Monitoring report form
(Version 03.2)

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	03
Completion date of the monitoring report	07/06/2014
Registration date of the project activity	09/03/2009
Monitoring period number and duration of this monitoring period	3rd Monitoring period; 01/01/2013 – 31/12/2013 (both dates are included)
Project participant(s)	• Thai Biogas Energy Company • 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	48,167 tCO_2e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	67,904 tCO_2e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved during the period up to 31 December 2012(if applicable)	N/A
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved during the period from 1 January 2013 onwards (if applicable).	67,904 tCO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

>>

The Chao Khun Agro Biogas Energy Project was developed by Thai Biogas Energy Company Ltd is an industrial anaerobic wastewater treatment which treats wastewater from the cassava processing factory located in Saraburi, Thailand. The Covered 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 purpose 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	Description
Operation start date of project Activities	16/12/2006	The new anaerobic wastewater treatment facility had started its operation.
Start date of boiler/burner operation	16/12/2006	The new burner had started its operation.
UNFCCC Registered date	09/03/2009	The project activity was registered as CDM project.

The amount of emission reductions during this monitoring period; 01/01/2013 – 31/12/2013 (both dates are included) is 67,904 tCO_2e.

A.2. Location of project activity

>>

(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 geographical 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
Sweden	Swedish Energy Agency	Yes

The Asian Development Bank, as trustee of the Asian Pacific Carbon Fund, a representative of Spain and Sweden, has been withdrawn according to MoC Annex2 (Withdrawn Project Participant). All details can be found on the UNFCCC website; http://cdm.unfccc.int/Projects/DB/DNV-CUK1218616482.16

A.4. Reference of applied methodology

>>

(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” (EB28, Annex13)

The applied methodology and tool refer to UNFCCC website;

http://cdm.unfccc.int/methodologies/DB/BM4NZO7YAH9373G9P0UZHN6G1XM3IW/view.html

A.5. Crediting period of project activity

>>

Type of crediting period:	Fixed at 10 years
Starting date of the crediting period:	09/03/2009
The corresponding to this monitoring period:	01/01/2013 – 31/12/2013 (both dates are included)

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

>>

This section will include 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 a specification as shown in Table 2 and fully been operating since 16/12/2006 as mentioned in section A.1. In addition, a diagram of the project activity is shown in Figure 2.

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	15,000 kg/hr, 13 bar, 195^{o}C
Burner	Weishaupt WKGMS 70/2-A	S/N: 5591839 Rating: min 1400 kW/max 10800 kW
Flare system	Open flare	Flow rate 2000 m^3/hr

However, during this monitoring period there were downtimes of equipment which mainly due to no supplies of wastewater from the host factory. There were several reasons to stop operation of the host factory such as raw material shortage. The total downtime of the project activity during this monitoring period is presented in the Table 3.

Table 3: The summary of downtimes during 01/01/2013 – 31/12/2013 (both dates are included)

Total downtimes (mins)
70,560

From the above table, it can be summarized that the total downtimes during this monitoring period of equipment is approximately 49 days. All information on the downtimes is provided in Annex I.

B.2. Post registration changes

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

>> There was a temporary deviations in the 1st monitoring period (09/03/2009 – 31/03/2011, both dates are included), referred to the UNFCCC PRC approval reference# PRC-2138-001.

However, there are no temporary deviations in this monitoring period.

B.2.2. Corrections

>> No corrections in this monitoring period.

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

>> No permanent changes from registered monitoring plan or applied methodology.

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

>> No changes to project design of registered project activity.

B.2.5. Changes to start date of crediting period

>> No changes to start date of crediting period.

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

>> N/A

SECTION C. Description of monitoring system

>> Organizational structure, roles and responsibilities

The monitoring diagram of the project activity

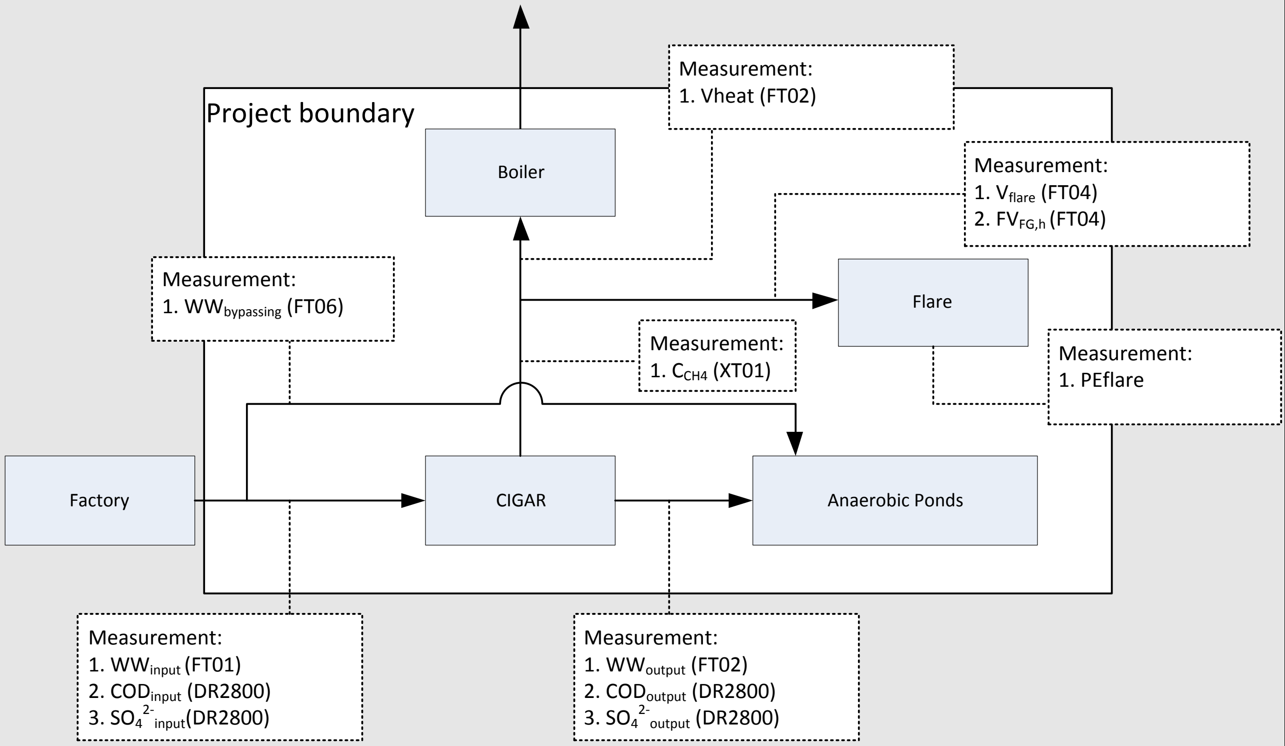

Figure 2: The project activity process diagram

TBEC is responsible for the on-site monitoring and implementation of the quality assurance and quality management system (ISO: 9001/2008) that has been certified since 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 is implemented to monitor emission reductions is described in the following diagram.

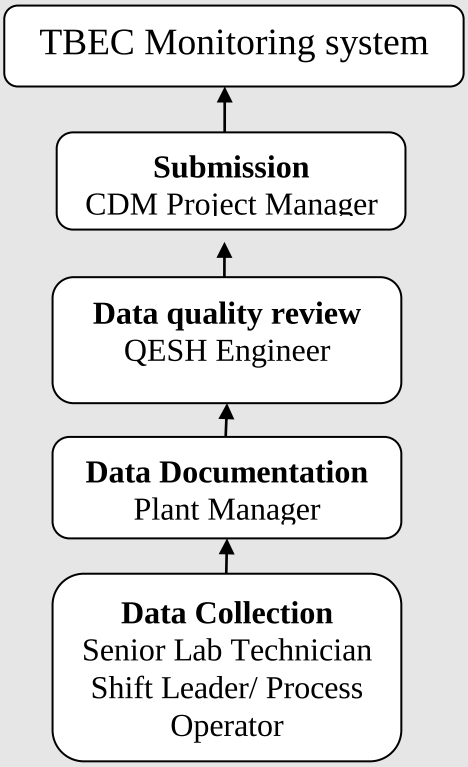

Figure 3: The organization structure to monitor the emission reductions

The roles and responsibility of positions presented in the diagram above has been clearly identified below:

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. QESH Engineer

TBEC will designate a QESH Engineer to administer the monitoring plan and ensure Quality Assurance and Quality Control Procedures are adherent. The QESH Engineer will be responsible for internal integrating the Monitoring Plan to TBECs operation and maintenance procedures for the site. The QESH 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 QESH Engineer will ensure that all meters and monitoring equipment meet the required accuracy and manufacturing standards. During the project, they will ensure the on-going 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 QESH Engineer who will ensure that the equipment is repaired/replaced as necessary.

The QESH Engineer is responsible for compiling the quarterly report and submitting it to TBEC management. Periodically the QESH 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 QESH 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

Procedures of Monitoring Plan

The proposed monitoring plan for the Project activity should be implemented and followed by the Project developer on-site. The methods and parameters to be monitored are as described in Section D.2 The monitoring plan should be 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 procedure 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
- Other documentations

• 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. 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.

• In case of data loss; all data have been scanned and written into a DVD-rom as backup data. These data are kept at two places, one at site and another one at Headquarters. If any corrupted of data, the backup data will be used to replace the broken section.

• In case of data corruption; the operator check-sheet will be used as source of data.

SECTION D. Data and parameters

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

Data / Parameter:	EF_{CH4}
Unit:	kgCH4/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 CH4/kg COD has been corrected to 0.21 kg CH4/kg COD to account for uncertainties. This is also the value applied in AM0022.

Data / Parameter:	GWP_{CH4}
Unit:	-
Description:	Methane emission factor
Source of data:	AM0022 ver.04
Value(s) applied):	25
Purpose of data:	Used for calculated both baseline emission and project emission calculation
Additional comment:	According to the UNFCCC, EB69, Annex3, the GWP_{CH4} is approved to change from 21 t_{CH4}/t_{CO2} to 25 t_{CH4}/t_{CO2} starting from the 2nd commitment period (1st January 2013 onward)

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):	96
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):	1.78
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 baseline emission; E_{CO2_heat}
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:	EFfuel 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 baseline emission; E_{CO2_heat}
Additional comment:	IPCC default value from Table 1.3 of Chapter 1 of Vol.2 gives an EF for residual fuel oil of $21.1kg_{carbon}/GJ_{fueloil}$. Applying the coefficient 44 g of CO_2 /12 g of Carbon gives 77.367 tCO_2/TJ

Data / Parameter:	Lagoon surface area
Unit:	Ha
Description:	Total lagoon area
Source of data:	Project developer
Value(s) applied):	2.09
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:	Used for calculated project emission calculation; PE_{flare}
Additional comment:	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

Data / Parameter:	Rso_4^{2-}
Unit:	kg/tonne (kg_{COD}/tSO_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 <u>Determining losses of Chemical Oxygen Demand through chemical oxidation:</u> “where the concentration of sulphate is observed to be 1 kg/m^3 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 $kg_{COD}/kgSO_4^{2-}$ => 651 kg_{COD}/tSO_4^{2-}

D.2. Data and parameters monitored

Data / Parameter:	WW_{input}
Unit:	m^3
Description:	Daily wastewater flows entering system boundary
Measured/ Calculated / Default:	Measured
Source of data:	Daily reports by SCADA
Value(s) of monitored parameter:	see table below
Monitoring equipment:	see below
Measuring/ Reading/ Recording frequency:	Measuring 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 emissions calculation
Additional comment:	-

Value(s) of monitored parameter:

Period	Total (m^3)
01/01/2013 – 31/12/2013 (both date are included)	590,488

Monitoring equipment:

Tag No: FT01
Manufacturer: ABB
Type/Model: COPA-XE DE43F
Serial No: Convert: 000469020/X002, Detector: 024436
Calibration frequency : every 2 years
Accuracy class : +/- 0.50 %
Date of last calibration and validity:

Certificate Number	Date of calibration	Validity	Calibrator
LC1208-085	16/08/2012	15/08/2014	Miracle International Technology (MIT)
L1008-187	19/08/2010	18/08/2012	MIT

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

Period	Total (m^3)
01/01/2013 – 31/12/2013 (both date are included)	574,132

Monitoring equipment:	Tag No: FT05 Manufacturer: ABB Type/Model: ProcessMaster Serial No: 3K672012180486 Calibration frequency : every 2 years Accuracy class : +/- 0.40 % Date of last calibration and validity:

Certificate Number	Date of calibration	Validity	Calibrator
12/2/2/500457	14/05/2012	13/05/2014	ABB

Measuring/ Reading/ Recording frequency:	Measuring continuously with a cumulative flow meter located at the pipe leaving 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:	Project emissions calculation
Additional comment:	-

Data / Parameter:	COD_{input}
Unit:	kg_{COD} / m^3
Description:	Wastewater organic material concentration entering the project boundary
Measured/ Calculated / Default:	Measured
Source of data:	Daily analyzed by Lab-technician
Value(s) of monitored parameter:	

Period	Average (kgCOD/m^3)
01/01/2013 – 31/12/2013 (both date are included)	22.062

Monitoring equipment:	Tag No: - Manufacturer: Hach Type/Model: Spectrophotometer / DR2800 Serial No. : 1156884 Calibration frequency : once a year Accuracy class : +/- 1.5 nm Date of last calibration and validity: Tag No: - Manufacturer: Hach Type/Model: COD Reactor / DRB200 Serial No. : 10110C0201 Calibration frequency : once a year Accuracy class : +/- 2 ºC Date of last calibration and validity:
Measuring/ Reading/ Recording frequency:	Measuring daily by an internal laboratory and recording result daily
Calculation method (if applicable):	The test result is reported in mg COD/l. This unit is converted to kg COD/m^3 by simple unit conversion
QA/QC procedures:	Weekly samples are sent to an accredited analytical laboratory for cross-checking with onsite data to assure accuracy
Purpose of data:	Baseline emissions calculation
Additional comment:	-

Spectrophotometer / DR2800:

Certificate Number	Date of calibration	Validity	Calibrator
C06130307	18/09/2013	17/09/2014	SPC
C06120262	22/09/2012	21/09/2013	SPC

COD Reactor / DRB200:

Certificate Number	Date of calibration	Validity	Calibrator
C17130095	19/09/2013	18/09/2014	SPC
C17120085	22/09/2012	21/09/2013	SPC

Data / Parameter:	COD_{output}
Unit:	kg_{COD} / m^3
Description:	Wastewater organic material concentration leaving the treatment facility
Measured/ Calculated / Default:	Measured
Source of data:	Daily analyzed by Lab-technician
Value(s) of monitored parameter:	(see table below)

Period	Average (kgCOD/m^3)
01/01/2013 – 31/12/2013 (both date are included)	5.979

Monitoring equipment:	Tag No: - Manufacturer: Hach Type/Model: Spectrophotometer / DR2800 Serial No. : 1156884 Calibration frequency : once a year Accuracy class : +/- 1.5 nm Date of last calibration and validity: (see table A below) Tag No: - Manufacturer: Hach Type/Model: COD Reactor / DRB200 Serial No. : 10110C0201 Calibration frequency : once a year Accuracy class : +/- 2 ºC Date of last calibration and validity: (see table B below)
Measuring/ Reading/ Recording frequency:	Measuring daily by an internal laboratory and recording result daily
Calculation method (if applicable):	The test result is reported in mg COD/l. This unit is converted to kg COD/m^3 by simple unit conversion
QA/QC procedures:	Weekly samples are sent to an accredited analytical laboratory for cross-checking with onsite data to assure accuracy
Purpose of data:	Project emissions calculation
Additional comment:	-

Table A:

Certificate Number	Date of calibration	Validity	Calibrator
C06130307	18/09/2013	17/09/2014	SPC
C06120262	22/09/2012	21/09/2013	SPC

Table B:

Certificate Number	Date of calibration	Validity	Calibrator
C17130095	19/09/2013	18/09/2014	SPC
C17120085	22/09/2012	21/09/2013	SPC

Data / Parameter:	V_{heat}
Unit:	Nm^3
Description:	Volume of biogas sent to facility heaters
Measured/ Calculated / Default:	Measured
Source of data:	Daily reports by SCADA
Value(s) of monitored parameter:	(see table below)

Period	Total (Nm^3)
01/01/2013 – 31/12/2013 (both date are included)	6,206,243

Monitoring equipment:	Tag No: FT02 Manufacturer: ABB Type : Sensyflow FMT500 IG Serial No. : 241163131 X001 Calibration frequency : every 3 years Accuracy class : +/- 0.50 % Date of last calibration and validity:

Certificate Number	Date of calibration	Validity	Calibrator
0184-D-K-15081-01-00-2011-11	25/11/2011	24/11/2014	ABB

Measuring/ Reading/ Recording frequency:	To be measured continuously, reading and recorded daily
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 calculation
Additional comment:	-

Data / Parameter:	V_{flare} (also $FV_{FG,h}$)
Unit:	Nm^3
Description:	Biogas sent to flare
Measured/ Calculated / Default:	Measured
Source of data:	Daily reports by SCADA
Value(s) of monitored parameter:	

Period	Total (Nm^3)
01/01/2013 – 31/12/2013 (both date are included)	297,102

Monitoring equipment:	Tag No: FT04 Manufacturer: ABB Type/Model: Sensyflow FMT500 IG Serial No. : Sensor: 241151957 X001 Converter: 241151957 Y001 Calibration frequency : every 3 years Accuracy class : +/- 0.50 % Date of last calibration and validity:

Certificate Number	Date of calibration	Validity	Calibrator
0186-D-K-15081-01-00-2011-12	15/12/2011	15/12/2011-14/12/2014	ABB

Measuring/ Reading/ Recording frequency:	To be measured continuously, reading and recorded daily
Calculation method (if applicable):	-

QA/QC procedures:	Biogas meters should be subject to a regular maintenance and testing regime to ensure accuracy. This parameter is equivalent to the variable $FV_{RG,h}$ (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"
Purpose of data:	Project emissions calculation
Additional comment:	-

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:	<table><tr><th>Period</th><th>Average (tonnes/m^3)</th></tr><tr><td>01/01/2013 – 31/12/2013 (both date are included)</td><td>0.000337</td></tr></table>
Monitoring equipment:	Tag No: - Manufacturer: Hach Type/Model: Spectrophotometer / DR2800 Serial No. : 1156884 Calibration frequency : once a year Accuracy class : +/- 1.5 nm 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>C06130307</td><td>18/09/2013</td><td>17/09/2014</td><td>SPC</td></tr><tr><td>C06120262</td><td>22/09/2012</td><td>21/09/2013</td><td>SPC</td></tr></table> Tag No: - Manufacturer: Hach Type/Model: COD Reactor / DRB200 Serial No. : 10110C0201 Calibration frequency : once a year Accuracy class : +/- 2 ºC 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>C17130095</td><td>19/09/2013</td><td>18/09/2014</td><td>SPC</td></tr><tr><td>C17120085</td><td>22/09/2012</td><td>21/09/2013</td><td>SPC</td></tr></table>
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 calculation
Additional comment:	-

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:	<table><tr><th>Period</th><th>Average (tonnes/m³)</th></tr><tr><td>01/01/2013 – 31/12/2013 (both date are included)</td><td>0.0000740</td></tr></table>
Monitoring equipment:	Tag No: - Manufacturer: Hach Type/Model: Spectrophotometer / DR2800 Serial No. : 1156884 Calibration frequency : once a year Accuracy class : +/- 1.5 nm 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>C06130307</td><td>18/09/2013</td><td>17/09/2014</td><td>SPC</td></tr><tr><td>C06120262</td><td>22/09/2012</td><td>21/09/2013</td><td>SPC</td></tr></table> Tag No: - Manufacturer: Hach Type/Model: COD Reactor / DRB200 Serial No. : 10110C0201 Calibration frequency : once a year Accuracy class : +/- 2 ºC 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>C17130095</td><td>19/09/2013</td><td>18/09/2014</td><td>SPC</td></tr><tr><td>C17120085</td><td>22/09/2012</td><td>21/09/2013</td><td>SPC</td></tr></table>
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:	Project emissions calculation
Additional comment:	-

Data / Parameter:	$WW_{bypassing}$
Unit:	m^3
Description:	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 analyzed by SCADA
Value(s) of monitored parameter:	**Period** / **Total (m^3)**: 01/01/2013 – 31/12/2013 (both date are included): 663
Monitoring equipment:	Tag No: FT06 Manufacturer: ABB Type/Model: ProcessMaster Serial No. : 3K672011450101 Calibration frequency : every 2 years Accuracy class : +/- 0.40% Date of last calibration and validity: (see table below)
Measuring/ Reading/ Recording frequency:	Measuring continuously and data recorded hourly
Calculation method (if applicable):	-
QA/QC procedures:	Regular maintenance and calibration of the flow meter
Purpose of data:	-
Additional comment:	-

Period	Total (m^3)
01/01/2013 – 31/12/2013 (both date are included)	663

Certificate Number	Date of calibration	Validity	Calibrator
LC1311-326	14/11/2013	13/11/2015	MIT
11/4/2/215103	17/11/2011	16/11/2013	ABB

Data / Parameter:	Biogas loss from pipeline
Unit:	%
Description:	Loss of biogas from pipeline
Measured/ Calculated / Default:	Measured
Source of data:	Hydrostatic test report by an Accredited Laboratory (see table below)
Value(s) of monitored parameter:	(see table below)

Report Number	Testing date	Validity	Tester
RP-P51-130924	09/08/2013	08/08/2014	STIC

Period	Biogas loss from pipeline
01/01/2013 – 31/12/2013 (both date are included)	0

Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	Integrity of biogas pipeline for losses of biogas methane is tested annually through pressurizing the system and establishing pressure drops through leakage
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.
Purpose of data:	Project emissions calculation
Additional comment:	-

Data / Parameter:	NCV_{biogas}
Unit:	J/Nm^3
Description:	Biogas calorific value
Measured/ Calculated / Default:	Measured
Source of data:	NCV test report by Accredited Laboratory
Value(s) of monitored parameter:	
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	To be measured annually
Calculation method (if applicable):	-
QA/QC procedures:	-
Purpose of data:	Baseline emissions calculation
Additional comment:	-

Source of data:

Testing report Number	Testing date	Validity	Tester
COA-EX-1309-00143	29/08/2013	28/08/2014	PTTGC

Value(s) of monitored parameter:

Period	NCV_{biogas} (J/Nm^3)
01/01/2013 – 31/12/2013 (both date are included)	21,125,827

Data / Parameter:	PE_{flare}
Unit:	tCO_2
Description:	Project emissions from flaring of the residual gas stream
Measured/ Calculated / Default:	Calculated
Source of data:	Emission reduction calculation sheet
Value(s) of monitored parameter:	**Period** / **PE_{flare} (tCO_2e)**: 01/01/2013 – 31/12/2013 (both date are included) — 1,481.457
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	-
Calculation method (if applicable):	Following the “Tool to determine project emissions from flaring gases containing methane”
QA/QC procedures:	-
Purpose of data:	Project emissions calculation
Additional comment:	-

Period	PE_{flare} (tCO_2e)
01/01/2013 – 31/12/2013 (both date are included)	1,481.457

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:	Emission reduction calculation sheet
Value(s) of monitored parameter:	**Period** / **Total (dm^3)**: 01/01/2013 – 31/12/2013 (both date are included) — 3,278,128.240
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	-
Calculation method (if applicable):	Calculated from the monitored V_{heat} multiplied by monitored NCV_{Biogas} and divided by fixed parameter NCV_{fuel}
QA/QC procedures:	-
Purpose of data:	Baseline emission calculation
Additional comment:	-

Period	Total (dm^3)
01/01/2013 – 31/12/2013 (both date are included)	3,278,128.240

Data / Parameter:	C_{CH4} (also $FV_{CH4,y}$)
Unit:	% of Nm^3/Nm^3
Description:	Biogas methane concentration
Measured/ Calculated / Default:	Measured
Source of data:	SCADA midnight report
Value(s) of monitored parameter:	<table><tr><th>Period</th><th>Average (% of Nm³/Nm³)</th></tr><tr><td>01/01/2013 – 31/12/2013 (both date are included)</td><td>58.285</td></tr></table>
Monitoring equipment:	Tag No: XT01 Manufacturer: JE Type : Guardian Plus Serial No. : 35184 Calibration frequency : 1 years Accuracy class : +/- 1 % Date of last calibration and validity: 19/06/2013 – 31/12/2013 <table><tr><th>Certificate number</th><th>Date of calibration</th><th>Validity</th><th>Calibrator</th></tr><tr><td>2013/04-18</td><td>18/04/2013</td><td>17/04/2014</td><td>JE</td></tr></table> Manufacturer: ANRI Type : Gas Analyser Serial No.: LFB-028 Calibration frequency : 1 years Accuracy class : +/- 1 % Date of last calibration and validity: 01/01/2013 – 18/06/2013 <table><tr><th>Certificate number</th><th>Date of calibration</th><th>Validity</th><th>Calibrator</th></tr><tr><td>G 550249</td><td>15/08/2012</td><td>17/08/2013</td><td>Entech</td></tr></table>
Measuring/ Reading/ Recording frequency:	Measured continuously, reading and recorded daily.
Calculation method (if applicable):	-
QA/QC procedures:	-
Purpose of data:	Project emissions calculation
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 CCH_4 in tCH_4/Nm^3.

Data / Parameter:	f_{heat}
Unit:	%
Description:	Heating system combustion efficiency
Measured/ Calculated / Default:	Measured
Source of data:	Combustion efficiency test report by External laboratory
Value(s) of monitored parameter:	**Period** / **f_{heat} (%)**: 01/01/2013 – 31/12/2013 (both date are included) / 90.760
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	Measuring and recording at least annually
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 calculation
Additional comment:	-

Period	f_{heat} (%)
01/01/2013 – 31/12/2013 (both date are included)	90.760

Data / Parameter:	$M_{Removed}$
Unit:	t COD
Description:	Organic material removed from wastewater facility
Measured/ Calculated / Default:	Calculated
Source of data:	Calculated based on monitored parameters COD_{input} and COD_{output}
Value(s) of monitored parameter:	**Period** / **$M_{Removed}$ (tCOD)**: 01/01/2013 – 31/12/2013 (both date are included) / 9,594.53
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	-
Calculation method (if applicable):	The parameter is calculated from COD_{input} and COD_{output}. $M_{Removed} = [(WW_{input} \times COD_{in}) - (WW_{output} \times COD_{out})]/1000$
QA/QC procedures:	-
Purpose of data:	-
Additional comment:	-

Period	$M_{Removed}$ (tCOD)
01/01/2013 – 31/12/2013 (both date are included)	9,594.53

D.3. Implementation of sampling plan

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There is no data and 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

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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 emissions.

Total Baseline emissions:

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

Where:

E_{BL}	=	total baseline emissions (tCO_2e).
$E_{CH4\_lagoons\_BL}$	=	the fugitive methane emisisons from lagoons in the baseline case (tCO_2e).
$E_{CO2\_heat\_BL}$	=	CO_2 emisisons 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 of 01/01/2013 – 31/12/2013

E_{BL}	$E_{CH4\_lagoon\_BL}$	$E_{CO2\_heat\_BL}$	$E_{CO2\_power\_BL}$
tCO_2e	tCO_2e	tCO_2e	tCO_2e
72,885	62,742	10,144	0

Total baseline emissions during period 01/01/2013 - 31/12/2013 (both dates are included) is 72,885 tCO_2e.

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

In the calculation of 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). This is estimated as product of: (1) Average specific fuel consumption for the output of the facility and (2) The annual production.
NCV	=	the net calorific value of the fossil fuel considers (TJ/unit).
EF	=	the carbon emission factor of the fossil fuel considers (tCO_2/TJ).

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:

$$E_{CO2\_heat} = \left(F_{biogas\_heat} \times \frac{NCV_{biogas}}{NCV_{fueloil}} \right) \times NCV_{fueloil} \times EF$$

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:

$$E_{CO2\_heat} = F_{biogas\_heat} \times NCV_{biogas} \times EF$$

Period of 01/01/2013 - 31/12/2013

E_{CO2_heat}	F	$NCV_{fuel\ oil}$	EF
tCO_2e	Nm^3	TJ/Nm^3	tCO_2/TJ
10,144	327,813	3.99960E-04	77.367

Noted: 77.367 tCO_2/TJ has been applied for the carbon emission factor of the fuel oil refereed to IPCC default value from Table 3.1, Chapter 1 vol.2

The total CO_2 emission from on-site heat displaced by biogas collected in the anaerobic treatment from 01/01/2013 - 31/12/2013 (both dates are included) is 10,144 tCO_2e.

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.

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 waste water 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.

Hence, the equation to determine the fugitive methane emission from lagoons for project emissions 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} = 25)

Note: A default COD to methane conversion factor of 0.21 kg CH_4/kg COD is used referred 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 of 01/01/2013 - 31/12/2013 (both dates are included)

$E_{CH4\_lagoon\_BL}$	$M_{lagoon\_anaerobic}$	EF_{CH4}	GWP_{CH4}
tCO_2e	kg COD	-	-
62,742	11,950,878	0.21	25

Total fugitive methane emission from lagoons in baseline scenario in this monitoring period from 01/01/2013 - 31/12/2013 (both dates are included) is 62,742 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
- 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 of 01/01/2013 - 31/12/2013 (both dates are included)

$M_{lagoon\_anaerobic}$	M_{lagoon_total}	$M_{lagoon\_aerobic}$	$M_{lagoon\_chemical\_ox}$	$M_{lagoon\_deposition}$
kg COD	kg COD	kg COD	kg COD	kg COD
11,950,878	12,505,972	193,764	129,449	231,882

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:

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

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

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

Period of 01/01/2013 - 31/12/2013 (both dates are included)

M_{lagoon_input}	M_{input_total}	R_{NAWTF}
kg COD	kg COD	-
13,027,055	13,027,055	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 period 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 tested during validation process. Refer to registered PDD-page 22, the R_{lagoon} is 96%.

Period of 01/01/2013 - 31/12/2013 (both dates are included)

M_{lagoon_total}	M_{lagoon_input}	R_{lagoon}
kg COD	kg COD	%
12,505,972	13,027,055	96

Material degraded aerobically in the lagoon system

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

Noted: 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 of 01/01/2013 - 31/12/2013 (both dates are included)

$M_{lagoon\_aerobic}$	Constant value	Pond surface area	Operation day
kg COD	kg COD/ha/day	ha	day
193,764	254	2.09	365

Material lost through chemical oxidation in lagoon system

$$M_{lagoon\_chemical\_ox} = C_{SO_4^{2-} in} \cdot R_{SO_4^{2-}}$$

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 absorbed (t SO_4^{2-})
$R_{SO4^{2-}}$ = reduction factor for SO_4^{2-} oxidative substance

Period of 01/01/2013 - 31/12/2013 (both dates are included)

$M_{lagoon\_chemical\_ox}$	$C_{so42-in}$	R_{SO42-}
kg COD	t $_{SO42-}$	kg COD / t $_{SO42-}$
129,449	198.85	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.

Noted: 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 of 01/01/2013 - 31/12/2013 (both dates are included)

$M_{lagoon\_deposition}$	M_{lagoon_input}	$R_{deposition}$
kg COD	kg COD	%
231,882	13,027,055	1.78

According to the calculation above, the conclusion of baseline emissions in this monitoring period (01/01/2013 - 31/12/2013, both dates included) can be presented in the table below:

Time Period	Baseline emissions or baseline net GHG removals by sinks (tCO_2e)
01/01/2013 - 31/12/2013	72,885
Total	**72,885**

Nevertheless, to verify that the equation delivers a conservative estimate of emission reductions, the equation below is taken into account;

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

Where:

E_{CH4_coll} = the amount of methane expressed in (tCO_2e) contained in the biogas collected from the anaerobic treatment facility

Result	$E_{CH4\_lagoon\_BL}$	E_{CH4_lagoon}	E_{CH4_nawtf}	E_{CH4_coll}
-	tCO_2e	tCO_2e	tCO_2e	tCO_2e
- 8,622	62,742	3,439	0	67,925

$E_{CH4\ coll}$ obtained from equation;

$$E_{CH4\_coll} = (V_{heat} + V_{power} + V_{flare}) \times C_{CH4} \times \rho_{CH4} \times GWP_{CH4})$$

E_{CH4_coll}	V_{heat}	V_{power}	V_{flare}	C_{CH4}	ρ_{CH4}	GWP_{CH4}
tCO_2e	Nm3	Nm3	Nm3	%	tCH_4/Nm^3CH_4	-
67,925	6,206,243	0	297,102	58.28	0.0007168	25

Since the result is negative, no need to be deducted from the baseline emissions. Therefore, the baseline emissions is 62,742 tCO_2e.

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

>>

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 emissions (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 of 01/01/2013 - 31/12/2013 (both dates are included)

$E_{project}$	E_{CH4_lagoon}	E_{CO2_NAWTF}	$E_{CO2\_IC+Leaks}$
tCO_2e	tCO_2e	tCO_2e	tCO_2e
4,981	3,439	0	1,542

Total project emissions during of 01/01/2013 - 31/12/2013 (both dates are included) is 4,981 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} = 25)

Noted: A default COD to methane conversion factor of 0.21 kg CH_4/kg COD is used referred 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 of 01/01/2013 - 31/12/2013 (both dates are included)

E_{CH4_lagoon}	$M_{lagoon\_anaerobic}$	EF_{CH4}	GWP_{CH4}
tCO_2e	kg COD	-	-
3,439	655,018	0.21	25

The total fugitive methane emission from lagoons during this monitoring period (01/01/2013 - 31/12/2013, both dates included) is 3,439 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 of 01/01/2013 - 31/12/2013 (both dates are included)

$M_{lagoon\_anaerobic}$	M_{lagoon_total}	$M_{lagoon\_aerobic}$	$M_{lagoon\_chemical\_ox}$	$M_{lagoon\_deposition}$
kg COD	kg COD	kg COD	kg COD	kg COD
655,018	892,999	193,764	27,660	16,558

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 (-).

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

Period of 01/01/2013 - 31/12/2013 (both dates are included)

M_{lagoon_input}	M_{input_total}	R_{NAWTF}
kg COD	kg COD	-
930,207	3,432,522	0.73

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

Noted: 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 period 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 tested during validation process. Referred to registered PDD-page 22, the R_{lagoon} is 96%.

Period of 01/01/2013 - 31/12/2013 (both dates are included)

M_{lagoon_total}	M_{lagoon_input}	R_{lagoon}
kg COD	kg COD	%
892,999	930,207	96

Material degraded aerobically in the lagoon system

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

Noted: 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 of 01/01/2013 - 31/12/2013 (both date are included)

$M_{lagoon\_aerobic}$	Constant value	Pond surface area	Operation day
kg COD	kg COD/ha/day	ha	day
193,764	254	2.09	365

Material lost through chemical oxidation in lagoon system

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

Where:

- $M_{lagoon\_chemical\_ox}$ = the amount of organic material lost through deposition in the lagoon system (kg COD)
- $C_{SO42-\ out}$ = concentrate of oxidative substance SO_4^{2-} at the effluent of the digester (t/m^3)
- $R_{SO_4^{2-}}$ = reduction factor for SO_4^{2-} oxidative substance

Period of 01/01/2013 - 31/12/2013 (both dates are included)

$M_{lagoon\_chemical\_ox}$	$Cso_4{}^{2-}{}_{out}$	Rso_4^{2-}
kgCOD	t/m^3	kgCOD/tso$_4^{2-}$
27,660	0.0000740	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.

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

Period of 01/01/2013 - 31/12/2013 (both dates are included)

$M_{lagoon\_deposition}$	M_{lagoon_input}	$R_{deposition}$
kg COD	kg COD	%
16,558	930,207	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 other party annually. The result during this monitoring period (01/01/2013-31/12/2013, both dates are included) found there were no leakages. Therefore, the methane emission from new anaerobic wastewater treatment facility is 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.

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

Since there is no electricity generated from biogas in this project, $E_{CH4\ power} = 0$;

therefore;

$$E_{CH4\_IC+Leaks} = (\sum_r V_r \cdot C_{CH4\_r} \cdot (1 - f_r) \cdot GWP_{CH4}) + PE_{flare}$$

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

For this project activity, r = heat only; then

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

E_{CH4_heat}	V_{heat}	C_{CH4_heat}	f_{heat}	GWP_{CH4}
tCO_2e	Nm^3	tCH_4/Nm^3	%	-
60	6,206,243	0.000418	90.76	25

PE_{flare} is 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 fare 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.

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

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 (N_2). 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 ($p_{CH4,n,h}$) 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 ($TM_{RG,h}$) 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	Temp	$TM_{RG,h}$	Hourly flare efficiency	$PE_{flare,h}$	$PE_{flare,y}$
Unit	hh:mm	Nm3/h	%	Minute	°C	kg/h	%	tCO2e/h	tCO2e
8-Oct-13	1:00	0	0	0	0	0.00	0	0.000	
	2:00	0	0	0	0	0.00	0	0.000	
	3:00	0	0	0	0	0.00	0	0.000	
	4:00	0	0	0	0	0.00	0	0.000	
	5:00	0	0	0	0	0.00	0	0.000	
	6:00	0	0	0	0	0.00	0	0.000	
	7:00	0	0	0	0	0.00	0	0.000	
	8:00	0	0	0	0	0.00	0	0.000	
	9:00	0	0	0	0	0.00	0	0.000	
	10:00	0	0	0	0	0.00	0	0.000	
	11:00	980	58.2	60	509	408.83	50	5.110	
	12:00	1010	58	60	510	419.90	50	5.249	
	13:00	1012	58.2	60	510	422.18	50	5.277	
	14:00	1020	58.4	60	509	426.98	50	5.337	
	15:00	1014	58.2	60	510	423.02	50	5.288	
	16:00	0	0	0		0.00	0	0.000	
	17:00	0	0	0		0.00	0	0.000	
	18:00	0	0	0		0.00	0	0.000	
	19:00	0	0	0		0.00	0	0.000	
	20:00	0	0	0		0.00	0	0.000	
	21:00	0	0	0		0.00	0	0.000	
	22:00	0	0	0		0.00	0	0.000	
	23:00	0	0	0		0.00	0	0.000	
	0:00	0	0	0		0.00	0	0.000	26.262

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

Period	PE_{flare} (tCO_2e)
01/01/2013 - 31/12/2013 (both dates are included)	1,481.457

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

$E_{CH4\_IC+leaks}$	E_{CH4_heat}	E_{CH4_power}	PE_{flare}
tCO_2e	tCO_2e	tCO_2e	tCO_2e
1,542	60	0	1,481

According to the calculation above, the conclusion of project emissions in this monitoring period (01/01/2013 - 31/12/2013, both dates included) can be presented in the table below:

Time Period	Project emissions or actual net GHG removals by sinks (tCO_2e)
01/01/2013 - 31/12/2013 (both date are included)	4,981
Total	**4,981**

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. Leaks monitored on a daily basis and the pipeline pressurized testing annually, as required by AM0022. A conservative value of 1 % was included in the ex-ante emissions reductions calculations. However, as the annual test report for pressure test at pipelines could be 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

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)
01/01/2013 - 31/12/2013 (both dates are included)	72,885	4,981	0	67,904
Total	**72,885**	**4,981**	**0**	**67,904**

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
Emission reductions or GHG removals by sinks (t CO_2e)	48,167 (per annum)	67,904

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

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The emission reductions achieved during this monitoring period (01/01/2013 – 31/12/2013, both dates are included) are higher than the ex-ante. This is occurred from a significant difference of project emissions between ex-ante and ex-post calculation. According to the project emissions in the ex-ante ER calculation on the UNFCCC project webpage, the COD of treated water from reactor to open lagoon was 26,099 mgCOD/l (registered PDD, page 47), which is the same amount as COD_{input} for baseline emissions calculation. In fact, this amount of COD should be deducted from the efficiency of new anaerobic reactor to be the COD used for project emissions calculation. The actual amount of COD out from the new anaerobic reactor to open lagoon was 5.979 mgCOD/m^3 (ER calculation sheet tab 'Raw data' cell H376). Hence, it makes the project emissions significantly lower than the calculation in the registered PDD.

Another reason that makes the emission reductions higher than the estimate in the registered PDD is about the change of methane emission factor (GWP_{CH4}), referred to the UNFCCC; EB69, Annex3. The GWP_{CH4} has been changed from 21 t_{CH4}/t_{CO2} to 25 t_{CH4}/t_{CO2}. Therefore, the emission reductions are found increased 29.07%, from 48,167 tCO_2e to be 67,904 t CO_2e.

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)	N/A	67,904

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ANNEX 1

The downtimes of plant during 01/01/2013 – 31/12/2013 (both dates are included)

Month	Date	Event	Reason
JAN	01/01/13	Host factory shutdown, no influent to the biogas system	Public holiday
	02/01/13	Host factory shutdown, no influent to the biogas system	Public holiday
	03/01/13	Host factory shutdown, no influent to the biogas system	Public holiday
APR	10/04/13	Host factory shutdown, no influent to the biogas system	Public holiday
	11/04/13	Host factory shutdown, no influent to the biogas system	Public holiday
	12/04/13	Host factory shutdown, no influent to the biogas system	Public holiday
	13/04/13	Host factory shutdown, no influent to the biogas system	Public holiday
	14/04/13	Host factory shutdown, no influent to the biogas system	Public holiday
	15/04/13	Host factory shutdown, no influent to the biogas system	Public holiday
	16/04/13	Host factory shutdown, no influent to the biogas system	Public holiday
	17/04/13	Host factory shutdown, no influent to the biogas system	Public holiday
	18/04/13	Host factory shutdown, no influent to the biogas system	Public holiday
MAY	11/05/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	12/05/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	13/05/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	14/05/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	15/05/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	31/05/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
JUL	02/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	03/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	04/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	05/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	06/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	07/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	08/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	09/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	10/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	11/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	12/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	13/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	14/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	15/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	16/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	17/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	18/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	19/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	20/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	21/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	22/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	23/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation

Month	Date	Event	Reason
JUL	24/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	25/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
	26/07/13	Host factory shutdown, no influent to the biogas system	Host factory no operation
DEC	26/12/13	Host factory shutdown, no influent to the biogas system	Public holiday
	27/12/13	Host factory shutdown, no influent to the biogas system	Public holiday
	28/12/13	Host factory shutdown, no influent to the biogas system	Public holiday
	29/12/13	Host factory shutdown, no influent to the biogas system	Public holiday
	30/12/13	Host factory shutdown, no influent to the biogas system	Public holiday
	31/12/13	Host factory shutdown, no influent to the biogas system	Public holiday

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Document information

Version	*Date*	*Description*
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 anthropogenic GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
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