PDD.
Monitoring equipment	-
Measuring/Reading/ Recording frequency	-
Calculation method (if applicable)	Calculated from the monitored Vheat multiplied by monitored NCV_{biogas} and divided by fixed parameter $NCV_{fuel\ oil}$ $F = \frac{V_{heat} \times NCV_{biogas}}{NCV_{fueloil}}$
QA/QC procedures	-
Purpose of data	Baseline emissions calculations
Additional comment	The unit dm^3 is converted to Nm^3 using a conversion factor of 10^3.

<table>
<tr><td>Data/Parameter</td><td>C_{CH4} (also $FV_{CH4,y}$)</td></tr>
<tr><td>Unit</td><td>% of Nm^3/Nm^3</td></tr>
<tr><td>Description</td><td>Biogas methane concentration</td></tr>
<tr><td>Measured/Calculated /Default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>SCADA midnight report</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th>Period</th><th>Measured C_{CH4} (also $FV_{CH4,y}$) (% of Nm^3/ Nm^3)</th><th>Adjusted C_{CH4} (also $FV_{CH4,y}$) (% of Nm^3/ Nm^3)</th></tr>
<tr><td>09/03/2009-08/03/2010</td><td>58.74</td><td>59.04*</td></tr>
<tr><td>09/03/2010-08/03/2011</td><td>58.48</td><td>Baseline emission 52.43**
Project emission 59.85**</td></tr>
<tr><td>09/03/2011-31/03/2011</td><td>58.15</td><td>58.15</td></tr>
</table>
Note: this parameter is an average annually.

*There was a delay calibration from 09/03/2009 to 08/09/2009. Then, paragraph 238 (a), CDM-EB70-A03 “Clean development mechanism validation and verification standard” version 03.0 has been applied for this period.

**This number is applied during the malfunction period of continuous gas analyser (02/04/2010 – 10/-5/2010). See any comment for the detail.
</td></tr>
</table>

Monitoring equipment

The specification of the continuous gas analyser provided below;

Tag No: XT01
Manufacturer: ANRI
Type : Gas analyzer
Serial No. : LFB-028
Calibration frequency : once a year
Accuracy class : +/- 1% of full values
Date of last calibration and validity:

Certificate number	Date of calibration	Validity	Calibrator
3907	21/02/2008	20/02/2009	ANRI
520144	09/09/2009	08/09/2010	Entech
530268	09/09/2010	08/09/2011	Entech

During this monitoring period, the continuous gas analyzer had been broken down from 02/04/2010 to 10/05/2010; the portable gas analyzer was used to measure and record hourly. And the calibration of portable gas analyzer covered the period of its use (04/04/2010 -15/09/2010).

The specification of portable gas analyser provided below;

Manufacturer: Geotechnical Instrument
Type : Portable Gas analyzer
Serial No. : BM11835
Calibration frequency : once a year
Accuracy class : ±0.31% of full scale
Date of last calibration and validity:

Certificate number	Date of calibration	Validity	Calibrator
BM1 1835_2/3987	30/06/2009	29/06/2010	Geotechnical

Measuring/Reading/ Recording frequency

Measured continuously and data recorded daily. In case of a device breakdown, a portable gas analyser is used and data will be recorded hourly for as long as biogas is being pumped up until the fixed spectrometer is repaired and fitted.

Calculation method (if applicable)

-

QA/QC procedures

-

Purpose of data

Project emissions calculations

Additional comment	Also referred as $fv_{CH4,h}$ (Volumetric fraction of component i in the biogas in the hour h, where i = CH_4) in the “Tool to determine project emissions from flaring gases containing methane”. Only CH_4 will be monitored, the remaining part will be considered as N_2 (simplified approach according to Tool).The monitored value will actually have to be multiplied by the CH_4 density of 0.0007168 tCH_4/m^3CH_4 from ACM0001 at normal conditions to obtain the value of CH4 in tCH_4/Nm^3. The conservative approach applied to this parameter. (a) The malfunction of continuous gas analyser in vintage year-2 (09/03/2010 – 08/03/2011). For the baseline emission period from 02/04/2010 to 10/05/2010 (including both dates), the minimum of: 1) minimum value from continuous analyser (52.43%) during the vintage year two, and 2) lower bound of 95% confident interval from portable gas analyser (59.04%) during 02/04/2010 to 10/05/2010 (including both dates) Then 52.43% is applied during 02/04/2010 to 10/05/2010 (including both dates) to be completely conservative for baseline emission calculation. For the project emission period from 02/04/2010 to 10/05/2010 (including both dates), the maximum of: 1) maximum value from continuous analyser (59.85%) during the vintage year two, and 2) upper bound of 95% confident interval from portable gas analyser (59.69%) during 02/04/2010 to 10/05/2010 (including both dates) Then 59.85% is applied during 02/04/2010 to 10/05/2010 (including both dates) to be completely conservative for project emission calculation. (a) The delay of calibration of continuous gas analyser. The paragraph 238 (a), CDM-EB70-A03 “Clean development mechanism validation and verification standard” version 03.0 has been applied during the calibration delay period which is from 09/03/2009 to 08/09/2009. Since this parameter is used for project emission calculation, then Adjusted value = Measured value x (1+Max. permissible error%/100)

Data/Parameter	f_{heat}
Unit	%
Description	Heating system combustion efficiency
Measured/Calculated /Default	Measured and Calculated
Source of data	Combustion efficiency test report

Value(s) of monitored parameter	<table><tr><th>Period</th><th>f_{heat} (%)</th></tr><tr><td>09/03/2009- 08/03/2010</td><td>92.08</td></tr><tr><td>09/03/2010- 08/03/2011</td><td>91.16</td></tr><tr><td>09/03/2011- 31/03/2011</td><td>91.16</td></tr></table> Note: Averaged value from test report dated 21/04/2009 and 01/02/2010 is applied for 1st vintage year which is defined from 09/03/2009 to 08/03/210. Moreover, the average result from test report date 31/05/2010 and 01/06/2010 is applied for 2nd vintage year (09/03/2010 – 08/03/2011) and 3rd vintage year (09/03/2011 – 31/03/2011)
Monitoring equipment	-
Measuring/Reading/ Recording frequency	Combustion efficient testing by third party annually, <table><tr><th>Testing Number</th><th>Date of Testing</th><th>Measuring by</th></tr><tr><td>N/A</td><td>21/04/2009</td><td>Thai Burner Industrial</td></tr><tr><td>0353</td><td>01/02/2010</td><td>Thai Burner Industrial</td></tr><tr><td>0006</td><td>30/05/2010</td><td>Thai Burner Industrial</td></tr><tr><td>0007</td><td>01/06/2010</td><td>Thai Burner Industrial</td></tr></table>
Calculation method (if applicable)	-
QA/QC procedures	Boiler is maintained regularly by Weishaupt in order to ensure optimal performance. During the monitoring period, there is one boiler used which is Weishaupt.
Purpose of data	Project emissions calculations
Additional comment	The 1st vintage year is defined from 09/03/2009 to 08/03/2010; the heating system combustion efficiency (f_{heat}) is averaged from the testing report in 2009 which was done at 21/04/2009 and testing report in 2010 which was done at 01/02/2010. Moreover, the other two testing results in 2010 from the report dated 31/05/2010 and 01/06/2010 is averaged and applied to 2nd vintage year (09/03/2010 – 08/03/2011) as well as to 3rd vintage year (09/03/2011 – 31/03/2011) since the test in 2011 was not done before 31/03/2011.

Data/Parameter	$M_{Removed}$
Unit	t COD
Description	Organic material removed from wastewater facility
Measured/Calculated /Default	Calculated
Source of data	Daily report
Value(s) of monitored parameter	<table><tr><th>Period</th><th>M_{Remove} (t COD)</th></tr><tr><td>09/03/2009- 08/03/2010</td><td>12,008.00</td></tr><tr><td>09/03/2010- 08/03/2011</td><td>7,134.00</td></tr><tr><td>09/03/2011- 31/03/2011</td><td>708.00</td></tr></table>
Monitoring equipment	-

Measuring/Reading/ Recording frequency	-
Calculation method (if applicable)	$M_{Remove} = (WW_{input} \times COD_{input}) - (WW_{output} \times COD_{output})$
QA/QC procedures	-
Purpose of data	Baseline emissions calculations
Additional comment	-

Data used for calculation of GHG emission reductions;

The previous table summarizes the data used to calculate the GHG emission reductions. Please refer to excel spread sheet files for the full set of data used for calculations. The raw data files are available onsite for review. Other sources, such as plant log books, laboratory analysis are available for cross check on site.

D.3. Implementation of sampling plan

>>

No data nor parameter monitored described in section D.2 are determined by a sampling approach. Therefore, this section is not applicable for this project activity.

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

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

>>

As per the equation set out in AM0022 version 04 which applied for registered project activity, the following equations are applied to calculate the baseline emission.

Total Baseline emissions:

$$E_{BL} = E_{CH4\_lagoons\_BL} + E_{CO2\_heat\_BL} + E_{CO2\_power\_BL}$$

Where:

E_{BL} = total Baseline emission (tCO_2e).
$E_{CH4\_lagoons\_BL}$ = the fugitive methane emissions from lagoons in the baseline case (tCO_2e).
$E_{CO2\_heat\_BL}$ = CO_2 emissions from on-site fossil heat in the baseline case (tCO_2) that are displaced by generation based on biogas collected in the anaerobic treatment facility.
$E_{CO2\_power\_BL}$ = CO_2 emissions from on-site power generation in the baseline case (tCO_2) that are displaced by generation based on biogas collected in the anaerobic treatment facility.

Since in this registered project activity, there are no any electricity generation that are displaced base on biogas collected in the anaerobic treatment facility, the $E_{CO2\_power\_BL} = 0$. Then the follow equation has been applied for this

case:

$$E_{BL} = E_{CH4\_lagoons\_BL} + E_{CO2\_heat\_BL}$$

Period	E_{BL}	$E_{CH4\_lagoon\_BL}$	$E_{CO2\_heat\_BL}$
	tCO_2e	tCO_2e	tCO_2e
09/03/2009- 08/03/2010	69,050	60,705	8,346
09/03/2010- 08/03/2011	41,010	35,637	5,373
09/03/2011- 31/03/2011	2,827	2,522	305

Total baseline emission during of 09/03/2009 to 31/03/2011 (both dates are included) is 112,887 tCO_2e.

To ensure that equation delivers a conservative estimate of emission reduction, the positive value (as calculated in section E.4) is deducted from the $E_{CH4\_lagoon\_BL}$. The deduction is applied during 09/03/2009 to 08/03/2010,09/03/2010 to 08/03/2011 and 09/03/2011 to 31/03/2011.

A. On-site heat generation emission displaced by generation base on biogas collected in the anaerobic treatment facility.

In calculating CO_2 emission from on-site heat displaced by biogas collected in the anaerobic treatment, the use of fossil fuels is considered:

$$E_{CO2\_heat} = F \cdot NCV \cdot EF$$

Where:

F = the corresponding amount of fossil fuel displaced by the use of biogas for the generation of on-site heat (dm^3). :(1) Average specific fuel consumption for the output of the facility, estimated using 3 years historical data; and (2) the annual production NCV is the net calorific value of the fossil fuel considered (TJ/unit). Site specific local NCV values should be applied where available; however, should this information not be available, IPCC data may suffice for that specific country.

NCV = the net calorific values of the fossil fuel consider (TJ/unit).

EF = the carbon emission factors of the fossil fuel consider (tCO_2/TJ).

The annual production NCV method is applied to estimate the corresponding amount of fossil fuel displace by the use of biogas for the generation of on-site heat. The NCV of fossil fuel value refer to IPCC data.

According to heat balance equation, the corresponding amount of fossil fuel displaced by the use of biogas for the generation of on-site heat can be calculated as equation below:

$$F_{fueloil} \times NCV_{fueloil} = F_{biogas\_heat} \times NCV_{biogas}$$

$$F_{fueloil} = F_{biogas\_heat} \times \frac{NCV_{biogas}}{NCV_{fueloil}}$$

Then:

As equation above, the CO_2 emission from on-site heat displaced by biogas collected in the anaerobic treatment, the use of fossil fuels is considered as:

Period	E_{CO2_heat}	F	NCV	EF

	tCO_2e	Nm^3	TJ/Nm^3	tCO_2/TJ
09/03/2009- 08/03/2010	8,346	269,704	3.9996E-04	77.367
09/03/2010- 08/03/2011	5,373	173,632	3.9996E-04	77.367
09/03/2011- 31/03/2011	305	9,858	3.9996E-04	77.367

Therefore, the total CO_2 emission from on-site heat displaced by biogas collected in the anaerobic treatment from 09/03/2009 to 31/03/2011 (both dates are included) is 14,024 tCO_2.

B. On-site and/or off site Grid Power Generation Emissions displaced by generation based on biogas collected in the anaerobic treatment facility

No electricity was generated in the project activity.

C. Baseline organic material entering lagoon system from new anaerobic wastewater treatment system:

$$M_{lagoon\_input\_BL} = M_{input\_total}$$

Where:

$M_{lagoon\_input\_BL}$ = the value used to specify the amount of organic material flowing into the lagoon system from the CIGAR in the project scenario equation (kg COD).

M_{input_total} = the total amount of organic material fed into the baseline wastewater treatment facility (kg COD). It is same amount as fed into the project water treatment facility.

In the baseline, organic material from the facility enters directly into the lagoon system with no degradation of the wastewater before entering the lagoon system and all organic material to be treated enters the lagoon system. The pond based fugitive methane emissions are quantified by determining;

- How much material enters the lagoon system;
- How much is lost through aerobic and oxidative processes;
- How much is lost through sedimentation in the lagoon system; and
- How much is removed through anaerobic process.

All emission factors, surface aerobic losses of organic material, aerobic degradation, deposition or removal as well as chemical oxidation are determined in the same way as described for the project scenario in the section on project emission above.

Therefore; the equation to determine the fugitive methane emission from lagoons for project emission has been applied for baseline scenario according to the methodology.

Fugitive methane emission from lagoons in baseline scenario

$$E_{CH4\_laoon\_BL} = M_{lagoon\_anaerobi} \cdot EF_{CH4} \cdot GWP_{CH4} / 1000$$

Where:

$E_{CH4\_lagoon\_BL}$ = the methane emission from the lagoons (tCO_2)

$M_{lagoon\_anaerobic}$ = the amount of organic material removed by anaerobic processes in the lagoon system (kg COD)

EF_{CH4} = the methane emission factor (kg CH_4 / kg COD)

GWP_{CH4} = the Global Warming Potential of methane (GWP_{CH4} = 21)

Note: A default COD to methane conversion factor of 0.21 kg CH_4/kg COD is used referring to IPCC, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, page 5.16 and/or methodology AM0022/ Version 04, page 3.

Period	$E_{CH4\_lagoon\_BL}$	$M_{lagoon\_anaerobic}$	EF_{CH4}	GWP_{CH4}
	tCO_2e	kg COD	kg CH_4/kg COD	-
09/03/2009- 08/03/2010	62,717	14,221,622	0.21	21
09/03/2010- 08/03/2011	38,123	8,644,654	0.21	21
09/03/2011- 31/03/2011	3,756	851,881	0.21	21

Total fugitive methane emission from lagoons in baseline scenario in this monitoring period from 09/03/2009 to 31/03/2011 (both dates are included) is 104,596 tCO_2e.

The total removal of COD from individual lagoons is a function of:

- Aerobic surface oxidation of COD;
- Chemical oxidation in lagoons (where oxidative species such as sulphate are present);
- Sedimentation of material that microbes are unable to degrade before they form a bottom sediment; and
- COD degradation as a result of anaerobic micro bacterial activity.

The mass balance in the considered lagoon system provides the amount of organic material by anaerobic process:

$$M_{lagoon\_anaerobic} = M_{lagoon\_total} - M_{lagoon\_aerobic} - M_{lagoon\_chemical\_ox} - M_{lagoon\_deposition}$$

Where:

$M_{lagoon\_anaerobic}$ = the amount of organic material removed by anaerobic processes in the lagoon system (kg COD)

M_{lagoon_total} = the total amount of organic material removed in the lagoon system

$M_{lagoon\_aerobic}$ = the amount of organic material degraded aerobically in the lagoon system (kg COD).

$M_{lagoon\_chemical\_ox}$ = the amount of organic material lost through chemical oxidation in the lagoon system (kg COD)

$M_{lagoon\_deposition}$ = the amount of organic material lost through deposition in the lagoon system (kg COD)

Period	$M_{lagoon\_anaerobic}$	M_{lagoon_total}	$Ml_{agoon\_aerobic}$	$M_{lagoon\_chemical\_ox}$	$M_{lagoon\_deposition}$
	kg COD	kg COD	kg COD	kg COD	kg COD
09/03/2009- 08/03/2010	14,221,622	14,743,575	193,764	54,819	273,370
09/03/2010- 08/03/2011	8,644,654	9,053,388	193,764	47,105	167,865
09/03/2011- 31/03/2011	851,881	883,757	12,210	3,280	16,386

In order to assess the amount of COD actually entering the anaerobic system (the lagoons) the amount of COD removed as a result of the new wastewater treatment facility must be determined. This is set out in equation below.

Project organic material entering lagoon system from new anaerobic water treatment system is:

$$M_{lagoon\_input} = M_{input\_total} \cdot (1 - R_{NAWTF})$$

Where:

M_{lagoon_input} = the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system (kg COD)

M_{input_total} = the total amount of organic material fed into the new project water treatment facility (kg COD)

R_{NAWTF} = the total organic material removal efficiency of the new project water treatment facility (-).

$$R_{NAWTF} = \frac{(COD_{in} - COD_{out})}{COD_{in}}$$

Note: In case of baseline calculation, the R_{NAWTF} = 0 is applied because the new project water treatment was not implemented yet.

Period	M_{lagoon_input}	M_{input_total}	R_{NAWTF}
	kg COD	kg COD	-
09/03/2009- 08/03/2010	15,357,891	15,357,891	0
09/03/2010- 08/03/2011	9,053,388	9,430,613	0
09/03/2011- 31/03/2011	920,581	920,581	0

Total material removal in lagoon system is:

$$M_{lagoon\_total} = M_{lagoon\_input} \cdot R_{lagoon}$$

Where:

M_{lagoon_total} = the total amount of organic material removed in the lagoon system through various routes (kg COD)

M_{lagoon_input} = the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system (kg COD)

R_{lagoon} = the total organic material removal ratio of the lagoon (-).

Note: the total organic material removal ratio of the lagoon is equal to the proportion of organic material removed within the boundaries of the lagoon system under consideration. This factor should be determined by carrying out a series of biochemical tests prior to project implementation. These tests will determine the COD flows into the system, and the COD flows out of the system boundary. The relative difference of COD flowing in and out of the system over a period of time will allow determination of the Total Organic Material Removed Ratio which already tested during validation process. Referred to registered PDD-page 22, the R_{lagoon} is 96.00%.

Period	M_{lagoon_total}	M_{lagoon_input}	R_{lagoon}
	kg COD	kg COD	%
09/03/2009- 08/03/2010	14,743,575	15,357,891	96
09/03/2010- 08/03/2011	9,053,388	9,430,613	96
09/03/2011- 31/03/2011	883,757	920,581	96

Material degraded aerobically in the lagoon system

$$M_{lagoon\_aerobic} = 254 \cdot pond\_surface\_area \cdot opertion\_time$$

Note: Surface aerobic losses of organic material in pond based system equal to 254 kg COD per hectare of pond surface area and per day is assumed to be lost through aerobic processes.

Period	$M_{lagoon\_aerobic}$	Constant value	Pond surface area	day
	kg COD	kg COD/ha/day	ha	day
09/03/2009- 08/03/2010	193,764	254	2.09	365
09/03/2010- 08/03/2011	193,764	254	2.09	365
09/03/2011- 31/03/2011	12,210	254	2.09	23

Material lost through chemical oxidation in lagoon system

$$M_{lagoon\_chemical\_ox} = C_{SO42-\_in} \cdot R_{SO42-}$$

Where:

$M_{lagoon\_chemical\_ox}$ = the amount of organic material lost through deposition in the lagoon system (kg COD)
$C_{SO4^{2-}\ in}$ = the concentration of sulphate is observed (t $_{SO42-}$)
$R_{SO4^{2-}}$ = the removal factor of COD through chemical reaction with the sulphate, 651 kg COD/ t $_{SO42-}$ referred to AM0022/Version 04, page 32

Period	$M_{lagoon\_chemical\_ox}$	$C_{so4^{2-}\ in}$	$R_{SO4^{2-}}$
	kg COD	t $_{SO42-}$	kg COD / t $_{SO42-}$
09/03/2009- 08/03/2010	54,819	84.21	651
09/03/2010- 08/03/2011	47,105	72.36	651
09/03/2011- 31/03/2011	3,280	5.04	651

Material deposition in lagoon system is:

$$M_{lagoon\_depositon} = M_{lagoon\_input} \cdot R_{deposition}$$

Where:

$M_{lagoon\_deposition}$ = the amount of organic material lost through deposition in the lagoon system (kg COD)
M_{lagoon_input} = the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system (kg COD)
$R_{deposition}$ = the organic material deposition ratio of the lagoon.

Note: The organic material deposition ratio of the lagoon is equal to the proportion of organic material physically sediment in lagoons within the project boundaries. For the baseline, $R_{deposition}$ is 1.78% mentioned in registered PDD, page 23.

Period	$M_{lagoon\_deposition}$	M_{lagoon_input}	$R_{deposition}$
	kg COD	kg COD	%
09/03/2009- 08/03/2010	273,370	15,357,891	1.78
09/03/2010- 08/03/2011	167,865	9,430,613	1.78
09/03/2011- 31/03/2011	16,386	920,581	1.78

According to the calculation above, the conclusion of baseline emission in this monitoring period (09/03/2009 – 31/03/2011 both dates are included) can be presented in the table below:

Time Period	Baseline emissions or baseline net GHG removals by sinks (tCO_2e)
09/03/2009- 08/03/2010	69,050
09/03/2010- 08/03/2011	41,010
09/03/2011- 31/03/2011	2,827
Total	112,887

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

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Total project emissions are the sum of fugitive methane emissions from the existing lagoon based water treatment system, from possible methane emission from the new anaerobic wastewater treatment facility, from incomplete biogas combustion, biogas leaks.

Total project emissions:

$$E_{project} = E_{CH4\_lagoons} + E_{CH4\_NAWTF} + E_{CH4\_IC+Leaks}$$

Where:

$E_{project}$ = the total project emission (tCO_2e)
$E_{CH4\_lagoons}$ = the fugitive methane emissions from lagoons (tCO_2e)
E_{CH4_NAWTF} = the fugitive methane emissions from the new anaerobic wastewater treatment facility (tCO_2e)
$E_{CH4\_IC+Leaks}$ = the methane emissions from inefficient combustion and leaks (tCO_2e)

Period	$E_{project}$	$E_{CH4\_lagoons}$	E_{CO2_NAWTF}	$E_{CO2\_IC+Leaks}$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e
09/03/2009- 08/03/2010	7,620	4,924	-	2,696
09/03/2010- 08/03/2011	3,572	1,405	-	2,167
09/03/2011- 31/03/2011	475	156	-	319

The total of project emission during this monitoring period (09/03/2009 - 31/03/2011 both dates are included) is 11,667 tCO_2e

A. Fugitive methane emission from lagoons

$$E_{CH4\_lagoons} = M_{lagoon\_anaerobic} \cdot EF_{CH4} \cdot GWP_{CH4} / 1000$$

Where:

E_{CH4_lagoon}	=	the methane emission from the lagoons (tCO_2)
$M_{lagoon\_anaerobic}$	=	the amount of organic material removed by anaerobic processes in the lagoon system (kg COD)
EF_{CH4}	=	the methane emission factor (kg CH_4 / kg COD)
GWP_{CH4}	=	the Global Warming Potential of methane (GWP_{CH4} = 21)

Note: A default COD to methane conversion factor of 0.21 kg CH_4/kg COD is used referring to IPCC, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, page 5.16 and/or methodology AM0022/ Version 04, page 3.

Period	$E_{CH4\_lagoons}$	$M_{lagoon\_anaerobic}$	EF_{CH4}	GWP_{CH4}
	tCO_2e	kg COD	kg CH_4 / kg COD	-
09/03/2009- 08/03/2010	4,924	1,116,508	0.21	21
09/03/2010- 08/03/2011	1,405	318,575	0.21	21
09/03/2011- 31/03/2011	156	35,334	0.21	21

The total fugitive methane emission from lagoons during this monitoring period (09/03/2009 – 31/03/2011 both dates are included) is 6,485 tCO_2e.

The total removal of COD from individual lagoons is a function of:

- Aerobic surface oxidation of COD;
- Chemical oxidation in lagoons (where oxidative species such as sulphate are present);
- Sedimentation of material that microbes are unable to degrade before they form a bottom sediment; and
- COD degradation as a result of anaerobic micro bacterial activity.

The mass balance in the considered lagoon system provides the amount of organic material by anaerobic process:

$$M_{lagoon\_anaerobic} = M_{lagoon\_total} - M_{lagoon\_aerobic} - M_{lagoon\_chemical\_ox} - M_{lagoon\_deposition}$$

Where:

$M_{lagoon\_anaerobic}$	=	the amount of organic material removed by anaerobic processes in the lagoon system (kg COD)
M_{lagoon_total}	=	the total amount of organic material removed in the lagoon system
$M_{lagoon\_aerobic}$	=	the amount of organic material degraded aerobically in the lagoon system (kg COD).
$M_{lagoon\_chemical\_ox}$	=	the amount of organic material lost through chemical oxidation in the lagoon system (kg COD)
$M_{lagoon\_deposition}$	=	the amount of organic material lost through deposition in the lagoon system (kg COD)

Period	$M_{lagoon\_anaerobic}$	M_{lagoon_total}	$M_{lagoon\_aerobic}$	$M_{lagoon\_chemical\_ox}$	$M_{lagoondeposition}$
	kg COD	kg COD	kg COD	kg COD	kg COD
09/03/2009- 08/03/2010	1,116,508	1,351,718	193,764	16,383	25,063
09/03/2010- 08/03/2011	318,575	532,441	193,764	10,230	9,872
09/03/2011- 31/03/2011	35,334	49,247	12,210	790	913

In order to assess the amount of COD actually entering the anaerobic system (the lagoons) the amount of COD removed as a result of the new wastewater treatment facility must be determined. This is set out in equation below.

Project organic material entering lagoon system from new anaerobic water treatment system is:

$$M_{lagoon\_input} = M_{input\_total} \cdot (1 - R_{NAWTF})$$

Where:

M_{lagoon_input} = the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system (kg COD)

M_{input_total} = the total amount of organic material fed into the new project water treatment facility (kg COD)

R_{NAWTF} = the total organic material removal efficiency of the new project water treatment facility (-).

$$R_{NAWTF} = \frac{(COD_{in} - COD_{out})}{COD_{in}}$$

Note: For the project emission calculation, the R_{NAWTF} is determined in methodology AM0022/Version 04, page 31.

Period	M_{lagoon_input}	M_{input_total}	R_{NAWTF}
	kg COD	kg COD	-
09/03/2009- 08/03/2010	1,408,040	4,721,072	0.70
09/03/2010- 08/03/2011	554,626	2,295,692	0.76
09/03/2011- 31/03/2011	51,299	212,337	0.76

Total material removal in lagoon system is:

$$M_{lagoon\_total} = M_{lagoon\_input} \cdot R_{lagoon}$$

Where:

M_{lagoon_total} = the total amount of organic material removed in the lagoon system through various routes (kg COD)

M_{lagoon_input} = the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system (kg COD)

R_{lagoon} = the total organic material removal ratio of the lagoon (-).

Note: the total organic material removal ratio of the lagoon is equal to the proportion of organic material removed within the boundaries of the lagoon system under consideration. This factor should be determined by carrying out a series of biochemical tests prior to project implementation. This test will determine the COD flows into the system, and the COD flows out of the system boundary. The relative difference of COD flowing in and out of the system over a period of time will allow determination of the Total Organic Material Removed Ratio which already tests during validation process. Referred to registered PDD page 22, the R_{lagoon} is 96.0%.

Period	M_{lagoon_total}	M_{lagoon_input}	R_{lagoon}
	kg COD	kg COD	%
09/03/2009- 08/03/2010	1,351,718	1,408,040	96
09/03/2010- 08/03/2011	532,441	554,626	96
09/03/2011- 31/03/2011	49,247	51,299	96

Material degraded aerobically in the lagoon system

$$M_{lagoon\_aerobic} = 254 \cdot pond\_surface\_area \cdot opertion\_time$$

Note: Surface aerobic losses of organic material in pond based system equal to 254 kg COD per hectare of pond surface area and per day is assumed to be lost through aerobic processes.

Period	$M_{lagoon\_aerobic}$	Constant value	Pond surface area	day
	kg COD	kg COD/ha/day	ha	day
09/03/2009- 08/03/2010	193,764	254	2.09	365
09/03/2010- 08/03/2011	193,764	254	2.09	365
09/03/2011- 31/03/2011	12,210	254	2.09	23

Material lost through chemical oxidation in lagoon system

$$M_{lagoon\_chemical\_ox} = C_{SO42-\_in} \cdot R_{SO42-}$$

Where:

$M_{lagoon\_chemical\_ox}$ = the amount of organic material lost through deposition in the lagoon system (kg COD)
$C_{SO42-\ in}$ = the concentration of sulphate is absorbed (t $_{SO42-}$)
R_{SO42-} = the removal factor of COD through chemical reaction with the sulphate, 651 kg COD/ t $_{SO42-}$ referred to AM0022/Version 04, page 32

Period	$M_{lagoon\_chemical\_ox}$	$C_{SO42-in}$	R_{SO42-}
	kg COD	t $_{SO42-}$	kg COD / t $_{SO42-}$
09/03/2009- 08/03/2010	16,383	25.166	651
09/03/2010- 08/03/2011	10,230	15.71	651
09/03/2011- 31/03/2011	790	1.213	651

Material deposition in lagoon system is:

$$M_{lagoon\_depositon} = M_{lagoon\_input} \cdot R_{deposition}$$

Where:

$M_{lagoon\_deposition}$ = the amount of organic material lost through deposition in the lagoon system (kg COD)
M_{lagoon_input} = the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system (kg COD)
$R_{deposition}$ = the organic material deposition ratio of the lagoon.

Note: The organic material deposition ratio of the lagoon is equal to the proportion of organic material physically sediment in lagoons within the project boundaries. For the baseline, $R_{deposition}$ is 1.78% mentioned in registered PDD, page 23.

Period	$M_{lagoon\_deposition}$	M_{lagoon_input}	$R_{deposition}$
	kg COD	kg COD	%
09/03/2009- 08/03/2010	25,063	1,408,040	1.78
09/03/2010- 08/03/2011	9,872	554,626	1.78
09/03/2011- 31/03/2011	913	51,299	1.78

B. Methane emissions from new anaerobic wastewater treatment facility

Methane emission from the specific anaerobic wastewater treatment facility that is implemented with the project should be assessed and estimated based on measurements, technology supplier data and expert estimates. They may be neglected if documented evidence for their insignificance is given.

In this case, the leakage of wastewater treatment facility has been inspected every day internally and inspecting and checking by third party annually. The result during this monitoring period (09/03/2009 – 31/03/2011 both dates are included) found there were no leakage. Then, the methane emissions from new anaerobic wastewater treatment facility are neglected in the project during this monitoring period.

C. Methane emissions from Inefficient Combustion Emissions

The combustion of biogas methane may give rise to significant methane emissions as a result of incomplete or inefficient combustion. The three predominant potential routes for the destruction of methane are:

- Biogas flaring;
- Biogas use in heating system
- Biogas use for onsite electricity generation

However, in this project activity there is no electricity generated from biogas; so, the methane emissions from biogas use for onsite electricity generation are not applicable and can be avoided.

$$E_{CH4\_IC+Leaks} = E_{CH4\_heat} + E_{CH4\_power} + PE_{flare}$$

There are no any power generated in the project activity; Then,

$$E_{CH4\_IC+Leaks} = E_{CH4\_heat} + PE_{flare}$$

$$E_{CH4\_IC+Leaks} = (V_{heat} \cdot C_{CH4\_heat} \cdot (1 - f_{heat}) \cdot GWP_{CH4}) + PE_{flare}$$

$$E_{CH4\_heat} = V_{heat} \cdot C_{CH4\_heat} \cdot (1 - f_{heat}) \cdot GWP_{CH4}$$

Period	E_{CH4_heat}	V_{heat}	C_{CH4_heat}	f_{heat}	GWP_{CH4}
	tCO_2e	Nm^3	tCH_4/Nm^3	%	-
09/03/2009- 08/03/2010	40	5,665,686	0.000423	92.08	21
09/03/2010- 01/04/2010*	5	630,179	0.0004191	91.16	21
02/04/2010 – 10/05/2010*	4	475,585	0.000429	91.16	21
11/05/2010 – 08/03/2011*	18	2,339,467	0.000419	91.16	21
09/03/2011- 31/03/2011	1	74,731	0.000417	91.16	21

*Note: in vintage year two (09/03/2010 – 08/03/2011), it is separated into three sub-period since the malfunction period of continuous gas analyser during 02/04/2010 to 10/05/2010.

Total project emission from combustion biogas for heat generation is 68 tCO_2e

PE_{flare} are the project emission from flaring of the residual gas stream calculated following the procedure described in the “Tool to determine project emission from flaring gases containing Methane”. Since no continuous monitoring takes place, the default flare efficiency prescribed by the tool is utilized. The calculation steps for project emissions are as follows:

Step1. Determination of the mass flow rate of the residual gas that is flared

This step calculates the residual gas mass flow rate in each hour h, based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$$FM_{RG,h} = \rho_{RGn,h} \cdot FV_{RG,h}$$

Step 2,3,4: As stated in the “Tool to determine project emission from flaring gases containing Methane”, a simplified approach may be taken, in which only the volumetric fraction of methane is measured and the difference to 100% is considered as nitrogen (N2). Hence step 2 is not applicable to the chosen methodological application of the tool and it is not included here for clarity purposes. As the methane combustion efficiency of the flare will not be continuously monitored as a default value for open flares will be used, step 3 and 4 are also not applicable and will not be included.

Step 5: Determination of methane mass flow rate in the residual gas on a dry basis

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane (pCH4,n,h) in the same reference conditions.

$$TM_{RG,h} = FV_{RG,h} \cdot fv_{CH4,RG,h} \cdot \rho_{CH4,n}$$

Step 7: Calculation of annual project emissions from flaring
Project emissions from flaring are calculated as the sum of emission from each hour h, based on the methane flow rate in the residual gas (TMRG,h) and the flare efficiency during each hour h, as follows:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \cdot (1 - \eta_{flare,h}) \cdot \frac{GWP_{CH4}}{1000}$$

Since the value is calculated on hourly basis, then only one day sample is taken in the monitoring report; however, the detail for calculation is provided in the calculation sheet.

Date where flaring occurred	Time	Gas flow to flare ($FV_{RG,h}$)	Methane Content ($fv_{CH4,RG,h}$)	Minute Flaring	$TM_{RG,h}$	Hourly flare efficiency	$PE_{flare,h}$	$PE_{flare,y}$
Unit	hh:mm	Nm3/h	%	Minute	kg/h	%	tCO2e/h	tCO2e
6-Nov-09	1:00	0.00	0.00	0.00	0.00	0	0.00	10.355
	2:00	0.00	0.00	0.00	0.00	0	0.00	
	3:00	0.00	0.00	0.00	0.00	0	0.00	
	4:00	0.00	0.00	0.00	0.00	0	0.00	
	5:00	0.00	0.00	0.00	0.00	0	0.00	
	6:00	0.00	0.00	0.00	0.00	0	0.00	
	7:00	0.00	0.00	0.00	0.00	0	0.00	
	8:00	0.00	0.00	0.00	0.00	0	0.00	
	9:00	0.00	0.00	0.00	0.00	0	0.00	
	10:00	0.00	0.00	0.00	0.00	0	0.00	
	11:00	0.00	0.00	0.00	0.00	0	0.00	
	12:00	654.00	58.30	43.00	273.30	50	2.87	
	13:00	678.00	58.80	32.00	285.76	50	3.00	
	14:00	0.00	0.00	0.00	0.00	0	0.00	
	15:00	0.00	0.00	0.00	0.00	0	0.00	
	16:00	0.00	0.00	0.00	0.00	0	0.00	
	17:00	0.00	0.00	0.00	0.00	0	0.00	
	18:00	0.00	0.00	0.00	0.00	0	0.00	
	19:00	441.00	57.40	55.00	181.45	50	1.91	
	20:00	0.00	0.00	0.00	0.00	0	0.00	
	21:00	0.00	0.00	0.00	0.00	0	0.00	
	22:00	587.00	58.40	49.00	245.72	50	2.58	
	23:00	0.00	0.00	0.00	0.00	0	0.00	
	0:00	0.00	0.00	0.00	0.00	0	0.00	

The conclusion of emission from flaring of the residual gas stream is presented below:

Period	PE_{flare}
	tCO_2e
09/03/2009- 08/03/2010	2,656
09/03/2010- 08/03/2011	2,140
09/03/2011- 31/03/2011	318

The fugitive methane emission from inefficient combustion and leaks; $E_{CH4\ IC+leaks}$ are presented as:

$$E_{CH4\_IC+Leaks} = E_{CH4\_heat} + PE_{flare}$$

Period	$E_{CH4\ IC+leaks}$	$E_{CH4\ heat}$	PE_{flare}
	tCO_2e	tCO_2e	tCO_2e
09/03/2009- 08/03/2010	2,696	40	2,656
09/03/2010- 08/03/2011	2,167	27	2,140
09/03/2011- 31/03/2011	319	1	318

Thus, the total project emissions during this monitoring period (09/03/2009 – 31/03/2011 both dates are included) can be concluded as shown in the table below:

Time Period	Project emissions or actual net GHG removals by sinks (tCO2e)
09/03/2009- 08/03/2010	7,620
09/03/2010- 08/03/2011	3,572
09/03/2011- 31/03/2011	475
Total	11,667

E.3. Calculation of leakage

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Leaks in the biogas system include leaks from any anaerobic digester and leaks from the biogas pipeline delivery system. As per the annual test report for pressure test at pipelines that confirmed that 0% or no leakage can be account for this project.

Methane emissions from the CIGAR are zero in this project. Because the CIGAR is being operated effectively under sub atmospheric pressures, it is reasonable to expect that air will actually be sucked in as opposed to biogas leaking out. The biogas delivery pipe to the off-taker site is also less than 2km, and thus there is no expectation that there will be significant leaks of biogas.

E.4. Summary of calculation of emission reductions or net anthropogenic GHG removals by sinks

Emission reductions, ER (tCO_2e) are calculated as the difference between baseline and project emission. Leakage is considered to be negligible.

$$ER = E_{BL} - E_{project}$$

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)	Emission reductions or net anthropogenic GHG removals by sinks (t CO_2e)
09/03/2009- 08/03/2010	69,050	7,620	0	61,430
09/03/2010- 08/03/2011	41,010	3,572	0	37,438
09/03/2011- 31/03/2011	2,827	475	0	2,352
Total	**112,887**	**11,667**	**0**	**101,220**

However, to verify that this equation delivers a conservative estimate of emission reduction, the equation below is considered:

$$E_{CH4\_lagoon\_BL} - (E_{CH4\_lagoon} + E_{CH4\_nawtf} + E_{CH4\_coall})$$

If the difference is positive, it has to be deducted from the result obtained through emission reduction equation in order to obtain the final estimation of the emission reduction.

As per the verify equation, E_{CH4_coll} is amount of methane expressed in (tCO_2e) contained in the biogas collected from the anaerobic treatment facility (e.g the sum of the biogas sent to heaters, the biogas sent to the gen set and the biogas sent to the flare). In this case, the sum of the biogas sent to heaters and the biogas sent to the flare are consider because there is not electricity generation in this project activity.

$E_{CH4\_coll} = (V_h$	E_{CH4_coll}	V_{heat}	V_{power}	V_{flare}	C_{CH4}	ρ_{CH4}	GWP_{CH4}
Period	tCO_2e	Nm^3	Nm^3	Nm^3	%	tCH_4/Nm^3CH_4	-
09/03/2009- 08/03/2010	55,781	5,665,686	-	611,122	59.04	0.0007168	21
09/03/2010- 01/03/2010*	5,547	630,179	-	0	58.48	0.0007168	21
02/04/2010 – 10/05/2010*	4,040	475,585	-	36,357	52.43	0.0007168	21
11/05/2010 – 08/03/2011*	24,646	2,339,467	-	460,495	58.48	0.0007168	21
09/03/2011- 31/03/2011	2,366	195,611	-	74,731	58.15	0.0007168	21

* Note: in vintage year two (09/03/2010 – 08/03/2011), it is separated into three sub-period since the malfunction period of continuous gas analyser during 02/04/2010 to 10/05/2010.

Therefore, $E_{CH4\_lagoon\_BL}$ will be;

Period	$E_{CH4\_lagoon\_BL}$	E_{CH4_lagoon}	E_{CH4_nawtf}	E_{CH4_coll}	Result
	tCO_2e	tCO_2e	tCO_2e	tCO_2e	
09/03/2009- 08/03/2010	62,795	4,966	0	55,781	2,012
09/03/2010- 08/03/2011	38,350	1,632	0	34,168	2,550
09/03/2011- 31/03/2011	3,756	156	0	2,366	1,232

E.5. Comparison of actual emission reductions or net anthropogenic 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**
09/03/2009- 08/03/2010	48,167	61,430
09/03/2010- 08/03/2011	48,167	37,438
09/03/2011- 31/03/2011	3,035	2,352
Emission reductions or GHG removals by sinks (t CO_2e)	**99,369**	**101,220**

The comparison above is based on 753 days and the increase versus ex-ante calculation of registered PDD is 1.86%.

E.6. Remarks on difference from estimated value in registered PDD

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The higher ER achieved as compared to ex-ante ER during the monitoring period is contributed by the higher ER achieved for vintage year 1. This is due to the high amount of wastewater treated which is 7.34% higher than ex-ante calculation of registered PDD.

According to the ex-ante ER calculation on the CDM webpage, the estimated amount of wastewater input was 575,280 m^3 and COD_{input} 26,099 mg/l while the actual of the 1st year was 704,362 m^3 and COD_{input} was 21,800 mg/l. This makes the significant difference of project emission between ex-ante and ex-post calculation. Then, the baseline emission is still in the range compared to ex-ante baseline emission in registered PDD.

Moreover, for project emission the COD of treated water from reactor to open lagoon was used to calculate ex-ante project emission was 26,099 mg COD/l (registered PDD, page 47) which is same as COD_{input} calculated for baseline emission (http://cdm.unfccc.int/Projects/DB/DNV-CUK1218616482.16/view). In fact, this amount of COD should be deducted from the efficiency of new anaerobic reactor to be the COD used for project emission calculation. While the actual COD out from the new anaerobic reactor to open lagoon was 6,050 mg COD/l (ER calculation sheet tab "Raw data Year 1" Cell H375), the project emission significantly lower than project emission in registered PDD. This is a main reason why the project emissions in the registered PDD for the first year are significantly higher than the actual.

E.7. Actual emission reductions or net anthropogenic GHG removals by sinks during the first commitment period and the period from 1 January 2013 onwards

Item	Actual values achieved up to 31 December 2012	Actual values achieved from 1 January 2013 onwards
Emission reductions or GHG removals by sinks (t CO_2e)	101,220	-

ANNEX 1

The downtimes of equipment during this monitoring period
The downtimes of equipment from 09/03/2009 to 31/03/2011(both date included)

Date	Event	Total of downtimes (days)	Reason
14/04/2009 – 19/04/2009	Factory shut down	6	Public holiday
12/05/2009	Factory shut down	1	Maintenance process
25/05/2009	Factory shut down	1	Maintenance process
30/10/2009 – 31/10/2009	Factory shut down	2	Maintenance process
05/12/2009	Factory shut down	1	Public holiday
31/12/3009 – 04/01/2010	Factory shut down	5	Public holiday
10/04/2010 – 19/04/2010	Factory shut down	10	Public holiday
07/06/2010 – 30/06/2010	Factory shut down	24	Raw material shortage
10/07/2010	Factory shut down	1	Maintenance process
12/07/2010	Factory shut down	1	Maintenance process
17/07/2010 – 29/07/2010	Factory shut down	13	Raw material shortage
27/08/2010 – 30/09/2010	Factory shut down	35	Raw material shortage
21/12/2010	Factory shut down	1	Maintenance process
29/12/2010 – 07/01/2011	Factory shut down	10	Public holiday
04/03/2011 – 05/03/2011	Factory shut down	2	Maintenance process

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Document information

Version	*Date*	*Description*
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 anthropogenic 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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