MONITORING REPORT FORM (CDM-MR)
Version 01 - in effect as of: 28/05/2010

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MONITORING REPORT
version 01 , 24/06/11

CHAO KHUN AGRO BIOGAS ENERGY PROJECT
Project Number: 2138
(1st monitoring period; 09/03/2009 - 31/03/2011 include both dates)

SECTION A. General description of the project activity

A.1. Brief description of the project activity: >>

>>
1. Purpose of the project activity and the measures taken to reduce greenhouse gas emissions;

The Chao Khun Agro Biogas Energy Project (hereafter, the Project) developed by Thai Biogas Energy Company Ltd (hereafter referred to as "TBEC, "or the Project Developer) is an anaerobic digestion project, which treats wastewater from the cassava processing factory owned by Chao Khun Agro Products (hereafter referred to as the Facility) in Saraburi, Thailand.

The Covered In-Ground Anaerobic Reactor (CIGAR) removed the organic material in the wastewater, thus reducing the Chemical Oxygen Demand (COD) and subsequent fugitive CH_4 emissions. Biogas produced in the CIGAR is used in the Chao Khun Agro Products factory to dry the wet starch cake to the final dry starch product, thereby displacing the fuel oil currently employed to dry the starch product. Surplus biogas, where produced, is flared rather than released to the atmosphere.

2. Brief description of the installed technology and equipments;

The technology for the proposed project , and the equipment had to be imported. The technology adopted is an advanced a Covered In-Ground Anaerobic Reactor (CIGAR), a technology developed by a New Zealand company, Waste Solutions Ltd. The CIGAR system consists of a series of baffled reactors covered by thick HDPE covers, connected by overflow weirs, plus gas blowers, as well as a state-of-the-art monitoring system. Besides, major equipments such as dual fuel burner and gas blowers have been imported from Germany and New Zealand, respectively.

3. Total emission reductions achieved in this monitoring period; The calculated emission reduction amounts to a total of 85,487 tCO2e

A.2. Project Participants

>>
Host Parties **Thailand ,** involved indirectly; Authorized Participants: Thai Biogas Energy Company

Other Parties Involved;

- **United Kingdom of Great Britain and Northern Ireland**, involved indirectly; Authorized Participants: EcoSecurities Group plc.
- **Sweden**, involved indirectly; Authorized Participants: Swedish Energy Agency
- **Spain**, involved directly; Authorized Participants: Kingdom of Spain

A.3. Location of the project activity:

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Chao Khun Agro Products Project, 44 Moo 2, Songkorn, Kaengkoi, Saraburi, 18110, Thailand. The GPS coordinates are: 14°35'59.28"N 101°00'41.30"E.

A.4. Technical description of the project

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The project involve three important components, each requiring the transfer of technology, each at different stages of characterization in the region and worldwide.

1. Fugitive Methane Mitigation: The primary emissions reduction component stems from capturing fugitive methane emissions through a Covered In-Ground Anaerobic Reactor, a type of anaerobic digester, which consists of a series of baffled reactors connected only by overflow weirs. The CIGAR may include a final settling unit. The CIGAR was first developed by Waste Solutions Ltd. in New Zealand. In addition to the anaerobic digester itself, the CIGAR consists of a piping system that moves the biogas from the digester to the flare and dual fuel burner, as well as a state-of-the-art monitoring system.

2. Fuel Switching to use Biogas: In the project activity, heat is generated in a Loos boiler with capacity 15 ton steam per hour at 195°C and 13 bar. The burner is a WKGMS70/2-A Weishaupt burner. Both the boiler and burner are sourced from Germany.

Any excess biogas is sent to a flare. The flare is an Organics Ltd flare with a capacity of 2,000 Nm^3 per hour. The flame is detected by a UV sensor.

A.5. Title, reference and version of the baseline and monitoring methodology applied to the project activity:

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AM0022 ver. 4 - Avoided Wastewater and On-site Energy Use Emissions in the Industrial Sector

A.6. Registration date of the project activity:

>>

09/03/09

A.7. Crediting period of the project activity and related information (start date and choice of crediting period):

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09/03/09 – 08/03/09 (Fixed)

A.8. Name of responsible person(s)/entity(ies):

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The monitoring report is compiled by Thai Biogas Energy Company and reviewing by EcoSecurities

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SECTION B. Implementation of the project activity

B.1. Implementation status of the project activity

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The project activity was commissioned on 16/12/06. Since then the CDM project activity has been implemented and operated as per the registered PDD.

Events or situations that occurred during the monitoring period:

Date or time frame	Special events
29/08/09 – 21/09/08	**FT01 flow meter fails** due to the thunder bolt. The following method has been applied to calculate the WW volume: • 29/08/09 – 30/08/09: WWinlet was estimated based on the average WWinlet from 22/08/2009 – 28/08/2009. • 31/08/09 – 21/09/09: FT01 has been replaced with FT05. In the same time WWoutlet was calculated base on the mass balance equation. The detail of calculation is showed below this table*
02/04/10 – 10/05/10	**Gas analyzer was broken** – Gas analyzer of project had been broken because of moisture in gases, so methane content was not measured at that time. The methane content was fixed the values by average historical value from the previous months while the equipment was in a well functional. The constant value at 59.11 %CH_4 is used for the failure period. This value is calculated base on the 95% confidence interval. No spare part was unavailable, until end of period. For more details on the calculation please refer to the excel workbook under tab “95%confidencial analysis” and “%CH4_normal distribution”. The calculated step is provided at Annex 4 and excel spreadsheet.
09/03/09 – present	**FT06 changes history:** 09/03/09 – Installed bypassing meter Endress Houser S/N: A4014420000 01/04/10 – Endress Houser S/N: A4014420000 has been replaced with ABB S/N: 6710090063 due to the failure. 08/09/10 **-** ABB S/N: 6710090063 has been replaced with ABB S/N: DE41F/Converter: 00042083 1/Y004 Detector: 000282 I 53D (001) due to the failure.
	According to the CDM procedure a cross check was carried out every week among the results of COD testing carried out by internal and external laboratories. (Both for Inlet & outlet streams). The results are found in the acceptable tolerance limits of ±10%. In few cases where the variation was greater than the said limit , the results of testing carried out by in-house laboratory is used because the same are found to be more accurate and conservative. The variation in the result are attributed to inconsistencies in testing methods and the far distance between site and external lab and time gap between collection

	and testing of samples.. The analysis of result of this checking has been plotted below as well as included in the excel workbook.
21/04/10 - 31/05/10	The efficient boiler testing (f_{heat}) was missed the test by 71 days in year 2010 which started from 21/04/10 to 31/05/10 The 95%confidence interval analysis is applied to this period which is calculated base on the %efficient testing value both 2009l and 2010.

*, The effluent values was fixed by theoretically conservative values refer to Mass balance equation [1] of which one have been used to be calculating the sludge remaining within anaerobic digester system. Actually, Solid substance will be remain in system by using this equation which it was depend on retention time of reactor capacity, Concentration of solid substance in reactor (M), Mean cell residence time (MCRT), Sludge abandonment rate of reactor (F_w) and other values relevance as follow equation table in Annex 3.

Mass Balance Equation;

$$M = \left(\frac{\theta_c}{T}\right) x \left[\left(1-\xi_g\right)\times M_{go} + M_{fo}\right]$$

And

$$F_w = \left[V\times\left(\frac{M}{M_w}\right)\right] / \theta_{ch}$$

Where;

M	=	Concentration of solid substance in reactor (M)
θ_c	=	Mean cell residence time (MCRT)
T	=	Retention times
ξ_g	=	Demolition fraction of VSS at θ_c (95% from TSS)
M_{go}	=	Influents of volatile solid substance concentration
M_{fo}	=	Influents of solid substance of sludge concentration
F_w	=	Sludge abandonment rate of reactor
V	=	Reactor Capacity
M_w	=	Effluent of volatile solid substance concentration
θ_{ch}	=	MCRT; Mean cell residence time

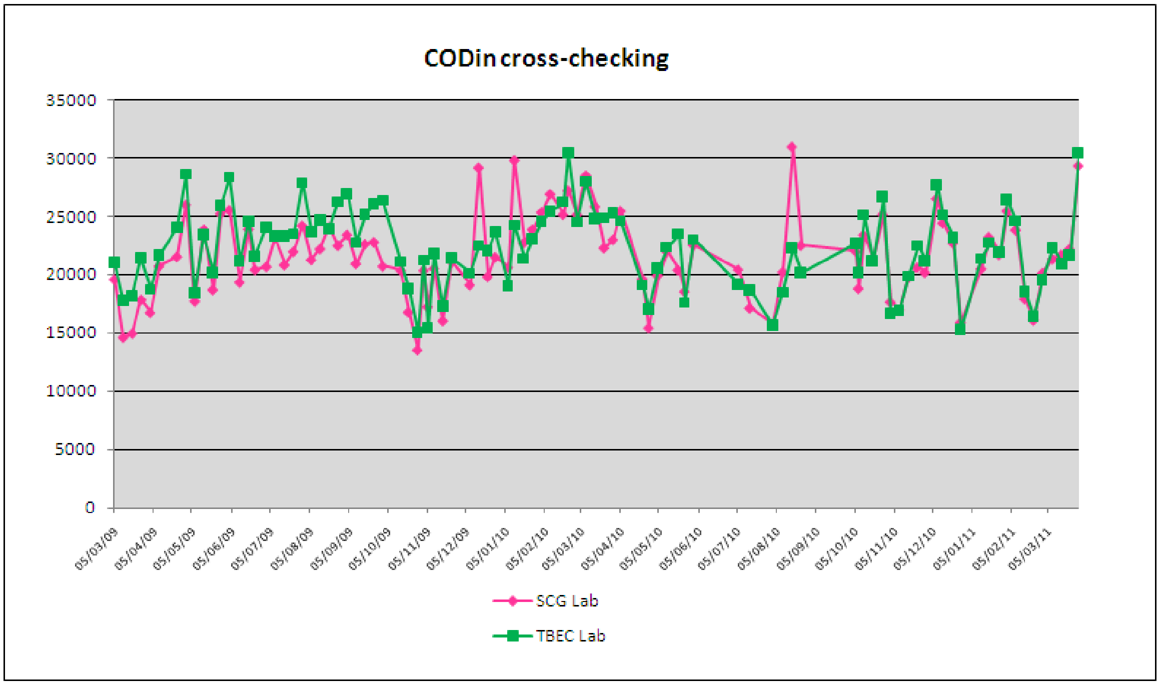
[1] Tom D. Reynolds and Paul A. Richards. (1995) Unit Operations and Processes in Environmental Engineering, PWS Publishing Co.tld.

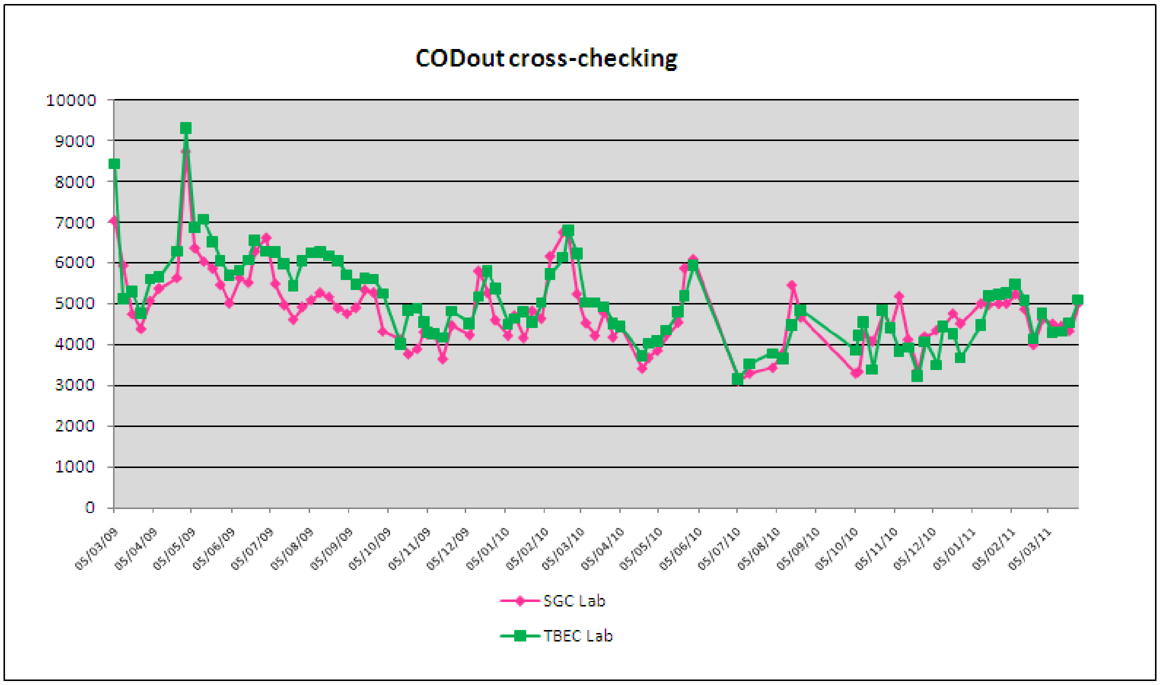
Table 1

This table shows the effluent values that are calculated based on the above mass balance equation.

Date	Influent rate m^3	$TSS_{\inf low}$ Mg/l	$TSS_{outflow}$ Mg/l	F_w m^3	Effluent m^3
31/08/09	1,867	8,300	3,650	150.79	1,716
01/09/09	1,685	8,300	3,650	122.83	1,562
02/09/09	1,314	8,550	3,450	81.40	1,233
03/09/09	2,175	6,550	4,800	122.81	2,052
04/09/09	2,251	6,550	4,800	131.54	2,119
05/09/09	2,184	6,550	4,800	123.83	2,060
06/09/09	940	8,100	4,250	32.04	908
07/09/09	1,852	6,400	3,500	119.32	1,733
08/09/09	1,893	6,850	3,450	135.36	1,758
09/09/09	2,480	7,200	3,950	213.28	2,267
10/09/09	2,187	8,850	4,200	191.74	1,995
11/09/09	2,017	8,850	4,200	163.09	1,854
12/09/09	2,256	8,850	4,200	204.02	2,052
13/09/09	1,798	10,150	3,800	164.28	1,634
14/09/09	2,011	4,350	4,350	76.94	1,934
15/09/09	2,286	7,250	3,850	187.21	2,099
16/09/09	2,351	10,200	3,800	282.25	2,069
17/09/09	1,890	7,900	4,350	123.42	1,767
18/09/09	2,053	7,900	4,350	145.62	1,907
19/09/09	2,140	7,900	4,350	158.23	1,982
20/09/09	2,196	7,900	4,350	166.61	2,029
21/09/09	2,206	9,950	5,500	167.49	2,039

COD cross-checking against external lab





In case of actual operation of the project, the host factory stopped operation in 2 main cases as follow;

a. The price of cassava was high on mid of this year (June, 2010). Therefore, the host factory stopped operation for a month.

b. In case of the low season of cassava during the public holidays such as New year day

and Songkarn days, it directly affected to the project because it didn't have the wastewater for reducing emission which tCO_2 will be directly affected to the total emission reduction.

COD cross-checking against external lab

According to the CDM procedure that the differentiate percentage between COD internal and external lab will be accepted at ±10%. The result of this checking is that almost every weeks that have passed the acceptable point. However, please be clarified that there were an uncontrolled factors that made the differentiate higher or lower than ±10% which are the different method used in the lab, the far distance between site and external lab that might cause the COD result.

However, this does not have any impact on the conservativeness of the reported data because analysis of the results show that it is more accurate and conservative to maintain the COD performed on site as being the reported COD. The analysis of result of this checking has been included in the excel workbook.

B.2. Revision of the monitoring plan

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The monitoring plan was not revised and no revision is pending.

B.3. Request for deviation applied to this monitoring period

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No request for deviation was applied during this monitoring period.

B.4. Notification or request of approval of changes

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No notification or request of approval of changes has been made.

SECTION C. Description of the monitoring system

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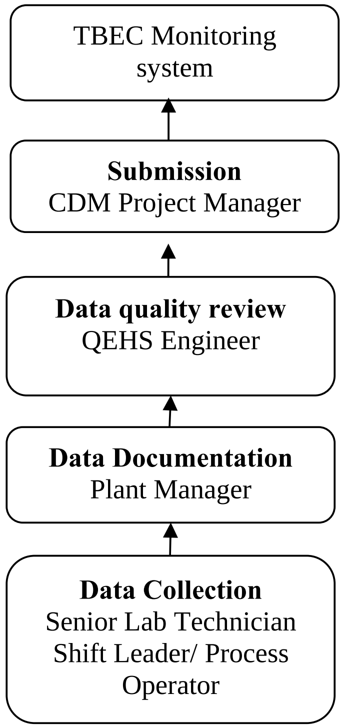
Organizational structure, roles and responsibilities

TBEC is responsible for the on-site monitoring and implementation of the quality assurance and quality management system (ISO: 9001/2008) 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.



a. Shift Leader/Process Operator

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

b. Senior Lab Technician

TBEC has designated Senior Lab Technician to fulfil the primary monitoring activities, mostly on wastewater analysis. Senior Lab Technician is 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 is 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 designate a QEHS Engineer to administer the monitoring plan and ensure Quality Assurance and Quality Control Procedures are adherent. The QEHS Engineer is responsible for internal integrating the Monitoring Plan to TBECs operation and maintenance procedures for the site. The QEHS Engineer

is 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 ensure that all meters and monitoring equipment meet the required accuracy and manufacturing standards. During the project, they 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 is followed up by the QEHS Engineer who 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 are also participate in a yearly audit.

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

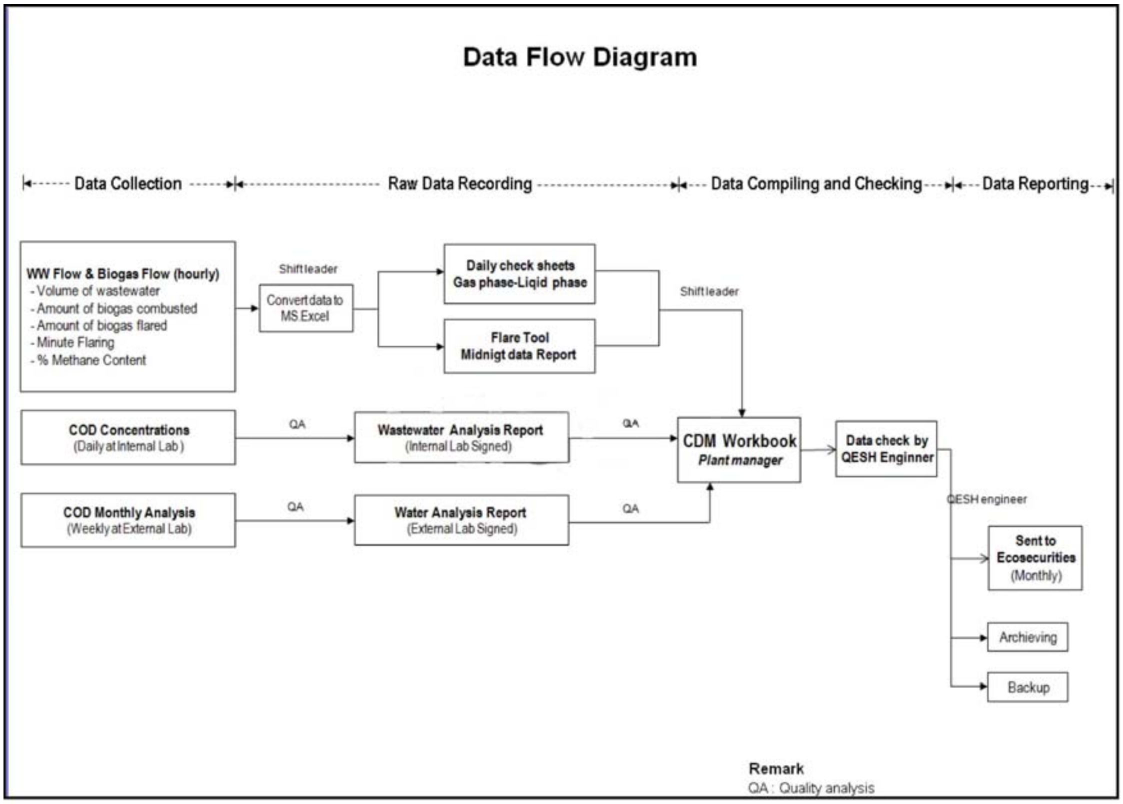
e. Senior Engineer/CDM Project Manager

TBEC designate a Senior Engineer/CDM Project Manager to oversee the preparation of the project annual Monitoring Report. They 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. However, if this position is under vacancy, the COO of the company act in place of this position until the company could find the qualify person for this position.

All data required for verification and issuance are 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 is archived electronically and data backup are maintained. Paper data backup is also 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
Data generation: TBEC reads the monitored parameters mentioned in section D.2. daily.
Data recording: The data are written down in a form and put into an excel sheet. Except for the SCADA midnight report that is automatically printed out every day at midnight for the flare monitoring parameters
Data aggregation: The calculated of CERs are summed over the monitoring period.
Calculation: See section D.2. and section E.
Reporting: The calculated values are included in an Excel sheet and reported in the CDM-MR.


Data Flow Diagram
Data Collection
Raw Data Recording
Data Compiling and Checking
Data Reporting
WW Flow & Biogas Flow (hourly)
- Volume of wastewater
- Amount of biogas combusted
- Amount of biogas flared
- Minute Flaring
- % Methane Content
Shift leader
Convert data to MS Excel
Daily check sheets
Gas phase-Liqid phase
Flare Tool
Midnigt data Report
Shift leader
COD Concentrations
(Daily at Internal Lab)
QA
Wastewater Analysis Report
(Internal Lab Signed)
QA
CDM Workbook
Plant manager
Data check by
QESH Enginner
COD Monthly Analysis
(Weekly at External Lab)
QA
Water Analysis Report
(External Lab Signed)
QA
QESH engineer
Sent to
Ecosecurities
(Monthly)
Archieving
Backup
Remark
QA : Quality analysis

Process Flow diagram

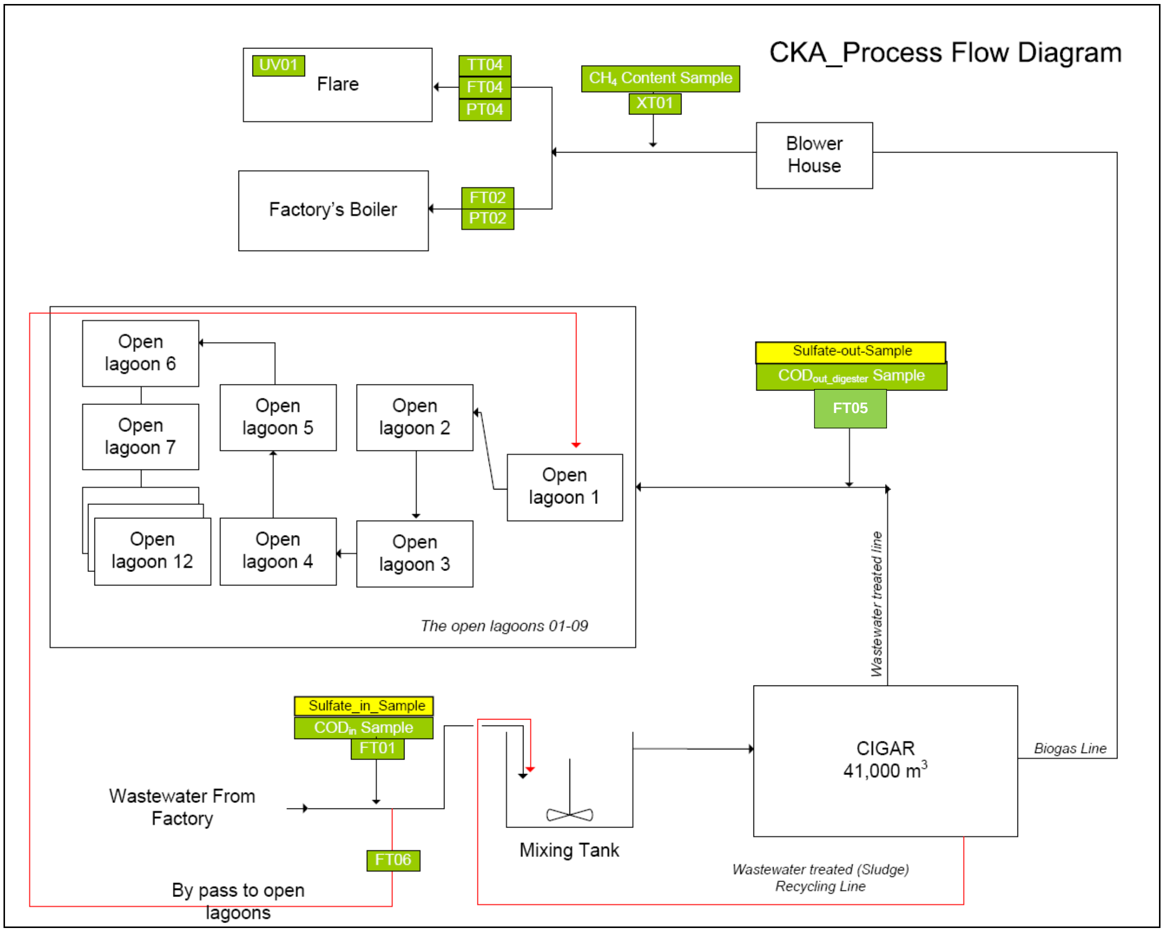


Figure 1 : Process flow & Sampling location
Source : Thai Biogas Energy Company

SECTION D. Data and parameters

D.1. Data and parameters determined at registration and not monitored during the monitoring period, including default values and factors

Data / Parameter:	EF_{CH4}
Data unit:	$kgCH_4/kg$ COD
Description:	Methane emission factor
Source of data used:	AM0022
Value(s) :	0.21
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	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.
Additional comment:	

Data / Parameter:	GWP_{CH4}

Data unit:	Global Warming Potential of methane
Description:	Methane emission factor
Source of data used:	AM0022
Value(s) :	21
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	IPCC default, as set in the Kyoto Protocol
Additional comment:	

Data / Parameter:	$M_{lagoon\_aerobic}$
Data unit:	kg COD/ha/day
Description:	Amount of organic material degraded aerobically in the lagoon system
Source of data used:	AM0022
Value(s) :	254
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	As provided by the Methodology and tested by the sensitivity analysis
Additional comment:	

Data / Parameter:	R_{lagoon}
Data unit:	%
Description:	Total organic material removal ratio of the lagoon
Source of data used:	Project developer
Value(s) :	96
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Determined in accordance with AM0022 prior to the start of the project activity through on-site biochemical testing in the lagoon system.
Additional comment:	

Data / Parameter:	$R_{deposition}$
Data unit:	%
Description:	Organic material deposition ratio of the lagoon
Source of data used:	Project developer
Value(s) :	1.78
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	In accordance with AM0022, testing was done prior to the start of the project activity which determined the rate of deposition.
Additional comment:	

Data / Parameter:	$NCV_{fuel,oil}$
Data unit:	TJ/dm^3
Description:	Net calorific value of fuel oil
Source of data used:	IPCC 2006 and density from Engineer's Edge
Value(s) :	39.996×10^{-6}
Indicate what the data are used for (Baseline/ Project/	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

Leakage emission calculations)	density value of 0.99Kg/l from Engineer's Edge (http://www.engineersedge.com/fluid_flow/fluid_data.htm).
Additional comment:	

Data / Parameter:	$EF_{fuel\ oil}$
Data unit:	tCO_2/TJ
Description:	Carbon emission factor of the fuel oil
Source of data used:	IPCC 2006
Value(s) :	77.367
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	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
Additional comment:	

Data / Parameter:	Lagoon surface area
Data unit:	Ha
Description:	Total lagoon area
Source of data used:	Project developer
Value(s) :	2.09
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	
Additional comment:	

Data / Parameter:	Flare efficiency
Data unit:	%
Description:	Flare efficiency for open flare
Source of data used:	Tool to determine project emissions from flaring gases containing methane
Value(s) :	50
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	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:	$R_{SO_4^{2-}}$
Data unit:	Kg/tonne (kg_{COD}/tSO_4^{2-})
Description:	Reduction factor for SO_4^{2-} oxidative substance
Source of data used:	AM0022 v4
Value(s) :	651
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	AM0022 v4 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/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}/tSO_4^{2-} => 651 kg_{COD}/tSO_4^{2-}

D.2. Data and parameters monitored

Data / Parameter:	WW_{input}
Data unit:	m^3
Description:	Total wastewater flows entering system boundary
Measured /Calculated /Default:	Measured
Source of data:	Magnetic Flow meter
Value(s) of monitored parameter:	1,172,213
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emissions: $E_{CH4\_lagoons\_BL}$ and Project emissions: $E_{CH4\_lagoons}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Manufacturer: ABB Tag No: FT01 Type/Model: COPA-XE DE43F Serial No: Convert: 000469020/X002, Detector: 024436 Calibration frequency : 2 years Accuracy class : +/- 0.50 % Next planned calibration: 18/05/12 Certificate Number / Date of calibration / Validity / Calibrator: L0808-162 / 22/8/08 / 22/8/08-21/8/10 / Miracle L1008-187 / 19/8/10 / 19/8/10-18/8/12 / 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):	N/A
QA/QC procedures applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.

Data / Parameter:	WW_{output}
Data unit:	m^3
Description:	Total wastewater flows leaving project treatment system
Measured /Calculated /Default:	Measured
Source of data:	Magnetic Flow meter
Value(s) of monitored parameter:	1,150,057
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emissions: $E_{CH4\_lagoons\_BL}$ and Project emissions: $E_{CH4\_lagoons}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last	Manufacturer: ABB Tag No: FT05 Type/Model: COPA-XE DE43F Serial No: Convert:000422483/X002, Detector:019442

calibration, validity)	Calibration frequency : 2 years Accuracy class : +/- 0.50 % Next planned calibration: 18/05/12 <table><tr><th>Certificate Number</th><th>Date of calibration</th><th>Validity</th><th>Calibrator</th></tr><tr><td>L0808-163</td><td>22/8/08</td><td>22/8/08-21/8/10</td><td>Miracle</td></tr><tr><td>L1008-188</td><td>19/8/10</td><td>19/8/10-18/8/12</td><td>Miracle</td></tr></table>
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 applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.

Data / Parameter:	COD_{input}
Data unit:	kg_{COD}
Description:	Total wastewater organic material concentration entering the project boundary
Measured /Calculated /Default:	Measured
Source of data:	Spectrophotometer
Value(s) of monitored parameter:	26,859,098
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emissions: $E_{CH4\_lagoons\_BL}$ and Project emissions: $E_{CH4\_lagoons}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Manufacturer: Hach Tag No: N/A Type/Model: DR2800 Serial No. : 1156884 Calibration frequency : 1 years Accuracy class : +/- 1.5 nm Next planned calibration: 03/07/11 <table><tr><th>Certificate Number</th><th>Date of calibration</th><th>Validity</th><th>Calibrator</th></tr><tr><td>C06080789</td><td>09/10/08</td><td>09/10/08-08/10/09</td><td>SPC Calibration Center</td></tr><tr><td>C06090191</td><td>05/10/09</td><td>05/10/09-04/10/10</td><td>SPC Calibration Center</td></tr><tr><td>.C06100204.</td><td>04/10/10</td><td>04/10/10-03/10/11</td><td>SPC Calibration Center</td></tr></table>
Measuring/ Reading/ Recording frequency:	Wastewater is sampled and analysed onsite at the facility’s laboratory daily.
Calculation method (if applicable):	
QA/QC procedures applied:	Weekly samples are sent to an accredited analytical laboratory for cross-checking with on-site data to assure accuracy.

Data / Parameter:	COD_{output}
Data unit:	kg_{COD}
Description:	Total wastewater organic material concentration leaving the treatment facility.
Measured /Calculated /Default:	Measured
Source of data:	Spectrophotometer
Value(s) of monitored parameter:	6,679,545
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emissions: $E_{CH4\_lagoons\_BL}$ and Project emissions: $E_{CH4\_lagoons}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Manufacturer: Hach Tag No: N/A Type/Model: DR2800 Serial No. : 1156884 Calibration frequency : 1 years Accuracy class : +/- 1.5 nm Next planned calibration: 03/07/11
Measuring/ Reading/ Recording frequency:	Wastewater is sampled and analysed onsite at the facility's laboratory daily.
Calculation method (if applicable):	
QA/QC procedures applied:	Weekly samples are sent to an accredited analytical laboratory for cross-checking with on-site data to assure accuracy.

Certificate Number	Date of calibration	Validity	Calibrator
C06080789	09/10/08	09/10/08-08/10/09	SPC Calibration Center
C06090191	05/10/09	05/10/09-04/10/10	SPC Calibration Center
C06100204.	04/10/10	04/10/10-03/10/11	SPC Calibration Center

Data / Parameter:	V_{heat}
Data unit:	Nm^3
Description:	Total volume of biogas sent to facility heaters.
Measured /Calculated /Default:	Measured
Source of data:	Thermal mass flow meter
Value(s) of monitored parameter:	9,336,618
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emissions: $E_{CO2\_heat+power\_BL}$ Project emissions: $E_{CH4\_IC\_heat}$

Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Manufacturer: ABB Tag No: FT02 Type : Sensyflow IG-EX Serial No. : 27751279 Calibration frequency : 3 years Accuracy class : +/- 0.2 % Next planned calibration: 28/04/11
Measuring/ Reading/ Recording frequency:	Volume in Nm3 is measured continuously by a flow meter and reading recorded daily
Calculation method (if applicable):	
QA/QC procedures applied:	Biogas meters should be subject to a regular maintenance and testing regime to ensure accuracy.

Certificate Number	Date of calibration	Validity	Calibrator
1612 DKD-K-05701 2008-07	29/7/08	29/7/08-28/7/11	ABB

Data / Parameter:	V_{flare} (also $FV_{FG,h}$)
Data unit:	Nm^3
Description:	Total biogas sent to flare.
Measured /Calculated /Default:	Measured
Source of data:	Thermal mass flow meter
Value(s) of monitored parameter:	1,176,300
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emissions: PF_{flare}
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Manufacturer: ABB Tag No: FT04 Type/Model: Sensy flow IG-EX Serial No. : 26750814 , 27751278 Calibration frequency : 3 years Accuracy class : +/- 0.2 % Next planned calibration: 13/07/12

Certificate Number	Start and stop using date	Serial Number	Date of calibration	Validity	Calibrator
469020	01/09/08-28/08/09	27751278	27/10/06	27/10/06-26/10/09	ABB
240236990	28/08/09-02/11/09	26750814	24/06/09	24/6/09-22/6/12	ABB
240278981	02/11/09-being used	27751278	14/10/09	14/10/09-13/10/12	ABB

The flow meter SN 27751278 was sent to ABB for calibration between 28/08/09 to 02/11/09 and replacing by a spare calibrated flow meter SN

	26750814. This flow meter was installed by the supplier and has same accuracy as the old one.
Measuring/ Reading/ Recording frequency:	Volume in Nm3 is measured continuously by a flow meter and reading recorded hourly
Calculation method (if applicable):	
QA/QC procedures applied:	Biogas meters should be subject to a regular maintenance and testing regime to ensure accuracy. This parameter is equivalent to the variable FVRG,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:	f_{heat}
Data unit:	%
Description:	Heating system combustion efficiency
Measured /Calculated /Default:	Measured and Calculated
Source of data:	Combustion efficiency test report by External laboratory
Value(s) of monitored parameter:	91.77
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project Emissions: $E_{CH4\_IC+leaks}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Combustion efficient testing <table><tr><td>Certificate Number</td><td>Date of calibration</td><td>Validity</td><td>Calibrator</td></tr><tr><td>N/A</td><td>21/04/09</td><td>21/04/09 – 20/04/10</td><td>Thai Burner Industrial</td></tr><tr><td>N/A</td><td>01/06/10</td><td>01/06/10 – 31/05/11</td><td>Thai Burner Industrial</td></tr></table>
Measuring/ Reading/ Recording frequency:	Annually
Calculation method (if applicable):	The efficient boiler testing was missed the test by 71 days in year 2010 which started from 21/04/10 to 31/05/10 The 95%confidence interval analysis is applied to this period which is calculated base on the %efficient testing value both 2009l and 2010.
QA/QC procedures applied:	Boiler is maintained regularly by Weishaupt in order to ensure optimal performance. Currently, There is one boiler used which is Weishaupt (f_{heat} = 91.77).

Data / Parameter:	$CSO_4^{2-}in$
Data unit:	Tonnes/m^3
Description:	Amount of chemical oxidising agents entering system boundary.
Measured /Calculated /Default:	Measured

Source of data:	Spectrophotometer
Value(s) of monitored parameter:	164
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emissions: $E_{CH4\_lagoons\_BL}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Manufacturer: Hach Tag No: N/A Type/Model: DR2800 Serial No. : 1156884 Calibration frequency : 1 years Accuracy class : +/- 1.5 nm Next planned calibration: 03/07/11

Certificate Number	Date of calibration	Validity	Calibrator
C06080789	09/10/08	09/10/08-08/10/09	SPC Calibration Center
C06090191	05/10/09	05/10/09-04/10/10	SPC Calibration Center
C06100204.	04/10/10	04/10/10-03/10/11	SPC Calibration Center

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 applied:	

Data / Parameter:	$CSO_4^{2-}out$
Data unit:	Tonnes/m^3
Description:	Amount of chemical oxidising agents out of the digester.
Measured /Calculated /Default:	Measured
Source of data:	Spectrophotometer
Value(s) of monitored parameter:	42
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emissions: $E_{CH4\_lagoons}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Manufacturer: Hach Tag No: N/A Type/Model: DR2800 Serial No. : 1156884 Calibration frequency : 1 years Accuracy class : +/- 1.5 nm

<table>
<tr><td></td><td>Next planned calibration: 03/07/11

<table><tr><td>Certificate Number</td><td>Date of calibration</td><td>Validity</td><td>Calibrator</td></tr><tr><td>C06080789</td><td>09/10/08</td><td>09/10/08-08/10/09</td><td>SPC Calibration Center</td></tr><tr><td>C06090191</td><td>05/10/09</td><td>05/10/09-04/10/10</td><td>SPC Calibration Center</td></tr><tr><td>C06100204.</td><td>04/10/10</td><td>04/10/10-03/10/11</td><td>SPC Calibration Center</td></tr></table></td></tr>
<tr><td>Measuring/ Reading/ Recording frequency:</td><td>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.</td></tr>
<tr><td>Calculation method (if applicable):</td><td></td></tr>
<tr><td>QA/QC procedures applied:</td><td></td></tr>
</table>

<table>
<tr><td>Data / Parameter:</td><td>$WW_{bypassing}$</td></tr>
<tr><td>Data unit:</td><td>m^3</td></tr>
<tr><td>Description:</td><td>Total flow of wastewater directly to the current water treatment system, and bypassing the new wastewater treatment facility.</td></tr>
<tr><td>Measured /Calculated /Default:</td><td>Measured</td></tr>
<tr><td>Source of data:</td><td>Magnetic Flow meter</td></tr>
<tr><td>Value(s) of monitored parameter:</td><td>0</td></tr>
<tr><td>Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)</td><td>N/A</td></tr>
<tr><td>Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)</td><td>Manufacturer: ABB
Tag No: FT06
Type : DE41F
Serial No. : Converter 000420831/Y004 Detector: 000282153/X001
Calibration frequency : 2 Years
Date of last calibration : 07/09/10
Accuracy class : +/- 0.49 of full scale
Next planned calibration: 06/07/12
<table><tr><td>Certificate Number</td><td>Date of calibration</td><td>Validity</td><td>Calibrator</td></tr><tr><td>L1009-028</td><td>07/09/10</td><td>07/09/10-06/09/12</td><td>Miracle</td></tr></table>
The changing history for FT06 please refer to section B.1 - Events or situations that occurred during the monitoring period.</td></tr>
<tr><td>Measuring/ Reading/ Recording frequency:</td><td>Measured continuously and data recorded hourly. After commissioning of the project activity, all wastewater flow from the factory into the</td></tr>
</table>

	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 applied:	Regular maintenance and calibration of the flow meter.

Data / Parameter:	Biogas loss from pipeline
Data unit:	%
Description:	Loss of biogas from pipeline
Measured /Calculated /Default:	Measured
Source of data:	Pressure test report by External laboratory Report Number / Testing date / Validity / Tester: Pressure test 2009 / 24/08/09 / 24/08/09-23/08/10. / CK Thai Pressure test 2010 / 24/08/10 / 24/08/10-23/08/11. / CK Thai
Value(s) of monitored parameter:	0
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project Emissions: $E_{CH4\_IC+leaks}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Next planned testing: 23/05/11
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):	ASTM
QA/QC procedures applied:	

Source of data (nested table):

Report Number	Testing date	Validity	Tester
Pressure test 2009	24/08/09	24/08/09-23/08/10.	CK Thai
Pressure test 2010	24/08/10	24/08/10-23/08/11.	CK Thai

Data / Parameter:	NCV_{biogas}
Data unit:	J/Nm^3
Description:	Biogas calorific value
Measured /Calculated /Default:	Measured
Source of data:	NCV test report by External Laboratory
Value(s) of monitored parameter:	20,498,817
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emissions: $E_{CO2\_heat+power\_BL}$

<table>
<tr><td>Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)</td><td>Next planned testing: 29/03/11
<table><tr><td>Certificate Number</td><td>Testing date</td><td>Validity</td><td>Tester</td></tr><tr><td>COA-L6-0906-01279</td><td>27/06/09</td><td>27/06/09-26/06/09</td><td>PTT</td></tr><tr><td>COA-L6-1007-00987</td><td>23/07/10</td><td>23/07/10-22/06/11</td><td>PTT</td></tr></table></td></tr>
<tr><td>Measuring/ Reading/ Recording frequency:</td><td>Since there was 26 days in year 2010 which start from 27/06/10 to 22/07/10 that has missed the test. The differential percentage is applied to these period which is calculated base on the CCH4 value between external and internal lab.</td></tr>
<tr><td>Calculation method (if applicable):</td><td>N/A</td></tr>
<tr><td>QA/QC procedures applied:</td><td>N/A</td></tr>
</table>

<table>
<tr><td>Data / Parameter:</td><td>PE_{flare}</td></tr>
<tr><td>Data unit:</td><td>tCO_2</td></tr>
<tr><td>Description:</td><td>Project emissions from flaring of the residual gas stream.</td></tr>
<tr><td>Measured /Calculated /Default:</td><td>Calculated</td></tr>
<tr><td>Source of data:</td><td>ER Workbook</td></tr>
<tr><td>Value(s) of monitored parameter:</td><td>5,154</td></tr>
<tr><td>Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)</td><td>Project Emissions: $E_{CH4\_IC+leaks}$</td></tr>
<tr><td>Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)</td><td>Manufacturer: FM
Tag No: N/A
Type : UVS
Serial No: 84315200
Equipment lifetime: 10,000 Operation hour
Accuracy class: N/A
<table><tr><td>Date of installation</td><td>Validity</td></tr><tr><td>16/12/06</td><td>N/A</td></tr></table></td></tr>
<tr><td>Measuring/ Reading/ Recording frequency:</td><td></td></tr>
<tr><td>Calculation method (if applicable):</td><td>Efficiency of flaring process: for open flares, the flaring process has a conservative default efficiency of 50%.
In case of open flares, the flare efficiency in the hour h ($n_{flare,h}$) is
- 0% if the flame is not detected for more than 20 minutes during the hour h.
- 50%, if the flare is detected for more than 20 minutes during the hour h.</td></tr>
<tr><td>QA/QC procedures applied:</td><td>A flame detection system has been installed which records the detection of flame are monitored hourly.</td></tr>
</table>

Data / Parameter:	F

Data 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:	Measured and calculated
Source of data:	ER workbook
Value(s) of monitored parameter:	4,785,219
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emissions: $E_{CO2\_heat+power\_BL}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	N/A
Measuring/ Reading/ Recording frequency:	N/A
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 applied:	N/A

Data / Parameter:	C_{CH4} (also $FV_{CH4,y}$)
Data unit:	% of Nm^3/Nm^3
Description:	Biogas methane concentration
Measured /Calculated /Default:	Measured
Source of data:	Gas Analyser
Value(s) of monitored parameter:	58.64
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emissions: $E_{CO2\_heat+power\_BL}$ Project Emissions: $E_{CH4\_IC+leaks}$
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Manufacturer: ANRI Tag No: XT01 Type : CAM-3L Serial No. : LFB-028 Calibration frequency : 1 years Accuracy class : +/- 0.5 of full scale Next planned calibration: 08/06/11
Measuring/ Reading/ Recording frequency:	Measured continuously by infrared spectrometer and data recorded hourly.
Calculation method (if applicable):	N/A

Date of calibration	Validity	Calibrator
21/02/08	21/02/08 -20/02/09	Entech Associate
09/09/09	09/09/09 -08/09/10	Entech Associate
09/09/10	09/09/10 -08/09/11	Entech Associate

QA/QC procedures applied:	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 is monitored, the remaining part is considered as N_2 (simplified approach according to Tool). The monitored value actually have to be multiplied by the CH4 density of 0.0007168 t_{CH4}/m^3_{CH4} from ACM0001 at normal conditions to obtain the value of C_{CH4} in t_{CH4}/Nm^3.

Data used for calculation of GHG emission reductions ;

The following table summarises the data used to calculate the GHG emission reductions. Please refer to excel spreadsheet files for the full set of data used for calculations which it was provided on **Annex 2.** The raw data files are available onsite for review. Other sources, such as plant log books, laboratory analysis are available for cross check onsite.

SECTION E. Emission reductions calculation

E.1. Baseline emissions calculation

>>

Baseline emissions calculation took place as per the following steps for the data generated:

A) For the lagoon (methane emissions)

1. Overall amount of COD entering into the lagoon 'M_{lagoon_input}' is obtained by summing the daily product between wastewater into the lagoon and the content of COD in the wastewater.

Where :

$$M_{lagoon\_input} = M_{lagoons\_intal}$$
$$= \mathbf{26{,}859{,}098} \quad kg_{COD}$$

2. The total amount of COD that can be removed through various routes 'M_{lagoon_total}' is calculated by multiplying 'Mlagoon_input_BL' by the project specific lagoon efficiency parameter 'R_{lagoon}'(AM0022v4, equation 5).

Where :

$$M_{lagoon\_total} = M_{lagoon\_input} * R_{lagoon}$$
$$= 25{,}784{,}734 \quad kg_{COD}$$

3. The amount of COD transformed aerobically '$M_{lagoon\_aerobic}$' is the product of the Surface aerobic losses constant (254 Kg COD/ha/day), the surface of the pond and total days of monitoring period.

Where :

$$M_{lagoon\_aerobic} = 254 \quad kg_{COD} * 2.09 \text{ ha} * 753 \text{ days}$$
$$= 399{,}738 \quad kg_{COD} / \text{ha}$$

4. The amount of COD transformed by chemical oxidation ‘ $M_{lagoon\_chemical\_ox}$ ’ is the product of the sulphate oxidative factor (651 Kg COD/tso42-) and the amount of oxidative substance at the entrance of the digester Mso42-_input_total in tonnes.

Where :

$$M_{lagoon\_chemical\_ox} = Cso_{4\ input}^{2-} * Rso_4^{2-}$$

$$= 106{,}553\ kg_{COD}$$

5. The amount of COD depositing and hence lost ‘Mdeposition’ is the product of M_{lagoon_total} and $R_{disposition}$ (1.78%). (AM0022v4, equation 6).

Where :

$$M_{lagoon\_disposition} = M_{lagoon\_input} * R_{disposition}$$

$$= 478{,}092\ kg_{COD}$$

6. The amount of COD removed anaerobically ‘ $M_{lagoon\_anaerobic}$ ’ is the total amount of COD removed through various routes (result from 2.) subtracted by the COD amounts removed through all the other routes (aerobically (result from 3.), chemically (result from 4.) and deposition (result from 5.)) (AM0022v4, equation 2).

Where :

$$M_{lagoon\_anaerobic} = M_{lagoon\_input} - M_{lagoon\_total} - M_{lagoon\_chemical\_ox} - M_{lagoon\_disposition}$$

$$= 24{,}800{,}352\ kg_{COD}$$

7. The baseline emissions from the lagoons is obtained by multiplying the amount of COD removed anaerobically (result from 6.), the COD methane emission factor and the GWP of methane (AM0022v4, equation 2).

Where :

$$E_{CH4\_lagoons} = M_{lagoon\_anaerobic} * EF_{CH4} * GWP_{CH4} / 1{,}000$$

$$= 22{,}019{,}350\ kg_{COD} * 21 * 0.21\ kg_{CH4} / kg_{COD}\ /1{,}000$$

$$= 109{,}370\ tCO_2$$

B) For the Heat (carbon dioxide emissions)

1. The amount of fuel oil equivalent (tonnes) sent to the boiler is obtained by multiplying the monitored volume of biogas sent to boiler by the ratio of NCV_{fuel} (annually Monitored) over NCV_{fuel} (fixed ex-ante).

Where :

Total biogas used	=	9,336,618 Nm^3
Biogas to fuel oil conversion factor	=	0.510 dm^3/Nm^3
F	=	9,336,618 Nm^3 * 0.510 dm^3/Nm^3
	=	4,785,219 dm^3

2. The emissions resulting from heat usage in the baseline are obtained by multiplying the fuel oil equivalent used (result from 1.) with the NCV of fuel oil and the CO2 emission factor per energy unit of fuel oil (AM0022v4, equation 9).

Where :

$$E_{CO2\_heat+power\_BL} = F * NCV_{fuel,oil} * EF_{fuel,oil}$$

$$= 4{,}785{,}219 \ dm^3 * 39.996 \text{ x } 10^{-6} \ TJ/dm^3 * 77.367 \ tCO_2/TJ$$

$$= 14{,}807 \ tCO_2$$

E.2. Project emissions calculation

>>

Project emissions calculation took place as per the following steps for the data generated:

A) For the lagoon (methane emissions)

1. The amount of COD getting into the lagoon ‘M_{lagoon_input}’ is the product of the total amount of COD fed into the new anaerobic water treatment facility and the complement to one of the new water treatment facility efficiency parameter ‘R_{NAWTF}’ (methodology AM0022v4, equation 4)

Where :

$$R_{NAWTF} = ((COD_{input} - COD_{output})/COD_{input})*100$$

$$= 75.13 \%$$

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

$$= 26{,}859{,}098 \ kg_{COD} * (1-0.7513)$$

$$= 6{,}679{,}545 \ kg_{COD}$$

2. The amount of COD that can be removed from the lagoon through various routes ‘M_{lagoon_total}’ is the product of the amount of COD entering into the lagoon (result from 1.) and the project specific lagoon efficiency parameter ‘R_{lagoon}. (methodology AM0022v4, equation 5).

Where :

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

$$= 5{,}847{,}282 \ kg_{COD} * 96 \%$$

= 6,412,363 kg_{COD}

3. The amount of COD transformed aerobically ‘ $M_{lagoon\_aerobic}$ ’ is the product between the Surface aerobic losses constant (254 kg_{COD} /ha/day), the surface of the pond and total days of monitoring period. The COD transformed aerobically is unchanged regarding the baseline since the surface of the pond remains the same.

Where :

$M_{lagoon\_aerobic}$ = kg_{COD} /ha /day

= 254 kg_{COD} * 2.09 ha * 753 days

= 399,738 kg_{COD}

4. The amount of COD transformed by chemical oxidation ‘ $M_{lagoon\_chemical\_ox}$ ’ is the product of the sulphate oxidative factor (651 kg_{COD} / tso_4^{2-}) and the amount of oxidative substance at the output of the digester $Mso_4^{2-}{}_{output\_total}$ in tonnes.

Where :

$M_{lagoon\_chemical\_ox}$ = 41.61 tso_4^{2-} * 651 kg_{COD} / tso_4^{2-}

= 27,090 kg_{COD}

5. The amount of COD depositing and hence lost ‘ $M_{lagoon\_deposition}$ ’ is the product of M_{lagoon_input} and $R_{deposition}$ (methodology AM0022v4, equation 6)

Where :

$M_{lagoon\_deposition}$ = M_{lagoon_input} * $R_{deposition}$

= 6,679,545 kg_{COD} * 1.78 %

= 118,896 kg_{COD}

6. The amount of COD removed anaerobically ‘ $M_{lagoon\_anaerobic}$ ’ is the total amount of COD removed through various routes (result from 2.) subtracted by the COD amounts removed through all the other routes (aerobically (result from 3.), chemically (result from 4.) and deposition (result from 5.)) (AM0022v4, equation 3).

Where :

$M_{lagoon\_anaerobic}$ = M_{lagoon_total} - M_{lagoon_input} - $M_{lagoon\_chemical\_ox}$ - $M_{lagoon\_deposition}$

= 5,866,640 kg_{COD}

7. The project emissions from the lagoons are obtained by multiplying the amount of COD

removed anaerobically (result from 6.) with the COD emission factor and the global warming potential of methane (AM0022v4, equation 2).

Where :

$$E_{CH4\_lagoon} = M_{lagoon\_anaerobic} * EF_{CH4} * GWP_{CH4} /1000$$

$$= 25{,}872 \ tCO_2$$

B) <u>Methane emissions from Inefficient Combustion Emissions</u>

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

1. Biogas use in heating systems.

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

$$= 5{,}493{,}350 \ Nm_3 * 0.0007168 * (1- 0.9203)*21$$

.

$$= 6{,}811 \ tCO_2$$

2. Biogas flaring

$$PE_{flare,y} = (\sum_{h=1} TM_{RG,h} \bullet (1-n_{flare,h}) \ \bullet GWP_{CH4} /1{,}000)$$

$$= 5{,}157 \ tCO_2$$

C) For inefficient combustion and leaks (methane emissions)

The emissions due to incomplete combustion in the facility heaters ‘ $E_{CH4\_IC\_heat}$ ’ is calculated by multiplying the amount of biogas going to the boiler by the methane content in the biogas in tCH4/Nm3 biogas (it is the product of the monitored parameter ‘CCH4’

E.3. Leakage calculation

>>

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. Emission reductions calculation / table

>>

Overall emission reductions are calculated in the following steps:

1. The Baseline Emissions are the sum of the lagoons baseline emissions and the heat baseline emissions.
2. The Project Emissions are the sum of the lagoons (AM0022ver4, equation 2) project emissions and the emissions resulting from incomplete combustion (AM0022v4, equation 7).
3. The Emission Reductions are the difference between the Baseline Emissions and the Project Emissions (AM0022v4, equation 12).
4. The conservativeness check (AM0022v4, equation 13) is applied and it is determined whether it is positive or negative. When positive as it is for this monitoring period for both 2009 and 2010, the result is deducted from the emission reductions obtained (result from 3.) to establish final emission reductions.

Table 2

Total Emission Reduction calculation summary for the period of 09/03/2009 until 31/03/2011

CHECK equation 13: ECH_lagoon_BL < ECH4_lagoon + ECH4_NAWTF + ECH4_coll					
ECH4_coll	tCO2	43,784	38,524	10,692	
ECH_lagoon_BL - (ECH4_lagoon + ECH4_NAWTF + ECH4_coll)	tCO2	(3,517)	(4,670)	(2,172)	
TOTAL		2009	2010	2011	Total
		09/03/2009 - 31/12/2009	01/01/2010 - 31/12/2010	01/01/2011 - 31/03/2011	09/03/2009 - 31/03/2011
		298 days	365 days	90 days	753 days
Baseline Emissions	tCO2	60,272	50,083	13,822	
Project Emissions	tCO2	17,340	15,823	5,525	
Leakage	tCO2	0	0	0	
Emission Reductions - before application of equation 13 (cor	tCO2	42,932	34,260	8,297	
Emission Reductions - including equation 13	tCO2	**42,932**	**34,259**	**8,296**	**85,487**

E.5. Comparison of actual emission reductions with estimates in the CDM-PDD

>>

Item	Values applied in ex-ante calculation of the registered CDM-PDD/ year	Actual values reached during the monitoring period / year (calculated on the basis of No. Of days)	2009 values	2010 values	2011 values
Emission reductions (tCO_2e)	**48,167**	**=(85,487/753)*300= 34,058**	**42,932**	**34,259**	**8,296**

753- No. Of days in the Monitoring period 09.03.2009 to 31.03.2011

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

>>

The reason of tCO2 which applied in ex-ante calculation of the PDD register was higher than the actual values is that the registered days operation (300 days) less than the actual values reached during the monitoring period (753days) . As the COD depends on the operations or starch production of the host company, there is directly variation on the amount of COD delivered depending on the success of the host company to secure its feedstock and sell it product. Consequently, If there calculate to cross-check on the basic of number between actual days operation (753 days) with the registered days operation (300 days) ,it found that the values **(34,058 tCO2)** are lower than the number of the registered PDD. Because total ***tCO_2*** was increased by a longer period approximately 24 month, so this reason is the main factor explaining higher emission reductions.

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History of the document

Version	Date	Nature of revision
01	EB 54, Annex 34 28 May 2010	Initial adoption.
Decision Class: Regulatory **Document Type**: Guideline, Form **Business Function**: Issuance		

Annex 1

Total Emission Reduction calculation summary for the period
from 09/03/2009 - 31/03/2011

Project Summary

Monitoring Period	UNIT	2009	2010	2011	Total
09/03/2009 - 31/03/2011		09/03/2009 - 31/12/2009	01/01/2010 - 31/12/2010	01/01/2011 - 31/03/2011	09/03/2009 - 31/03/2011
		298 days	365 days	90 days	753 days
Baseline emissions: $E_{CH4\_lagoons\_BL}$					
$M_{lagoon\_input\_BL}$ [= M_{input_total}]	kg COD	12,945,407	10,894,016	3,019,676	26,859,098
M_{lagoon_total} [= $M_{lagoon\_input\_BL}$*R_{lagoon}]	kg COD	12,427,590	10,458,255	2,898,889	25,784,734
$M_{lagoon\_aerobic}$ [transformed to kg COD in total]	kg COD	158,196	193,764	47,777	399,738
$M_{lagoon\_chemical\_ox}$	kg COD	44,215	45,979	16,359	106,553
$M_{deposition}$ [= $M_{lagoon\_input\_BL}$*$R_{deposition}$]	kg COD	230,428	193,913	53,750	478,092
$M_{lagoon\_anaerobic}$ [= M_{lagoon_total} - $M_{lagoon\_aerobic}$ - $M_{lagoon\_chemical\_ox}$ -	kg COD	11,994,751	10,024,599	2,781,002	24,800,352
$E_{CH4\_lagoons\_BL}$	**tCO2**	**52,897**	**44,208**	**12,264**	**109,370**
Baseline emissions: $E_{CO2\_heat+power\_BL}$					
Biogas used	Nm3	4,650,357	3,703,987	982,274	9,336,618
Amount of fossil fuel used (F)	dm3	2,383,409	1,898,374	503,437	4,785,219
$E_{CO2\_heat+power\_BL}$	**tCO2**	**7,375**	**5,874**	**1,558**	**14,807**
Project Emissions: $E_{CH4\_lagoons}$					
M_{lagoon_input} [= M_{input_total}*(1-R_{NAWTF})]	kg COD	3,219,372	2,709,215	956,802	6,679,545
M_{lagoon_total} [= M_{lagoon_input}*R_{lagoon}]	kg COD	3,090,597	2,600,846	918,530	6,412,363
$M_{lagoon\_aerobic}$ [transformed to kg COD in total]	kg COD	158,196	193,764	47,777	399,738
$M_{lagoon\_chemical\_ox}$	kg COD	11,332	10,968	4,790	27,090
$M_{deposition}$ [= M_{lagoon_input}*$R_{deposition}$]	kg COD	57,305	48,224	17,031	118,896
$M_{lagoon\_anaerobic}$ [= M_{lagoon_total} - $M_{lagoon\_aerobic}$ - $M_{lagoon\_chemical\_ox}$ -	kg COD	2,863,764	2,347,891	848,931	5,866,640
$E_{CH4\_lagoons}$	**tCO2**	**12,629**	**10,354**	**3,744**	**25,872**
Project Emissions: E_{CH4_NAWTF}		N/A	N/A		N/A
Project Emissions: $E_{CH4\_IC+leaks}$					
$E_{CH4\_IC\_heat}$ [V_{heat}*C_{CH4}*(1-f_{heat})*GWP_{CH4}]	tCO2	3,382	2,713	710	6,804
PE_{flare}	tCO2	1,329	2,756	1,072	5,157
Leak	tCO2	0	0	0	0
$E_{CH4\_IC+leaks}$	**tCO2**	**4,711**	**5,469**	**1,782**	**11,961**
Leakage		N/A	N/A		

CHECK equation 13: ECH_lagoon_BL < ECH4_lagoon + ECH4_NAWTF + ECH4_coll					
E_{CH4_coll}	tCO2	43,784	38,524	10,692	
$E_{CH\_lagoon\_BL}$ - (E_{CH4_lagoon} + E_{CH4_NAWTF} + E_{CH4_coll})	tCO2	(3,517)	(4,670)	(2,172)	

TOTAL		2009	2010	2011	Total
		09/03/2009 - 31/12/2009	01/01/2010 - 31/12/2010	01/01/2011 - 31/03/2011	09/03/2009 - 31/03/2011
		298 days	365 days	90 days	753 days
Baseline Emissions	tCO2	**60,272**	**50,083**	**13,822**	
Project Emissions	tCO2	**17,340**	**15,823**	**5,525**	
Leakage	tCO2	**0**	**0**	**0**	
Emission Reductions - before application of equation 13 (cor	tCO2	**42,932**	**34,260**	**8,297**	
Emission Reductions - including equation 13	tCO2	**42,932**	**34,259**	**8,296**	**85,487**

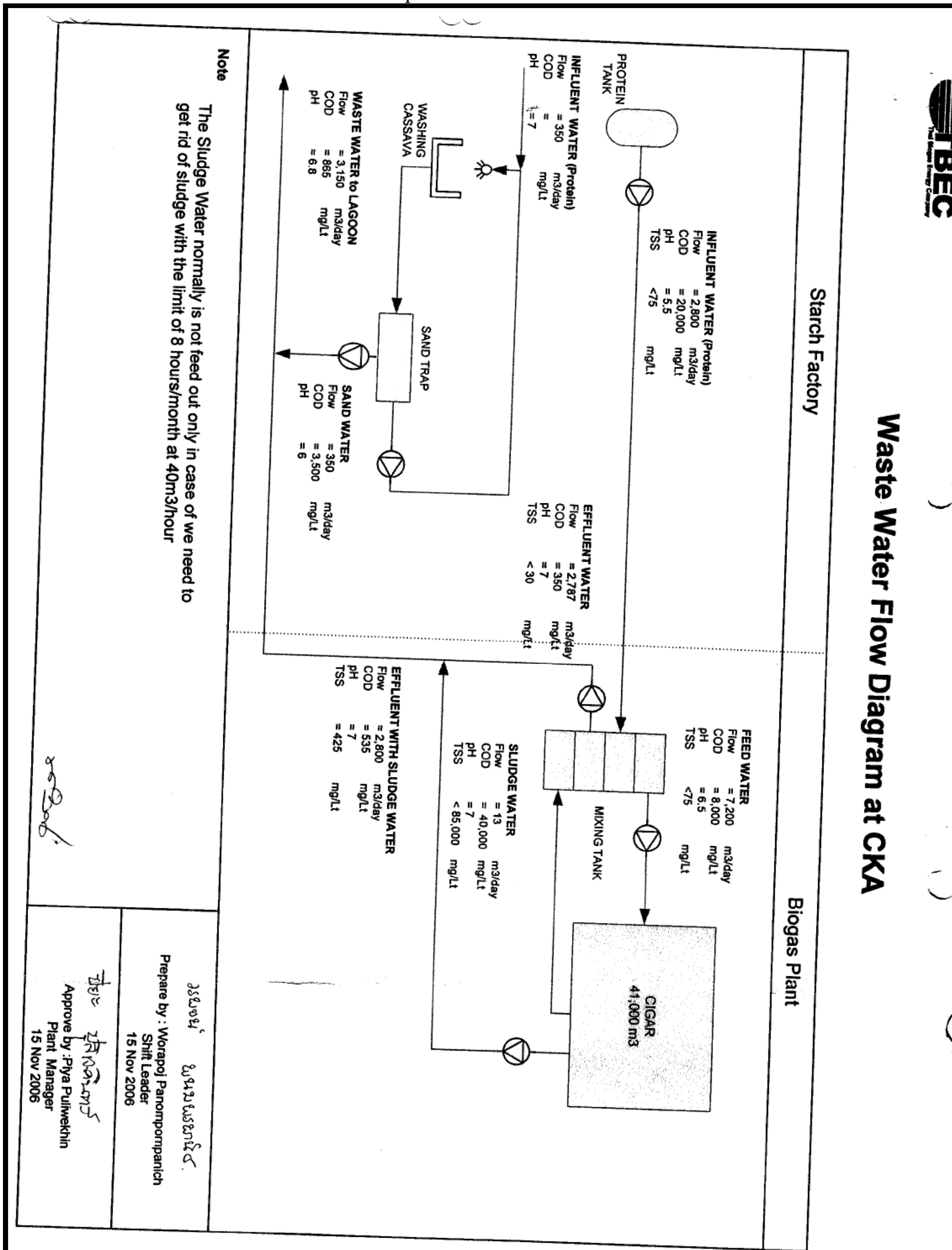
Annex 2

Reference data for Emission Reduction calculation for the
Period from 09/03/2009 - 31/03/2011

Reference Data			
Parameter	**Value**	**Unit**	**Comments**
Available at validation - Ex-ante			
EF_{CH4}	0.21	kg CH4/Kg COD	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.
GWP_{CH4}	21		IPCC default, as set in the Kyoto Protocol
$M_{lagoon\_aerobic}$	254	kg COD/ha/day	As provided by the Methodology and tested by the sensitivity analysis
R_{lagoon}	98.2	%	Determined in accordance with AM0022 prior to the start of the project activity through on-site biochemical testing in the lagoon system.
$R_{deposition}$	2.1	%	In accordance with AM0022, testing was done prior to the start of the project activity which determined the rate of deposition.
Rso_4^{2-}	651	Kg_{COD}/tso_4^{2-}	
$NCV_{fuel\ oil}$	3.9996E-05	TJ/dm3	IPCC 2006 Table 1.2 Chapter 1 Volume 2
$EF_{fuel\ oil}$	77.367	tCO_2/TJ	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 tCO2/TJ
Grid CEF	0.524	tCO_2/MWh	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 set out in AMS.I.D. version 12, which follows the calculations of ACM0002, version 06
Lagoon surface area	1.105	ha	Project developer
Flare efficiency	50	%	Applied if Manufacturer's conditions are met
Other parameters			
Methane $density_{normal\ conditions}$	0.0007168	tCH_4/m^3CH_4	Density is as per Meth ACM0001 and Normal conditions are 0°C and 1.013 bar
Conversion factors			
1 BTU	1055.056 J		
1 Nm3	35.31467 ft3		

Annex 3

Mass Balance Equation of total wastewater effluents



Calculation rate of sludge remain within anaerobic digestor

Thai Biogas Energy Company

1) Retention time of Digester

Digester capacity	=	41,000	m^3 / day
Inffluent rate	=	1,867	m^3 / day
Thus: Retention time	=	Digester Capacity / Inffluent waste water	
	=	*21.96*	Day

2) Concerntration of solid substance in Digester (M)

$$M = (\theta_c / T) \times [(1 - \xi_g) \times M_{go} + M_{fo}]$$

Assume

θ_c	=	Mean cell residence time (MCRT)
T	=	Retention time
ξ_g	=	Devolatilization ensures the removal of volatile rate θ_c
M_{go}	=	Inffluent of volatine solid substance concerntration
M_{fo}	=	Inffluent of solid substance of sludge concerntration

Mean cell residence time (MCRT)	=	8	วัน
Devolatilization ensures the removal of volatile rate	=	95	%
Inffluent of volatine solid substance concerntration	=	95	%
Total solid substance (TSSin)	=	8,300	g /m^3

2.1) Concerntration of volatine substance of influent wastewater (M_{go})

M_{go} = TSS x ξg

M_{go} = *7,885* g /m^3

2.2) Concerntration of solid substance of influent sludge (M_{fo})

M_{fo} = TSS - M_{go}

M_{fo} = *415* g /m^3

From equation above which variable will be calculated to be replacing ;

M = 294.80 g /m^3

Thus ;

Concerntration of solid substance in Degester = *342* g /m^3

3) Rate of sludge remaining on the bottom (F_w)

$$F_w = [V \times (M / M_w)] / \theta_{ch}$$

โดยที่

V	=	Reactor capacity
M	=	Concerntration of solid substance in Digester
M_w	=	Effluent of volatine solid substance concerntration
Θ_{ch}	=	MCRT; Mean cell residence time

Reactor capacity	=	41,000	m^3	
Concerntration of solid substance in Digester	=	342	g/m^3	
Effluent of volatine solid substance concerntration	=	3,650	g/m^3	(TSSout)
MCRT; Mean cell residence time	=	21.96	days	

From equation above which variable will be calculated to be replacing ;

F_w = [84,000 x (432 / 65,000)] / 100

F_w = *150.79* m^3 / day

Reference information

Tom D. Reynolds and Paul A. Richards. (1995) Unit Operations and Processes in Enveronmental Engineering, PWS Publishing Co.

ธีระ เกรอต. (1996) วิศวกรรมน้ำเสีย การบำบัดน้ำเสียทางชีวภาพ, สำนักพิมพ์จุฬาลงกรณ์มหาวิทยาลัย

Annex 4

Description on 95% confidence interval calculation for CH4%

data logging period(02/04/10 – 10/05/10)

For the period with constant logged data, the following approach (based on 95% confidence interval principles) (source: IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, page 6.6*)* was taken:

Data collection on before period (01/01/10 – 03/04/10) and after period (11/05/10 – 11/08/10) the constant data period was used to calculate the 95% confidence interval boundaries.

The values of the mean and standard deviation were calculated. The values are as follow:

Mean: 59.12

Standard deviation: 0.011

The lower bound and upper bound of the interval boundaries were calculated as shown as below:

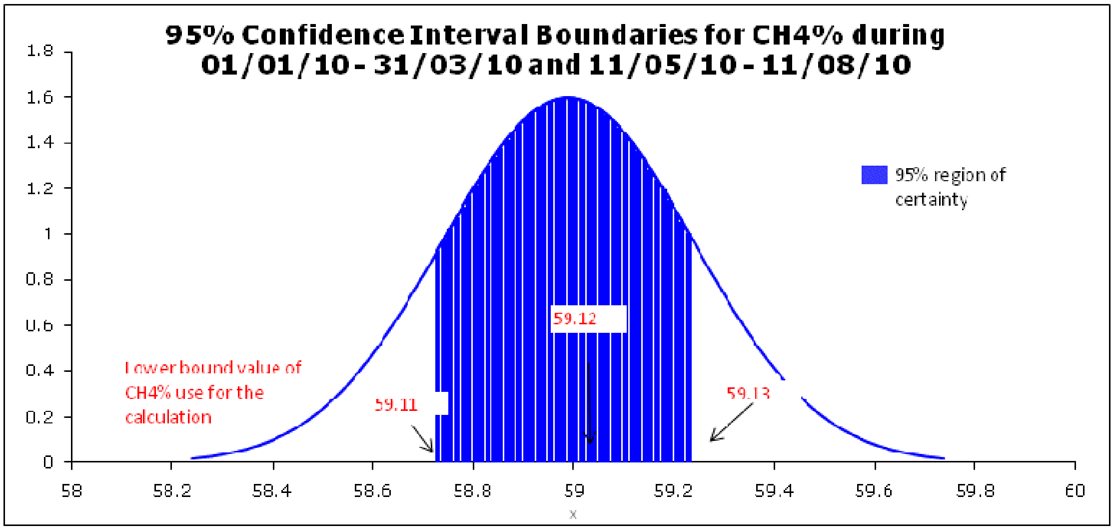
Low value	Parameter			High value
59.11	≤	**CH4%**	≥	**59.13**

The lower bound of the interval boundaries was applied to the period for the constant data as a conservative approach.

For more details on the calculation of 95% of confidence interval boundaries, please refer to the calculation sheet.

The mean and standard deviation calculated from above were used to generate the function for normal distribution, f(x). The graph limits of -3 and 3 were chosen to calculate the values of x, i.e. the FT2 readings. The values of f(x) and x were then used to plot the normal distribution graph.

The normal distribution graph plotted for the confidence interval is as shown below:



Theoretically, it is possible under worst conditions to have a minimize current approximately equal to be number of fixed values as 59.11% methane was reasonable.