MONITORING REPORT FORM (CDM-MR) *
Version 01 - in effect as of: 28/09/2010

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* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

MONITORING REPORT
Version 2.2 12/06/2012

Siam Quality Starch Wastewater Treatment and Energy Generation Project in Chaiyaphum, Thailand

UNFCCC reference number 1993
Monitoring period number 1; 15/04/2009 – 30/11/2009

SECTION A. General description of the project activity

A.1. Brief description of the project activity:

A.1.1. Purpose of the project activity

Siam Quality Starch Co., Ltd. (SQS) is a Native and Modified starch manufacturer whose factory, with a production capacity of 200,000 tpy, is located in the North Eastern region of Thailand. The starch production process involves extraction and refinement of tapioca roots. This production process emits a large amount of organic content wastewater, which not only affects the local environment, but also releases methane, a potent greenhouse gas (GHG).

To alleviate GHG emission and other environmental issues, a new anaerobic digestion and methane recovery system coupled with a thermal energy generation system have been implemented to replace the previous open lagoon treatment system from which methane was freely emitted into the atmosphere.

A.1.2. Installed technology and equipments

The Project involves installation and operation of an anaerobic digestion and methane recovery system for the treatment of wastewater. The captured methane will be utilized in the thermal energy generation system as fuel for burners that produce heated air for the factory’s drying process, which prior to the project activity implementation was fuelled entirely by bunker oil, a fossil fuel.

The Project reduces GHGs through two activities. The first is avoidance of methane that was previously emitted from the open lagoons, and the second is from displacement of bunker oil by utilizing captured methane generated from biogas digester as fuel.

Please also refer to Section A.4.

A.1.3. Important dates

Table 1: Relevant dates relating to project implementation and operation

Date	Milestone	Notes
26/06/2006	Commissioning	-
15/04/2009	CDM registration	-
15/04/2009 – 10/05/2009	Non operation period	Factory closure

Please also refer to Section B.1.

A.1.4. Emission reductions achieved

Emission reductions achieved during this monitoring period was 36,384 tCO_2.

A.2. Project Participants

Project Participants are listed below.

- Siam Quality Starch Company Limited of Thailand (host)
- Mitsubishi UFJ Morgan Stanley Securities Co., Ltd of Japan

A.3. Location of the project activity:

The project is located at 222 Moo 10, Suranarai Road, Kokroengrom, Bumnet-Narong, Chaiyaphum 36160, Thailand.

The GPS coordinates are: 15°24'20"N, 101°37'35"E.

A.4. Technical description of the project

The project activity is illustrated by the schematic diagram below.

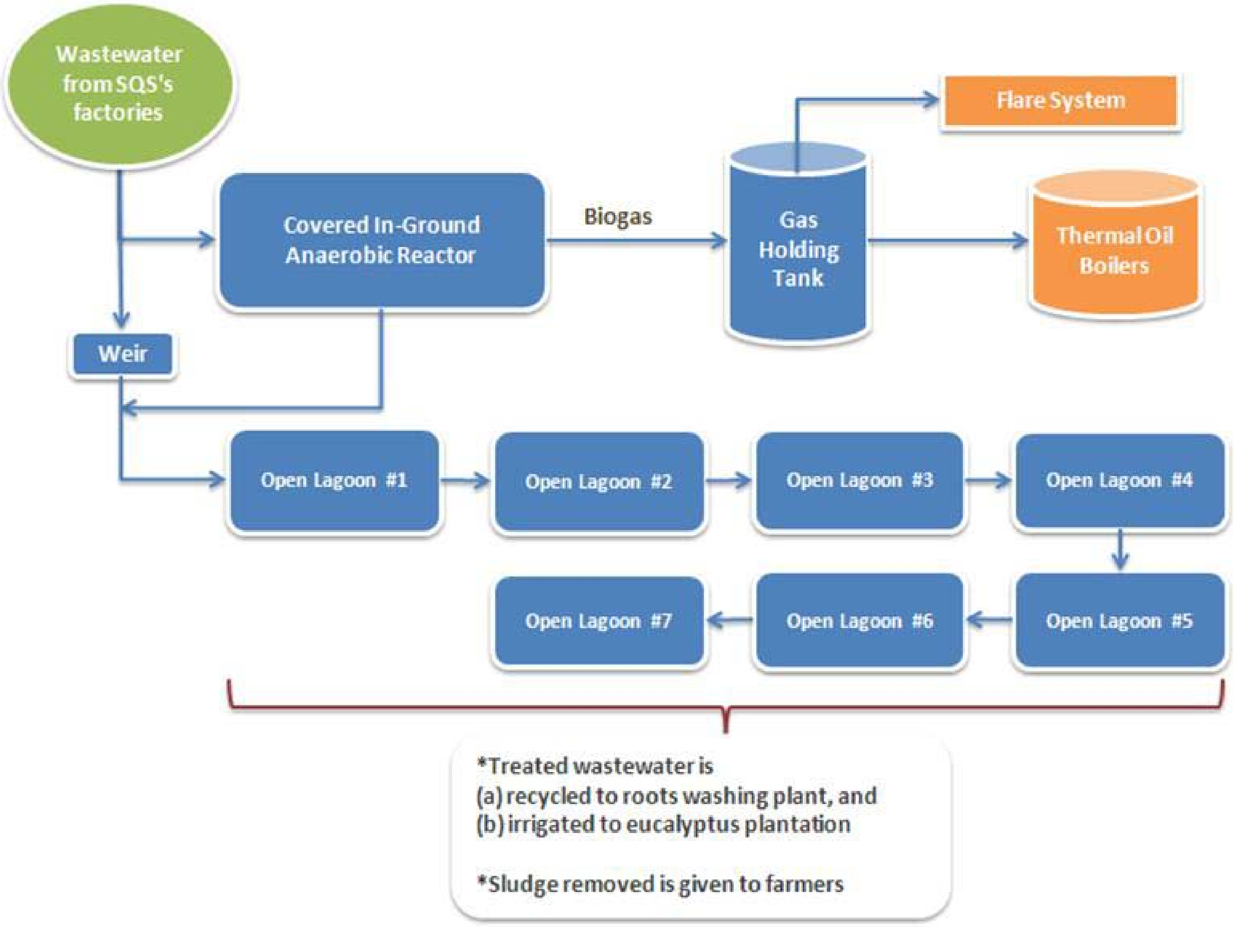

Figure 1: Schematic diagram of project boundary

The project activity involves three main technologies as follows:
- Wastewater treatment system;
- Thermal energy generation system; and
- Flare system.

To elaborate on each project component, influent fresh wastewater from the starch factory is firstly treated in a Covered In-Ground Anaerobic Reactor (CIGAR) which has a capacity of 90,000 m^3. Anaerobic bacteria activity decreases the loading of Chemical Oxygen Demand (COD) dramatically, by about 74%. The anaerobic process results in the production of methane-rich biogas, which is trapped within the digester and recovered.

In the thermal energy generation system, the recovered biogas from digester will be fed into two dual fuel burners (2 x 5,234 kW) installed at factory 1, and two others (2 x 5,234 KW) installed at factory 2. All burners can co-fire biogas and bunker oil.

Finally, any excess biogas will be combusted in the flare system, when there is overpressure in the biogas stream. It is also sometimes utilized for the purpose of checking that the flare system is properly functioning.

The wastewater exiting the CIGAR system is fed into the existing open lagoons, for secondary treatment. Final effluent is then discharged using a pump to the nearby eucalyptus plantation, within SQS's factory bounds. Sludge, when removed, is given (free of charge) to local farmers as fertilizer for application on tapioca fields.

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

The following methodologies and tools are applied:

- AM0013 "Avoided methane emissions from organic waste-water treatment" Version 4
- AMS-I.C. "Thermal energy for the user" Version 12
- "Tool to determine project emission from flaring gases containing methane" as contained in EB 28 Annex 13.
- "Tool to determine mass flow rate of greenhouse gas in gaseous stream" Version 2.0

A.6. Registration date of the project activity:

15/04/2009

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

Start of crediting period: 15/04/2009
Choice of crediting period: 10 years (fixed)

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

The monitoring report was prepared by:

Carbon Partners Asiatica

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SECTION B. Implementation of the project activity

B.1. Implementation status of the project activity

Status	Date
Commissioning date	26/06/2006
Discontinued operation during this monitoring period	15/04/2009 – 10/05/2009
Overhaul times	N/A
Downtime of major equipment	N/A
Exchange of major equipment	N/A
Any other special events	N/A

The Project has been in commercial operation since June 26, 2006. During the CDM period (i.e. 15 April 2009 onwards), the plant has since been operated by SQS in accordance with the registered PDD, except for (a) a delay in the arrival of biogas flow meter for the total biogas recovered from digester and (b) the absence of electricity meter for measuring electricity consumption in the ancillary decanter facility. During this monitoring period (i.e. 15/04/2009 – 30/11/2009), the Project plant was under normal operation.

For the delay in the arrival of the meter for the total biogas recovered and the absence of electricity meter for electricity consumed at the ancillary decanter facility, deviation request I-DEV0319 and I-DEV0406 was submitted and accepted, respectively. In addition, there were several relatively minor changes required for the monitoring plan, for which a request for revision of monitoring plan was submitted and accepted by CDM EB. These are detailed in the ensuing sections.

B.2. Revision of the monitoring plan

The monitoring plan has been revised during this monitoring period. The revision was approved on 03/06/2011.

The revisions to the monitoring plan from that described in the registered PDD are summarized in the table below.

Table 2: Revisions of the monitoring plan from the registered PDD

Monitored Parameters	Monitoring Plan in Registered PDD	Revisions to the Monitoring Plan	Reasons of revisions
$Q_{elec\_cons,y}$	"Quantity of electricity consumed due to the project activity in year y will be measured by a continuous electricity meter"	To include a back-up method for calculation of electricity consumption in project activity using the following manner: Electricity consumption = [Total MW capacity of all affected equipment] x [number of days during which meter is not operational] x [1.1]	To introduce a back-up method of calculating electricity consumed in the project activity for any reason measurement is not carried out.
$Q_{elec\_cons,y}$	Electricity meter will be calibrated according to appropriate industry/international standards	The monitoring plan was revised such that the electricity meters will either be calibrated by PEA or replaced, at a frequency recommended by the PEA or every 12 months, whichever occurs earlier.	Upon enquiring with the Provincial Electricity Authority of Thailand, it was found that there are no set industry standards for either calibration method or frequency for calibration of internal electricity meters.
$Q_{burner\_stack,y}$	"Amount of burner	The burner stack gas will be	i. The PP was unable to find

	stack gas in year y will directly be measured."	calculated from a) The monitored flow rate of the burner feed gas ($Q_{biogas\_burner,y}$) and b) A project –specific, empirically derived Nm^3 stack gas/Nm^3 feed biogas factor obtained from an annual 20-hour measurement campaign And, for conservativeness, two further measures will be taken as follows: 1. The highest Nm^3 stack gas/Nm^3 biogas ratio observed during the measurement campaign will be selected rather than the average ratio. 2. The highest SBSTA conservativeness of 1.37 will be applied to the ratio selected as per 1 above.	stack gas flow meter suitable for monitoring, given the high temperatures (~300 ^{O}C), large flows (up to 250m^3/min) and particulates present. ii. As the burners are co-fired with the fuel oil and shares the same stack, even when the hurdle in (i) is overcome and the total stack gas flow is directly monitored, a further calculation step is involved to determine the stack gas that is due to the biogas.
Conversion of biogas flow from volumetric basis to mass basis for calculation of CERs	No description is provided in the registered monitoring plan on how the biogas flows that are measured on volumetric basis will be converted to mass basis for the calculation of CERs.	The project participant has adopted the method given in the Tool to determine the mass flow rate of a greenhouse gas in a gaseous stream ("the Tool") in first monitoring period and revised the monitoring plan to include this Tool to properly calculate the mass flow of the gases stream from volumetric measurement in subsequent monitoring periods.	No description is provided in the registered monitoring plan on how the biogas flows that are measured on volumetric basis will be converted to mass basis for the calculation of CERs.
$Q_{biogas\_total,y}$, $Q_{biogas\_burner,y}$/ $Q_{biogas\_flare,y}$ and W_{CH4},	The validated PDD and underlying monitoring methodology AM0013 Version 04 for the project in question require the fraction of methane in biogas to be measured on wet basis. However, the methodology was silent on whether the biogas measurements will be carried out on a wet or dry basis, but this was addressed in the validated PDD as to be measured in dry basis.	The monitoring plan was revised to leave the flexibility in the measurement of biogas flows ($Q_{biogas\_total,y}$, $Q_{biogas\_burner,y}$/$Q_{biogas\_flare,y}$) and methane content in biogas (W_{CH4},) to be measured either in wet or dry basis. Then, when the conversion to/from wet/dry basis is required, the "Tool to determine the mass flow rate of a greenhouse gas in a gaseous stream" will be used.	In this monitoring period, the biogas flow rate is measured on wet basis, whereas the methane content in biogas is measured in dry basis. For subsequent monitoring periods, the project participant wishes to leave flexibility on whether the biogas measurement will be carried out on a wet or dry basis, as this may change if and when the meters and analyzers are replaced in future.

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

There are two monitoring activities that deviated from the monitoring plan as described in the registered PDD. The deviation requests for the monitoring of $Q_{biogas\_total,y}$ and $Q_{elec\_cons,y}$ were approved by CDM Executive Board with reference numbers I-DEV0319 (approved 16/09/2010) and I-DEV0406 (approved 3/05/2011), respectively.

The two approved deviation requests were applied to the monitoring report of this monitoring period and are summarized in the table below.

Table 3: Deviation from the monitoring plan as described in the registered PDD

I-DEV No.	Monitored Parameters	Monitoring Plan described in Registered PDD	Deviations found in this monitoring period	Reasons for deviations
0319	$Q_{biogas\_total,y}$,	"Quantity of biogas produced and collected in the digester in year y is to be monitored on a continuous basis with flow meter". (corresponding to ID18 "FR_{bio}" in AM0013 version4)	The "quantity of biogas produced and collected in digester" was not directly monitored with a "Total Flow Meter" during 15/04/2009 to 1/07/2009.	A total meter (GFM-008) was installed to monitor "quantity of biogas produced and collected in digester" on July 1, 2009. It was delayed by 2.5 months after the registration date of the project.
0406	$Q_{elec\_cons,y}$	"Quantity of electricity consumed due to the project activity in year y is to be measured by a continuous electricity meter, with data aggregated monthly"	The project activity has two sources of electricity consumption. One is for biogas facility, and the other for the ancillary decanter facility. These two sources of electricity are required to be monitored throughout the crediting period. But, in this monitoring period, the project participant did not monitor the quantity of electricity consumed at ancillary decanter facility.	The project participant did not install electricity meter to monitor electricity consumption at ancillary decanter facility.

Elaboration on variations between the readings of biogas flow meters were observed in this monitoring period

In this monitoring period, there were are a total of 8 biogas flow meters (GFM-001 to GFM-008) installed and used to monitor quantity of biogas recovered from digester, fed to four burners and a flare. Principally, total quantity of biogas recovered and fuelled or flared in the project activity, for CERs calculation, can be either taken from the total readings of the group of biogas flow meters classified as below;

- **Group A:** "Total Meter (GFM-008)"
- **Group B:** "Two Sub-Total Meters (GFM-001 and GFM-002)" plus a "Flare Meter (GFM-007)"
- **Group C:** "Four Individual Meters (GFM-003 to GFM-006)" plus a "Flare Meter (GFM-007)"

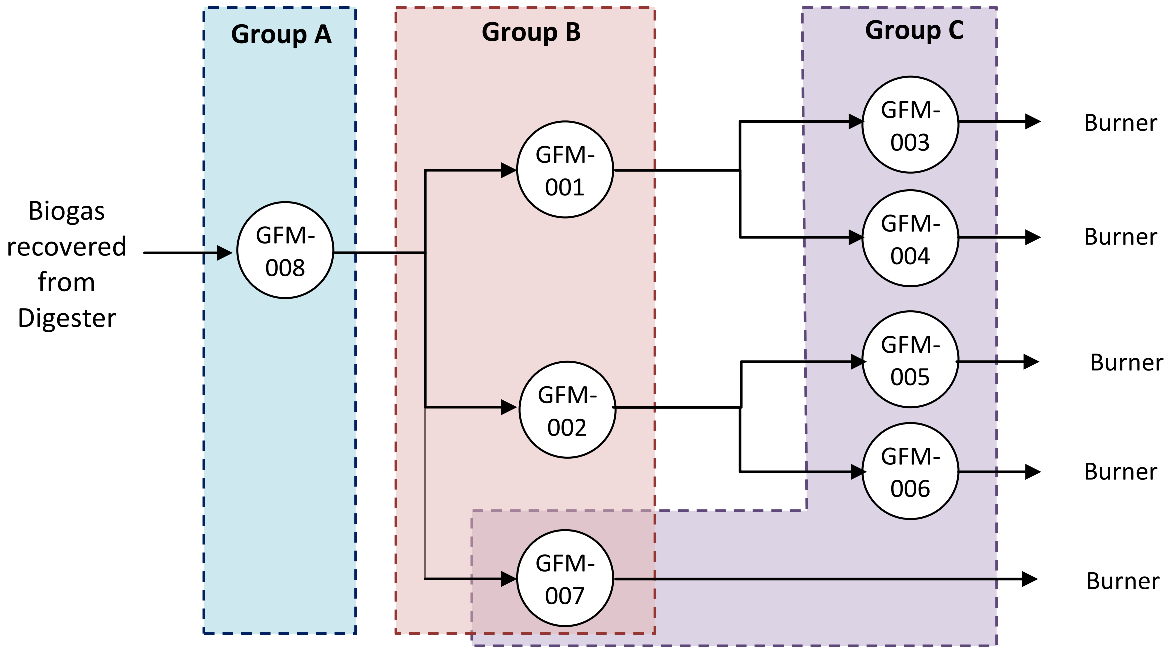

Figure 2: Classification of the groups of biogas flow meters

In accordance with the approved deviation request I-DEV0319, the following values are the readings from biogas flow meters taken for CERs calculation in this monitoring period.

Table 4: Summary of biogas flow readings taken for CERs calculation

Periods	Biogas Volume (Nm^3)			Selected Biogas Volume for BE calculation (Nm^3)	Selected Biogas Volume for PE calculation (Nm^3)	Variation between the readings of flow meters (%)
	Meters Group A	Meters Group B	Meters Group C			
<u>Period 1:</u> (15 Apr to 11 May 2009)	0	0	0	0	0	-
<u>Period 2:</u> (12 to 31 May 2009)	0	381,188	0	376,932[1] (376,240 + 692)[2]	385,444[1] (384,731 + 713)	-
<u>Period 3:</u> (1 Jun to 1 Jul 2009)	0	998,839	964,857	922,153[3]	1,040,549[3]	3.40%
<u>Period 4:</u> (2 Jul to 10 Aug 2009)	1,166,660	0	1,261,389	1,145,694[4]	1,282,355[4]	10.12%
<u>Period 5:</u> (11 Aug to 30 Nov 2009)	2,683,830	0	2,721,241	2,721,241[5]	2,721,241[5]	1.37%[6]
Total	-	-	-	5,166,020	5,429,589	-

[1] Monitored values of GFM-002 and GFM-007 were rectified using instruction in EB52 ANNEX 60 due to calibration being delayed.
[2] 376,240 Nm^3 was combusted at burners, while the remaining 692 Nm^3 was combusted at flare.
[3] In accordance with an approved deviation request, the lowest and the highest reading between the two groups of meters available in period 3 were conservatively selected (on a daily basis) for the BE and PE calculations, respectively. The selected biogas volumes (Nm^3) presented in this table is the sum of daily selection in each period. Monitored values of GFM-002 and GFM-007 were rectified using instruction in EB52 ANNEX 60 due to calibration being delayed.
[4] In accordance with an approved deviation request, the lowest and the highest reading between the two groups of meters available in period 4 were conservatively selected (on a daily basis) for the BE and PE calculations, respectively. The selected biogas volumes (Nm^3) presented in this table is the sum of daily selection in each period. Monitored values of GFM-007 were rectified using instruction in EB52 ANNEX 60 due to calibration being delayed.
[5] Monitored values of GFM-007 were rectified using instruction in EB52 ANNEX 60 due to calibration being delayed.
[6] The variation between the flow readings decreased to 1.37%, which is well within the permissible error of the flow meters.

B.4. Notification or request of approval of changes

No notification or request of approval of changes from the project activity as described in the registered CDM-PDD was filed during this monitoring period.

SECTION C. Description of the monitoring system

C.1. Monitoring points

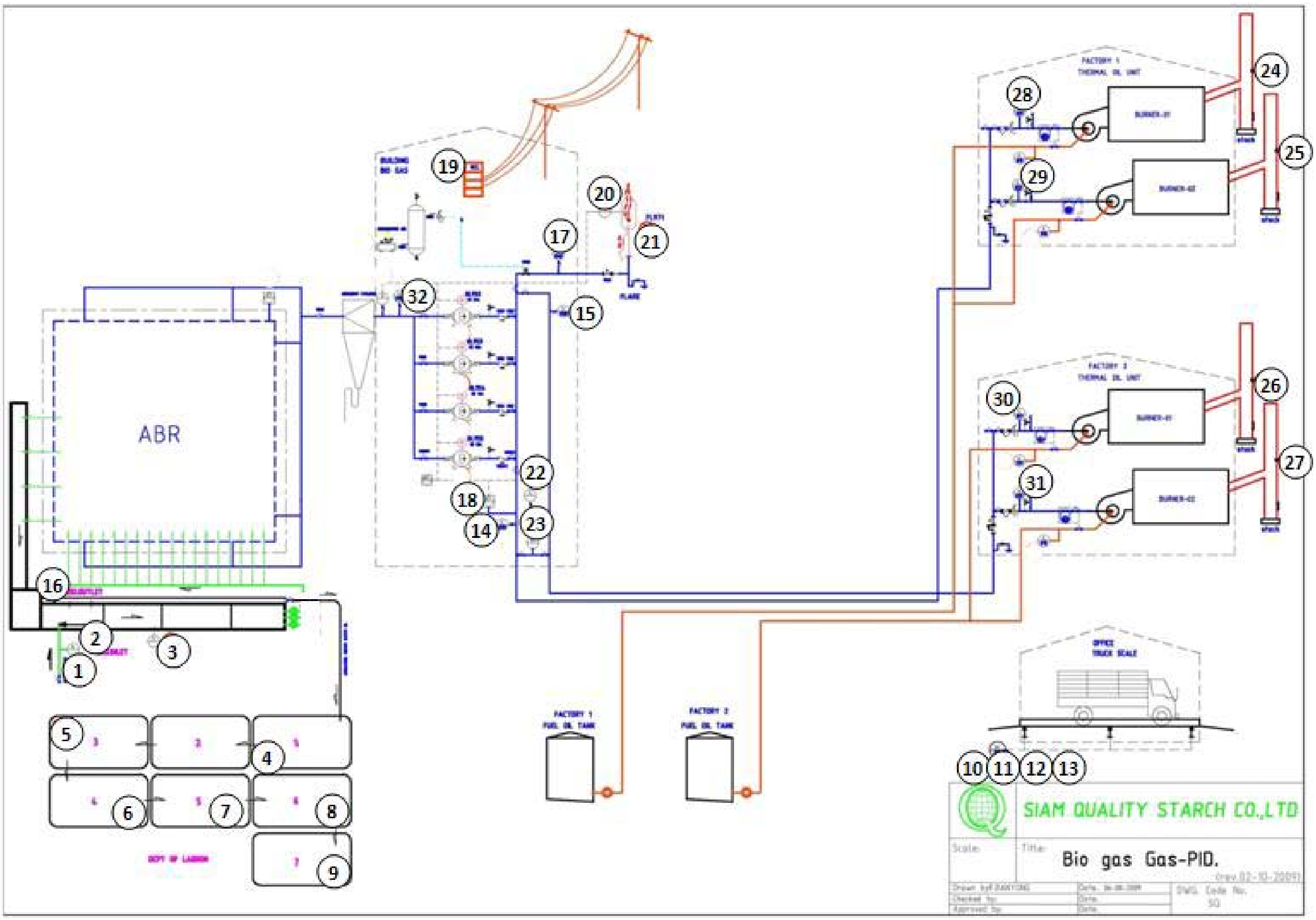

Figure 3: Location of monitoring equipments

C.2. Monitoring Team and System

Consistent with the registered CDM-PDD, SQS appointed a CDM monitoring team consisting of utility staff, laboratory supervisor, project engineer, environmental & CDM project manager and managing director to fully implement data collecting, quality control and internal evaluation process. The monitoring team structure is expressed in Figure 4, which in accordance with ISO 9001.

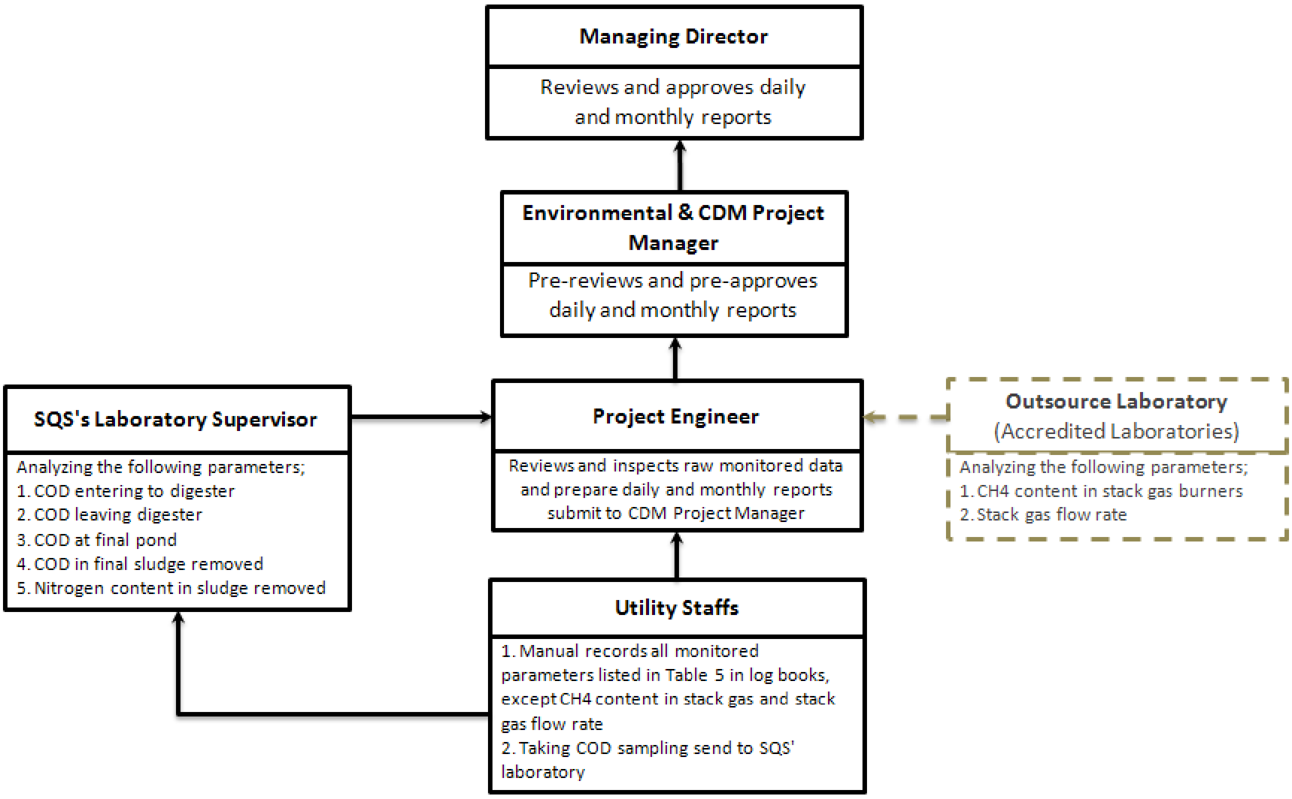

Figure 4: CDM monitoring team structure

C.3. Staff Training

Training has been carried out to make sure the relevant personnel has the necessary mechanical, electric and installation knowledge, know well the working principle and the fundamental structure of wastewater treatment and energy generation project, understand the reasons of common malfunction and the corresponding troubleshooting methods, expertly use the monitoring system and understand the importance of the monitoring system to the successful issuance of CERs. SQS also organizes professional training periodically to improve the professional skill of the operators after the project operation. Specifically, new employees have to receive training on project operation, monitoring requirements, and the importance of monitoring for the CDM. If personnel transfers happen, the worker taking over will receive the same training. The training programs relevant to CDM project activities carried out by SQS are listed in the following table.

Table 5: Summary of CDM-related training provided to operational staff

No	Courses	Training Materials	Trainees	Frequency
1	CDM Management	Appendix C in Environmental management system operation procedure [Doc no. 50-08-M] , and Project Design Document (PDD)	CDM monitoring committees	Once a year
2	Internal Audit	Centre system operation procedure [Doc no. 50-02-M]	Internal audit committees	Once a year
3	Emergency Plan	Emergency plan [Doc no. 50-07-M]	Project engineer Electrical engineer Water pollution controller Water pollution operator Electrician Utility staffs	Once a year

4	Biogas Operation	Biogas work instruction [Doc no. 26-04-M]	Utility staffs	Once a year
5	Wastewater Treatment Operation	Waste water treatment system work instruction [Doc no. 26-04-M]	Utility staffs	Once a year
6	Burner Operation	Burner work instruction [Doc no. 26-04-M]	Utility staffs	Once a year
7	Measuring Instrument Calibration	Measuring instrument calibration work instruction [Doc no.26-03-M]	Electrician & Utility staffs	Once a year
		Measuring instrument calibration work instruction [Doc no.38-07-M]	Laboratory staffs	Twice a year
8	COD Analysis	Process water and waste water analysis work instruction [Doc no. 38-09-M]	Laboratory staffs	Twice a year

The relevant documents pertaining to the training courses in Table 8 were shown to the DOE during the verification site visit.

C.4. Data Collection Procedures

To ensure maximum accuracy of monitored data, data record keeping has been carried out only by members of the specifically-appointed monitoring team. The following data collection and reporting procedure is applied;

1. Utility staff manually record all parameters read from meters every 8 hours (i.e. every shift) in the data log book.
2. Those values, taken every 8 hours, will be aggregated every 24 hours to get a total/average daily value. Then, the calculation result will be submitted to project engineer. The document number for this information is “Doc. No. 26-30-F”.
3. The project engineer will be responsible for inspecting and calculating daily sum and average values of parameters reported in “Doc. No. 26-30-F”. Then, these daily values are compiled each day in the “Biogas- CDM Daily Report”. Then, the data summarized in the “Biogas-CDM Daily Report” are compiled each month in “Biogas-CDM Monthly Report”. The reference number of document for “Biogas-CDM Daily Report” and “Biogas-CDM Monthly Report” is “Doc.50-97-F” and “Doc.50-98-F”, respectively.
4. Every month, the project engineer will submit 0daily and monthly operation data recorded in “Biogas-CDM Daily Report” and “Biogas-CDM Monthly Report” to Environmental & CDM Project Manager for review. After review, Environmental & CDM Project Manager will sign off the documents if there are no suspicions on the correctness of data. This document will then be submitted to Managing Director.
5. The Managing Director will review the documents signed by Environmental & CDM Project Manager and the documents will be returned to concern departments and sections.

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:	**B_o**
Data unit:	$kgCH_4/kgCOD$
Description:	Maximum methane producing capacity
Source of data used:	AM0013
Value(s) :	0.21
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Additional comment:	N/A

Data / Parameter:	**GWP_CH_4**
Data unit:	tCO_2e/tCH_4
Description:	Global warming potential for methane
Source of data used:	AM0013
Value(s) :	21
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Additional comment:	N/A

Data / Parameter:	**CO_2EF_{fuel}**
Data unit:	tCO_2/TJ
Description:	CO_2 emission factor for thermal energy generation using fuel oil
Source of data used:	IPCC 2006 table 2.2
Value(s) :	75.5 (baseline emission) 77.4 (project emission)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Additional comment:	The PDD for the Project was registered using an *ex ante* fixed value of 77.4. However, for conservatism, this was changed to 75.5 for the baseline emission calculations.

Data / Parameter:	**OX_{fuel}**
Data unit:	Fraction
Description:	Oxidation factor for fuel oil
Source of data used:	IPCC 2006 table 1.4
Value(s) :	1
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Additional comment:	N/A

Data / Parameter:	**LF**
Data unit:	Fraction
Description:	Rate of physical leakage from digester

Source of data used:	AM0013
Value(s) :	0.15
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Additional comment:	N/A

Data / Parameter:	**MCF_{la}**
Data unit:	Fraction
Description:	Methane correction factor of sludge in year y
Source of data used:	AM0013
Value(s) :	0.05
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Additional comment:	N/A

Data / Parameter:	**EF_{N2O}**
Data unit:	kgN_2O/kgN
Description:	Emission factor of nitrogen from sludge applied to land
Source of data used:	AM0013
Value(s) :	0.016
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Additional comment:	N/A

Data / Parameter:	**GWP_N_2O**
Data unit:	tCO_2e/tN_2O
Description:	Global warming potential for nitrous oxide
Source of data used:	IPCC
Value(s) :	310
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Additional comment:	N/A

Data / Parameter:	**$COD_{conc\ out,\ baseline,m}$**
Data unit:	$kgCOD/m^3$
Description:	COD concentration of final effluent in the baseline
Source of data used:	Registered CDM-PDD
Value(s) :	0.12
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Additional comment:	N/A

Data / Parameter:	**F_d**
Data unit:	Fraction
Description:	Fraction of anaerobic degradation as a function of depth, for depth 1 –

	5 m.
Source of data used:	AM0013
Value(s) :	0.5
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Additional comment:	N/A

Data / Parameter:	$\mathbf{Q_{fuel\ oil,y}}$
Data unit:	TJ
Description:	Maximum quantity of fuel oil consumed in year y in the absence of project activity
Source of data used:	Registered CDM-PDD
Value(s) :	140.6
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Additional comment:	N/A

Data / Parameter:	$\boldsymbol{\rho_{CH4}}$
Data unit:	kgCH4/Nm3CH4
Description:	Density of methane at normal condition
Source of data used:	Tool to determine project emissions from flaring gases containing methane
Value(s) :	0.716
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Additional comment:	N/A

Data / Parameter:	$\mathbf{NCV_{CH4}}$
Data unit:	TJ/Gg
Description:	Net Calorific Value of methane
Source of data used:	IPCC 2006 Table 1.2
Value(s) :	50.4
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Additional comment:	N/A

D.2. Data and parameters monitored

Data / Parameter:	$\mathbf{F_{digester}/\ F_{dig\_out,m}}$ (F_{dig}/F_{dig_out} in AM0013)
Data unit:	m^3/day
Description:	Flow rate of wastewater fed into/ discharge out of digester
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	877,086 (total for monitoring period)

Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: SIEMENS/SITRANS F M MAGFLO MAG6000 Accuracy: +/- 2.5% Serial Number: 7ME633000817N465 Calibration frequency: 12 months Date of last calibration: 16-July-09 Validity: 15-July-10 Monitoring position: (1)/FIC-001
Measuring/ Reading/ Recording frequency:	Measured continuously, recorded every shift (8 hours)
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	$\mathbf{OP_m}$
Data unit:	Days / month
Description:	Number of operation days in month
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	203 (total for monitoring period)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	N/A
Measuring/ Reading/ Recording frequency:	Measured and recorded daily
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	$COD_{conc\_in,baseline,m}$ ($COD_{c,BL}$ in AM0013)
Data unit:	kg COD/m^3
Description:	COD concentration of effluent entering the lagoon in the baseline
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	4.9 (average)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Monitoring equipment (type, accuracy class, serial	Equipment 1: Weight 1711269 Type: SATORIUS/CP224S

number, calibration frequency, date of last calibration, validity)	Accuracy: +/- 0.0005g at standard weights 5g, 10g, 20g and 200g Serial Number: 17111269 Calibration frequency: 1 month Date of last calibration: 13-November-09 Validity: 12-December-09 Equipment 2: Weight 58288 Type: PRECISA/205A Accuracy: +/- 0.0005g at standard weights 5g, 10g, 20g and 200g Serial Number: 58288 Calibration frequency: 1 month Date of last calibration: 13-November-09 Validity: 12-December-09 Monitoring position: (2)/-
Measuring/ Reading/ Recording frequency:	Measured and recorded at least monthly
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	**T2** (T_{lag} in AM0013)
Data unit:	Celsius
Description:	Ambient temperature
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	27 (average)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: SHENGZHAN/Thermometer 0-100^{o}C Mercury Accuracy: +/- 3 ^{o}C Serial Number: UN-02 Calibration frequency: 12 months Date of last calibration: 20-August-09 Validity: 19-August-10 Monitoring position: (3)/TIC-001
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	$D_{lagoon,project}$ (D_{lag} in AM0013)
Data unit:	m
Description:	Depth of open lagoons
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored	Average values:

parameter:	Lagoon 1 = 4.5 Lagoon 3 = 4.6 Lagoon 4 = 4.4 Lagoon 5 = 4.5 Lagoon 6 = 4.6 Lagoon 7 = 4.7
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Meter rods Monitoring position: (4), (5), (6), (7),(8), (9)/meter rods
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	$Q_{sludge,m}$ / $Q_{sludge,y}$ (F_{la} in AM0013)
Data unit:	Ton sludge
Description:	Amount of sludge generated/ and removed in month or year
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	136.37 (total for monitoring period)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	<u>Equipment 1: Truck scale 1</u> Type: METTLER TOLEDO/8142 PRO Accuracy: At 0-10,000 kg, +/- 10 kg; at >10,000-40,000kg, +/-20kg; at >40,000-100,000kg, +/-30kg. Serial Number: 00240926 Calibration frequency: 24 months Date of last calibration: 28-April-08 Validity: 27-April-10 <u>Equipment 2: Truck scale 2</u> Type: METTLER TOLEDO/8142 PRO Accuracy: At 0-10,000 kg, +/- 10 kg; at >10,000-40,000kg, +/-20kg; at >40,000-100,000kg, +/-30kg. Serial Number: 00241276 FE Calibration frequency: 24 months Date of last calibration: 2-December-08 Validity: 1-December-10 <u>Equipments 3 and 4: Truck scales 3 and 4</u> Type: METTLER TOLEDO/8530 COUGAR Accuracy: At 0-10,000 kg, +/- 10 kg; at >10,000-40,000kg, +/-20kg; at >40,000-100,000kg, +/-30kg.

	Serial Number: 5454117-5KF, 5453962-5KF Calibration frequency: 24 months Date of last calibration: 28-April-08 Validity: 27-April-10 Monitoring position: (10),(11),(12),(13)/Truck scale 01;02;03;04
Measuring/ Reading/ Recording frequency:	When sludge is removed
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	$COD_{conc\_sludge,m}$ ($COD_{c,la}$ in AM0013)
Data unit:	kg COD/ m^3 sludge
Description:	COD concentration of sludge removed in month
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	0.101 (average)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Equipment 1: Weight 1711269 Type: SATORIUS/CP224S Accuracy: +/- 0.0005g at standard weights 5g, 10g, 20g and 200g Serial Number: 17111269 Calibration frequency: 1 month Date of last calibration: 13-November-09 Validity: 12-December-09 Equipment 2: Weight 58288 Type: PRECISA/205A Accuracy: +/- 0.0005g at standard weights 5g, 10g, 20g and 200g Serial Number: 58288 Calibration frequency: 1 month Date of last calibration: 13-November-09 Validity: 12-December-09
Measuring/ Reading/ Recording frequency:	Measured and recorded at least monthly
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	$Q_{fuel\_oil,y}$ ($HG_{BL,y}$ in AM0013)
Data unit:	TJ/yr
Description:	Quantity of fuel oil displaced in year y
Measured /Calculated /Default:	Calculated
Source of data:	Logbook
Value(s) of monitored parameter:	89 (total for monitoring period)

Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	See $Q_{biogas\_burner,y}$
Measuring/ Reading/ Recording frequency:	Recorded monthly
Calculation method (if applicable):	Energy content of $Q_{biogas\_burner,y}$ considered to equal that of $Q_{fuel\_oil,y}$
QA/QC procedures applied:	N/A

Data / Parameter:	$COD_{conc\_dig\_out,m}$ (COD_{c,dig_out} in AM0013)
Data unit:	kg COD/m^3
Description:	COD out of digester to lagoons
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	4.9 (average)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	<u>Equipment 1: Weight 1711269</u> Type: SATORIUS/CP224S Accuracy: +/- 0.0005g at standard weights 5g, 10g, 20g and 200g Serial Number: 17111269 Calibration frequency: 1 month Date of last calibration: 13-November-09 Validity: 12-December-09 <u>Equipment 2: Weight 58288</u> Type: PRECISA/205A Accuracy: +/- 0.0005g at standard weights 5g, 10g, 20g and 200g Serial Number: 58288 Calibration frequency: 1 month Date of last calibration: 13-November-09 Validity: 12-December-09 Monitoring position: (16)/-
Measuring/ Reading/ Recording frequency:	Measured and recorded at least monthly
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	$Q_{biogas\_total,y}$ (FR_{bio} in AM0013)
Data unit:	Nm^3/yr
Description:	Quantity of biogas produced and collected in the digester in year y
Measured /Calculated /Default:	Measured

Source of data:	Logbook
Value(s) of monitored parameter:	Please refer to spreadsheet due to multiple results and missing meters
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Equipment 1: GFM-001 Type: EPI/8240MP Accuracy: (Ref.21C) +/- (1 % of reading+(0.5%+0.02%/C of Full scale)) Serial Number: 27031212 Calibration frequency: 12 months Date of last calibration: 17-November-08 Validity: 16-November-09 Equipment 2: GFM-002 Type: EPI/8240MP Accuracy: (Ref.21C) +/- (1 % of reading+(0.5%+0.02%/C of Full scale)) Serial Number: 27031211/28022001 Calibration frequency: 12 months Date of last calibration: 29-March-08 Validity: 28-March-09 Equipments 3 – 6: GFM-003 / 0004 / 005 / 006 Type: ALIA VTX/AVF7000 Accuracy: +/- 1.0 % Serial Number: 09110106, 09110005, 09110005, 09109904 Calibration frequency: 12 months Date of last calibration: 1-April-09 Validity: 31-March-10 Equipment 7: GFM-007 Type: EPI/8240MP Accuracy: (Ref.21C) +/- (1 % of reading+(0.5%+0.02%/C of Full scale)) Serial Number: 25100705/26120501 Calibration frequency: 12 months Date of last calibration: 9-November-09 Validity: 8-November-10 Equipment 8: GFM-008 Type: FCI/ST51 Accuracy: At > 0.21 nmps +/- 2% reading+/-0.5% full scale Serial Number: 306094 Calibration frequency: 18 months Date of last calibration: 22-June-09 Validity: 21-December-10 Monitoring position / ID: (14)/GFM-001 (Burner 1 + 2) (15)/GFM-002 (Burner 3 + 4) (28)/GFM-003 (Burner) (29)/GFM-004 (Burner) (30)/GFM-005 (Burner)

	(31)/GFM-006 (Burner) (17)/GFM-007 (Flare) (32)/GFM-008 (total meter)
Measuring/ Reading/ Recording frequency:	Measured continuously and recorded every shift (8 hours)
Calculation method (if applicable):	N/A
QA/QC procedures applied:	Individual streams are crosschecked against total stream

Data / Parameter:	W_{CH4} ($P_{CH4, bio}$ in AM0013)
Data unit:	m^3 CH_4/m^3 biogas (wet basis)
Description:	Fraction of methane in biogas
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	0.48 (average)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: ANRI/CAM-3L Accuracy: +/- 2% reading Serial Number: LFB-020 Calibration frequency: 12 months Date of last calibration: 11-February-09 Validity: 10-February-10 Monitoring position / ID: (18)/MTA-001
Measuring/ Reading/ Recording frequency:	Measured continuously and recorded every shift (8 hours)
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	NC
Data unit:	kg N/ kg sludge
Description:	Nitrogen content of sludge
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	0.003
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	<u>Equipment 1: Weight 1711269</u> Type: SATORIUS/CP224S Accuracy: +/- 0.0005g at standard weights 5g, 10g, 20g and 200g Serial Number: 17111269 Calibration frequency: 1 month Date of last calibration: 13-November-09 Validity: 12-December-09

	<u>Equipment 2: Weight 58288</u> Type: PRECISA/205A Accuracy: +/- 0.0005g at standard weights 5g, 10g, 20g and 200g Serial Number: 58288 Calibration frequency: 1 month Date of last calibration: 13-November-09 Validity: 12-December-09
Measuring/ Reading/ Recording frequency:	Measured and recorded monthly
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	$Q_{elec\_cons,y}$ ($EL_{p,y}$ in AM0013)
Data unit:	MWh
Description:	Quantity of electricity consumed due to the project activity
Measured /Calculated /Default:	Measured / calculated
Source of data:	Logbook
Value(s) of monitored parameter:	875 (total)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: MITSUBISHI/MH96H Accuracy: +/- 2% (class 2 IEC 60521) Serial Number: 9279973 Calibration frequency: 12 months Date of last calibration: 15-March-10 (outside monitoring period due to delayed calibration) Validity: 14-March-11 Monitoring position / ID: (19)/WM-01 (electricity meter)
Measuring/ Reading/ Recording frequency:	Measured continuously, recorded every shift (8 hours)
Calculation method (if applicable):	As per I-DEV0319
QA/QC procedures applied:	N/A

Data / Parameter:	CO_2 EF_{elec}
Data unit:	tCO_2e/MWh
Description:	CO_2 emission factor for electricity consumed at project site
Measured /Calculated /Default:	Calculated
Source of data:	Thailand Greenhouse Gas Management Organization
Value(s) of monitored parameter:	0.5756
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration	N/A

frequency, date of last calibration, validity)	
Measuring/ Reading/ Recording frequency:	Annually
Calculation method (if applicable):	As per the "Tool to calculate the emission factor for an electricity system" Version 02.2.1
QA/QC procedures applied:	N/A

Data / Parameter:	$Q_{biogas\_burner,y}$ / $Q_{biogas\_flare,\ y}$ ($FR_{e,inlet}$/$FR_{f,\ inlet}$ in AM0013)
Data unit:	Nm^3/hr
Description:	Volumetric flow rate of the biogas at normal conditions in the hour h. Same basis measurement (dry or wet) for all component in biogas
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	$Q_{biogas\_burner,y}$ = 5,428,876 (total for monitoring period) $Q_{biogas\_flare,\ y}$ = 713 (total for monitoring period)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Please refer to Qbiogas_total,y for details of each monitoring equipment Monitoring position / ID: (14)/GFM-001 (Burner 1 + 2) (15)/GFM-002 (Burner 3 + 4) (28)/GFM-003 (Burner) (29)/GFM-004 (Burner) (30)/GFM-005 (Burner) (31)/GFM-006 (Burner) (17)/GFM-007 (Flare)
Measuring/ Reading/ Recording frequency:	Measured hourly and recorded every shift (8 hours)
Calculation method (if applicable):	N/A
QA/QC procedures applied:	Individual streams are crosschecked against total stream

Data / Parameter:	T_{flare}
Data unit:	Celsius
Description:	Temperature of the exhaust gas of the flare
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	623
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: SIEMENS/SITRANS TH300 Accuracy: +/- 3^oC Serial Number: AZB/U9006971 Calibration frequency: 12 months Date of last calibration: 3-January-09

	Validity: 2-January-10 Monitoring position / ID: (20)/TIC-003
Measuring/ Reading/ Recording frequency:	Measured hourly and recorded every shift (8 hours)
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	Flare operation parameter
Data unit:	Minute/hr
Description:	Minutes that flare is detected during the hour h
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	127 (total for monitoring period)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: (Nais) Matsushita Electric Works, Ltd/ TH2385 Accuracy: +/- 3^{o}C Serial Number: 00912 Calibration frequency: N/A Date of last calibration: N/A Validity: N/A Monitoring position / ID: (21)/Flare detector & hour counter
Measuring/ Reading/ Recording frequency:	Measured continuously and recorded every shift (8 hours)
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	**T**
Data unit:	Celcius
Description:	Temperature of biogas
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	63 (average)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: RTD sensor: Rosemount/68 N11 N00B030T / Temperature transmitter: Rosemount/3144 Accuracy: +/- 3^{o}C Serial Number: RTD sensor: 0541593 / Temperature transmitter: 0187554 Calibration frequency: 12 months Date of last calibration: 2-January-09 Validity: 1-January-10

	Monitoring position / ID: (22)/TIC-002
Measuring/ Reading/ Recording frequency:	Measured continuously and recorded every shift (8 hours)
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	**P**
Data unit:	Bar (gauge)
Description:	Pressure of biogas
Measured /Calculated /Default:	Measured
Source of data:	Logbook
Value(s) of monitored parameter:	0.446 (average)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: SIEMENS/TRANS P 7MF1563-3BA01 Accuracy: At 25 C, 0.25 % of full scale-typical (0.5% of full scale max) Serial Number: AZB/R0100522 Calibration frequency: 12 months Date of last calibration: 30-April-09 Validity: 29-April-10 Monitoring position / ID: (23)/PIC-002
Measuring/ Reading/ Recording frequency:	Measured continuously and recorded every shift (8 hours)
Calculation method (if applicable):	N/A
QA/QC procedures applied:	N/A

Data / Parameter:	$Q_{burner\_stack,y}$ ($FR_{e,s}$ in AM0013)
Data unit:	Nm^3/yr
Description:	Amount of burner stack gas in year y
Measured /Calculated /Default:	Calculated
Source of data:	Logbook, measurement campaign
Value(s) of monitored parameter:	217,155,037
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	N/A Monitoring position / ID: (24)/BU-01 (25)/BU-02 (26)/BU-330-001 (27)/BU-330-002
Measuring/ Reading/ Recording frequency:	Calculated quarterly

Calculation method (if applicable):	As per approved revision of monitoring plan
QA/QC procedures applied:	N/A

Data / Parameter:	W_{CH4_stack} ($P_{CH4,e,s}$ in AM0013)
Data unit:	Nm^3 CH_4/ Nm^3 stack gas
Description:	Fraction of methane in burner stack gas
Measured /Calculated /Default:	Calculated
Source of data:	Measurement campaign
Value(s) of monitored parameter:	
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	N/A – measurement campaign by external laboratory
Measuring/ Reading/ Recording frequency:	Quarterly
Calculation method (if applicable):	As per revised monitoring plan, the flow rate of burner stack gas in Nm^3/second is measured through a measurement campaign and used to derive a project-specific, empirically-derived Nm^3 stack gas/Nm^3 feed biogas factor.
QA/QC procedures applied:	Measurement campaign is carried out by an accredited external laboratory

SECTION E. Emission reductions calculation

E.1. Baseline emissions calculation

Baseline emission are calculated as:

$$\mathbf{BE_y = BE_{lagoon,y} + BE_{fuel\_oil,y}}$$

where:

BE_y = Baseline emissions (tCO_2e/yr)
$BE_{lagoon,y}$ = Baseline CH_4 emissions from the open lagoons in year *y* (tCO_2e/yr)
$BE_{fuel\_oil,y}$ = Baseline CO_2 emissions from the combustion of fuel oil in year *y* (tCO_2/yr)

$\mathbf{BE_{lagoon,y}}$

$BE_{lagoon,y}$ is the baseline methane emission from the open lagoons. As described in AM0013, the lower figure of the two $BE_{lagoon,y}$ results computed in the following manner should be used for the calculation of emission reductions;

(i) baseline methane emission less the physical leakage, hereafter referred as "$BE_{lagoon,theoretical,y}$"; and

(ii) actual methane captured and flared/used for energy generation, hereafter referred as "$BE_{lagoon,monitored,\ y}$"

(i) $BE_{lagoon,theoretical,y}$

$BE_{lagoon, theoretical,y}$ can be estimated from the below equation. Relevant parameters and monitored data during reporting period are summarized in following table.

$$BE_{lagoon, theoretical, y} = BE_{total\_emission\_ lagoon, y} - PE_{phys\_leak,y}$$

Where:

$$BE_{total\_emission\_ lagoon, y} = \Sigma_m(COD_{available,m} \times MCF_{baseline,m}) \times B_o \times GWP\_CH_4$$

And:

$$PE_{phys\_leak,y} = Q_{biogas\_total, y} \times W_{CH4} \times \rho_{CH4} \times LF \times GWP\_CH_4$$

Where:

$BE_{lagoon, theoretical, y}$ = baseline methane emission less the physical leakage (tCO_2e)
$BE_{total\_emission\_lagoon, y}$ = baseline methane emission from open lagoons (tCO_2e)
$PE_{phys\_leak,y}$ = project methane emission due to physical leakage from the anaerobic digester (tCO_2e)
$COD_{available,m}$ = monthly COD available for conversion which is equal to sum of the monthly COD entering the digester and COD carried over from the previous month (kg COD/month)
$MCF_{baseline,m}$ = monthly methane conversion factor for the open lagoons in the baseline (fraction)
B_o = maximum methane producing capacity (kg CH_4/kg COD)
GWP_CH4 = global warming potential for methane (tCO_2e/tCH_4)
Q_{biogas_total} = Quantity of biogas produced and collected in the digester (Nm^3biogas)
W_{CH4} = fraction of methane in biogas (m^3CH_4/m^3biogas)
ρ_{CH4} = Density of methane (tCH_4/Nm^3CH_4)
LF = rate of physical leakage (fraction)

The summary results for $BE_{lagoon,theoretical,y}$ is given in the table below.

Table 6: Summary results for $BE_{lagoon,theoretical,y}$

Parameters	$BE_{total\_emission\_lagoon,m}$ (tCO_2e/m)	$PE_{\_phys\_leakage,m}$ (tCO_2e/m)	$BE_{lagoon,theoretical,m}$ (tCO_2e/m)
APR 2009	0	0	0
MAY 2009	2,125	431	1,694
JUNE 2009	6,687	1,096	5,591
JULY 2009	7,951	1,084	6,867
AUG 2009	9,334	965	8,369
SEP 2009	8,794	780	8,014
OCT 2009	8,917	662	8,255
NOV 2009	8,633	893	7,740
Total	**52,441**	**5,911**	**46,530**

(ii) $BE_{lagoon,monitored,y}$

Table 7: Summary results for $BE_{lagoon,monitored,y}$

Parameter	$BE_{biogas\_burner,m}$ (tCO_2e/m)	$BE_{biogas\_flare,m}$ (tCO_2e/m)	$BE_{lagoon, monitored,m}$ (tCO_2e/m)
APR 2009	0	0	0
MAY 2009	2,317	4	2,321
JUNE 2009	6,456	0	6,456
JULY 2009	6,365	0	6,365

AUG 2009	6,283	0	6,283
SEP 2009	5,196	0	5,196
OCT 2009	4,409	0	4,409
NOV 2009	5,951	0	5,951
Total	**36,997**	**4**	**36,981**

$BE_{lagoon,monitored,y}$ can be calculated as follows. The relevant parameters and monitored data during reporting period are summarized in the table above.

$$BE_{lagoon,\ monitored,y} = BE_{biogas\_burner,y} + BE_{biogas\_flare,y}$$
$$= \{Q_{biogas\_burner,y} + Q_{biogas\_flare}\} \times W_{CH4} \times \rho_{CH4} \times GWP\_CH_4$$

Where;

$BE_{lagoon,monitored,y}$ = baseline actual methane captured and flared/used for energy generation (tCO_2e)
$BE_{biogas\_burner,\ y}$ = baseline captured CH_4 used at burners (tCO_2e)
BE_{biogas_flare} = baseline captured CH_4 used at flare (tCO_2e)

In accordance with AM0013, a comparison between (i) baseline methane emission less the physical leakage ($BE_{lagoon,theoretical,y}$) and (ii) the actual methane captured and flared/used for energy generation ($BE_{lagoon,monitored,y}$) have been made as shown in table below;

Table 8: Comparison of $BE_{lagoon,theoretical,y}$ and $BE_{lagoon,monitored,y}$

Year	**Baseline methane emission from open lagoon**	
	(i) $BE_{lagoon,theoretical,y}$ (tCO_2e/month)	**(ii) $BE_{lagoon,monitored,y}$ (tCO_2e/month)**
APR 2009	0	0
MAY 2009	1,694	2,321
JUNE 2009	5,591	6,456
JULY 2009	6,867	6,365
AUG 2009	8,369	6,283
SEP 2009	8,014	5,196
OCT 2009	8,255	4,409
NOV 2009	7,740	5,951
Total	**46,530**	**36,981**

As is apparent from the above table, for the purpose of the calculation of emission reductions, it will be appropriate to apply (ii) which is lower than (i). Therefore, actual methane captured and flare used for energy generation ($BE_{lagoon,monitored,y}$) is selected as the calculation method for the baseline methane emission from open lagoon for this Project ($BE_{lagoon,\ y}$ = $BE_{lagoon,monitored,y}$ =**36,981** tCO_2e).

$BE_{fuel\_oil,y}$

$BE_{fuel\_oil,y}$ is baseline CO_2 emission from the combustion of fuel oil that is, displaced by biogas due to the project activity. According to the AM0013, the emission reduction claim for the displacement of fossil fuel should be capped according to the average of historical 3 years consumption which was validated as 140.6 TJ/year. This translates to a cap on the baseline CO_2 emission from the displacement of fuel oil of 10,615tCO_2e/year. Nevertheless, this cap does not affect the CER calculations for this monitoring period, and is expected to start to affect the project only in the next monitoring period. Relevant parameters and monitored data during reporting period and the result are expressed in following table.

Table 9: Summary results for $BE_{fuel\_oil,y}$

Parameter	**Energy in biogas displaced (actual, TJ/m)**	**$BE_{Fuel\ oil}$ (actual) (tCO_2e/m)**	**Energy in biogas displaced (capped, TJ/yr)**	**$BE_{Fuel\ oil}$ (capped at 140.6TJ/yr) (tCO_2e/m)**
APR 2009	0	0	89 TJ	0

MAY 2009	5.6	419	Not over 140.6 TJ So, no cap	419
JUNE 2009	15.5	1,170		1,170
JULY 2009	15.3	1,153		1,153
AUG 2009	15.1	1,138		1,138
SEP 2009	12.5	941		941
OCT 2009	10.6	799		799
NOV 2009	14. 3	1,078		1,078
Total	**89**	**6,698**		**6,698**

The baseline emission (BE_y) calculated in accordance with Equation 4 is summarized as follows.

Table 1: **Summary of baseline emission of the project**

Parameter	**$BE_{lagoon,y}$ (tCO_2e/m)**	**$BE_{Fuel\ oil,y}$ (TJ/m)**	**BE_y (tCO_2e/m)**
APR 2009	0	0	0
MAY 2009	2,321	419	2,740
JUNE 2009	6,456	1,170	7,626
JULY 2009	6,365	1,153	7,518
AUG 2009	6,283	1,138	7,421
SEP 2009	5,196	941	6,137
OCT 2009	4,409	799	5,208
NOV 2009	5,951	1,078	7,029
Total	**36,981**	**6,698**	**43,679**

E.2. Project emissions calculation

Project emissions are calculated as:

$$PE_y = PE_{lagoon,y} + PE_{phys\_leak,y} + PE_{sludge,y} + PE_{enegy\_cons,y} + PE_{stack,y}$$

Where:

ER_y = Emission reductions (tCO_2e/yr)
PE_y = Project emissions (tCO_2e/yr)
$PE_{lagoon,y}$ = Project CH_4 emissions from the open lagoons in year *y* (tCO_2e/yr)
$PE_{phys\_leak,y}$ = Project CH_4 emissions due to the physical leakage from the anaerobic digester in year *y* (tCO_2e/yr)
$PE_{sludge,y}$ = Project CH_4 emissions from the land application of sludge in year y (tCO_2e/yr)
$PE_{energy\_cons,y}$ = Project CO_2e emissions from the consumption of energy on the account of the project activity in year y (tCO_2e/yr)
$PE_{stack,y}$ = Project CH_4 emissions from incomplete combustion of biogas in the flare and boilers in year y (tCO_2e/yr)

It is noted that neither dewatering process nor leakage are associated with the project activity and both were excluded from the project emission calculation as indicated in the CDM-PDD.

Project emissions are summarized in the table below.

Table 10: Summary results of project emissions

Month	**$PE_{\_stack,m}$ (tCO_2e/m)**	**$PE_{\_phys\_leakage,m}$ (tCO_2e/m)**	**$PE_{\_lagoon,m}$ (tCO_2e/m)**	**$PE_{\_sludge,m}$ (tCO_2e/m)**	**$PE_{\_energy\_cons,m}$ (tCO_2e/m)**	**Total PE (tCO_2e/m)**
APR 2009	0	0	0	0	36	36
MAY 2009	13	0	486	0	56	555
JUNE 2009	26	0	1,483	0	75	1,584
JULY 2009	25	0	1,256	0	78	1,359
AUG 2009	33	0	1,084	0	71	1,188

SEP 2009	27	0	823	0	66	916
OCT 2009	23	0	583	1	63	670
NOV 2009	6	0	915	3	63	987
Total	**153**	**0**	**6,630**	**4**	**508**	**7,295**

Remark:

- As per AM0013, version 4.0, if lower (ii) "actual methane captured and flare/ used for energy generation ($BE_{lagoon,monitored,,y}$)" was used as baseline emission, then, emission from physical leakage from digester ($PE_{\_phys\_leak}$) is considered as zero.
- For $PE_{stack,y}$, the CE_{burner} factor of 0.997, 0.995 and 0.999 was applied to the calculation in May to July 2009, August to October 2009 and November 2009 respectively.
- $PE_{lagoon,y}$ is project CH_4 emissions from the in the secondary treatment open lagoons system (tCO_2e)
- $PE_{phys\_leak,y}$ is project CH_4 emission due to the physical leakage from anaerobic digester (tCO_2e)
- $PE_{sludge,y}$ is project CH_4 emission from the land application of sludge (tCO_2e)
- $PE_{energy\_cons,y}$ is project CH_4 emission from the consumption of energy on the account of the project activity (tCO_2e)
- $PE_{stack,y}$ is project CH_4 emission from the incomplete consumption of biogas in the flare and boilers (tCO_2e)

E.3. Leakage calculation

No leakage is associated with the project activity.

E.4. Emission reductions calculation / table

Consistent with AM0013, the emission reduction achieved during this monitoring period can be calculated from difference between baseline emission in year y (BE_y) and project emission in year y (PE_y) as:

$$ER_y = BE_y - PE_y$$

Table 11: Summary results of emission reductions

Month	$BE_{lagoon,y}$ (tCO_2e/m)	$BE_{Fuel\_oil,y}$ (tCO_2e/m)	PE_y (tCO_2e/ym)	ER_y (tCO_2e/m)
APR 2009	0	0	36	-36[13]
MAY 2009	2,321	419	555	2,185
JUNE 2009	6, 456	1, 170	1,584	6,042
JULY 2009	6, 365	1, 153	1,359	6,159
AUG 2009	6, 283	1,138	1,188	6,233
SEP 2009	5,196	941	916	5,221
OCT 2009	4,409	799	670	4,538
NOV 2009	5,951	1,078	987	6,042
Total	**36,981**	**6, 698**	**7,295**	**36,384**

[13] Emission reductions in April 2009 show a negative value due to a conservative assumption applied on a calculation of electricity consumption at ancillary decanter facility, as per an approved deviation request I-DEV0406.

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

This section shall include a comparison of actual values of the emission reductions achieved during the monitoring period with the estimations in the registered CDM-PDD.

Item	Values applied in ex-ante calculation of the registered CDM-PDD	Actual values reached during the monitoring period
Emission reductions (tCO_2e)	**60,513[1]**	**36,384**

5.1. PDD estimated emission reduction during this monitoring period

Table 2: **PDD estimated ERs during this monitoring period**

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[1] Extrapolated for 203 operating days

Source	Dates (203 days) [14]		ERy
	From	To	(tCO_2)
Registered PDD estimate	15/04/2009	30/11/2009	60,513

[14] Refer to Table 10 "Operation days in month"

5.2. Emission Reduction actually achieved during this monitoring period

Table 3: **Actual ERs during this monitoring period**

Source	Dates (203 days) [15]		ERy
	From	To	(tCO_2)
Actual emission reductions claimed during this monitoring period	15/04/2009	30/11/2009	36,384

[15] Refer to Table 10 "Operation days in month"

There was no significant increase between the registered PDD and claimed emission reductions during this period.

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

As there is no increase in CERs, this section is not applicable.

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Appendix I

Converting volume to mass flow rate for the biogas flows

To calculate emission reduction from the project, the total biogas produced from digester ($Q_{biogas,total,y}$), biogas flow rate fed to burners ($Q_{biogas\_burner,y}$), biogas flow rate fed to flare ($Q_{biogas\_flare,y}$) and methane content in biogas (W_{CH4}) is to be measured and monitored in the same basis as wet or dry. In SQS project, the biogas flow rate is measured on wet basis (where flow measurement is not possible in dry basis for a wet stream), whereas the methane content in biogas is measured in dry basis. Therefore, the procedure stipulated in Option B of "Tool to determine mass flow rate of greenhouse gas in gaseous stream (version 2.0)[2]", hereafter referred as "the Tool", is applied to convert the volumetric flow from wet to dry basis. It is noted that the registered PDD preceded the publication of the Tool, but, the monitoring plan in the registered PDD was revised and approved by CDM Executive Board to inclusive the application of the Tool. However, the application of the Tool was applied only when the measured (wet) biogas flow could not be considered as dry basis as per the statement mentioned in Step 5 of "Tool to determine project emissions from flaring gases containing methane", which is stated that *"It is necessary to refer both measurements (flow rate of the residual gas and volumetric fraction of methane in residual gas) to same reference condition that may be dry or wet basis. If the residual gas moisture is significant (temperature greater than $60^{O}C$), the measured flow rate of the residual gas that is usually referred to wet basis should be corrected to dry basis due to the fact that the measurement of methane is usually undertaken on a dry basis".*

The following equations are used for the calculation of total methane mass flow.

The mass flow rate of greenhouse gas ($F_{i,t}$) is determined as follows;

$$\mathbf{F_{i,t} = V_{t,\,db} \times v_{i,y,\,db} \times \rho_{i,t}}$$

with

$$\mathbf{\rho_{i,t} = \frac{P_t \times MM_i}{R_u \times T_t}}$$

Where;

$F_{i,t}$	= Mass flow rate of greenhouse gas *i* in the gaseous stream in the time interval t (kg gas/h)
$V_{t,\,db}$	= Volumetric flow rate of gaseous stream in the time interval t on a dry basis (m^3 dry gas/h)
$\rho_{i,t}$	= Density of greenhouse gas *i* in the gaseous stream in time interval t (kg gas i/m^3 gas i)
$v_{i,t,\,db}$	= Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis (m^3 gas i/m^3 dry gas)
P_t	= Absolute pressure of the gaseous stream in time interval t (Pa)
MMi	= Molecular mass of greenhouse gas i (kg/kmol)
Ru	= Universal ideal gases constant (Pa.m^3/kmol.K)
Tt	= Temperature of the gaseous stream in time interval t (K)

The volumetric flow of the gaseous stream in time interval t on a dry basis ($V_{t,db}$) is determined by converting the volumetric flow from wet basis to dry basis as follows

$$\mathbf{V_{t,db} = V_{t,wb} / (1 + v_{H2O,t,db})}$$

Where;

$V_{t,db}$	= Volumetric flow of the gaseous stream in time interval t on a dry basis (m^3dry gas/h)
$V_{t,wb}$	= Volumetric flow of the gaseous stream in time interval t on a wet basis (m^3wet gas/h)

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[2] <<Note to DNV: At the time PP revising the monitoring report, a revision of the "Tool to determine mass flow rate of greenhouse gas in gaseous stream" was requested, by Methodology Panel at its 49th meeting, for an approval from CDM Executive Board at its 61st Meeting. The monitoring report was revised on the assumption that it will be approved.>>

$v_{H2O,t,db}$ = Volumetric fraction of H_2O in the gaseous stream in time interval t on a dry basis (m³ H_2O/m³ dry gas)

The volumetric fraction of H_2O in time interval t on a dry basis ($v_{H2O,t,db}$) should be estimated as per the procedure provided below.

$$v_{H2O,t,db} = \frac{m_{H2O,t,db} \times MM_{t,db}}{MM_{H2O}}$$

Where;

$v_{H2O,t,db}$ = Volumetric fraction of H_2O in the gaseous stream in time interval t on a dry basis (m³ H_2O / m³ dry gas)

$m_{H2O,t,db}$ = Absolute humidity in the gaseous stream in time interval t on a dry basis (kg H_2O / kg dry gas)

$MM_{t,db}$ = Molecular mass of the gaseous stream in time interval t on a dry basis (kg dry gas / k mol dry gas)

MM_{H2O} = Molecular mass of H_2O (kg H_2O/kmol H_2O)

And $MM_{t,db}$ is determined as follows:

$$MM_{t,db} = \Sigma_K(v_{k,t,db} \times MM_k)$$

Where;

$MM_{t,db}$ = Molecular mass of the gaseous stream in time interval t on a dry basis (kg dry gas / kmol dry gas)

$v_{k,t,db}$ = Volumetric fraction of gas k in the gaseous stream in time interval t on a dry basis (m³ gas k / m³ dry gas)

MMk = Molecular mass of gas k (kg / kmol)

k = All gases contained in the gaseous stream (e.g. N_2, CO_2, O_2, CO, H_2, CH_4, N_2O, NO, NO_2, SO_2, SF_6 and PFCs)

The absolute humidity of the gaseous stream ($m_{H2O,t,db}$) can be determined using one of the following two options.

Option 1: Measurement of the moisture content in gaseous stream
Option 2: Simplified calculation without measurement of the moisture content

Option 2 is selected, as no test of moisture content in biogas stream has been carried out. This option does not require measuring the moisture content of the gas but provides a simple and conservative approach to determine the absolute humidity of the gaseous stream. It is assumed that the gas is saturated with H_2O or that no H_2O is in the gas, whichever is more conservative in the context of the underlying methodology.

If it is conservative to assume that no H2O in vapor phase is in the gaseous stream, assume $m_{H2O,t,db} = 0$. If it is conservative to assume that the gaseous stream is saturated with H_2O, determine $m_{H2O,t,db}$ as follows:

$$m_{H2O,t,db,Sat} = \frac{p_{H2O,t,Sat} \times MM_{H2O}}{(P_t - p_{H2O,t,Sat}) \times MM_{t,db}}$$

Where:

$m_{H2O,t,db,sat}$ = Saturation absolute humidity in time interval ton a dry basis (kg H_2O/kg dry gas)

$p_{H20,t,Sat}$ = Saturation pressure of H_2O at temperature T_t (Pa)

T_t = Temperature of the gaseous stream in time interval t (K)

P_t = Absolute pressure of the gaseous stream in time interval t (Pa)

MM_{H2O} = Molecular mass of H_2O (kg H_2O/kmol H_2O)
$MM_{t,db}$ = Molecular mass of the gaseous stream in a time interval t on a dry basis (kg dry gas / kmol dry gas)

For the case of baseline emission calculation of this project, the most conservative value is to assumed that $m_{H2O,t,db,sat} = [p_{H2O,t,Sat} \times MM_{H2O}]/[(P_t - p_{H2O,t,Sat}) \times MM_{t,db}]$. In the other hand, for project emission calculation, it is conservative to assumed that $m_{H2O,t,db,sat} = 0$.

The following equation should be used to convert the volumetric flow of the gaseous stream from actual conditions to normal conditions of temperature and pressure:

$$\mathbf{V_{t,wb,n} = V_{t,wb} \times [(T_n/T_t) \times (P_t/ P_n)]}$$

The abovementioned equation is applied when the wet flow rate of biogas is used to calculate with fraction of methane content which is measured in dry basis, to calculate the flow rate of methane gas in dry basis.

APPENDIX II

Grid Emission Factor for Thailand

Example Calculation of the baseline emission factor ($EF_{grid,CM,y}$)

The CO_2 emissions factor for the grid system 2009 is sourced from "*The study of emission factor for an electricity system in Thailand 2009*"[3] (hereinafter referred to as the "Study"), published by Thailand Greenhouse Gas Management Organization (TGO) on 29 June 2011. TGO is a public organization under the Ministry of Natural Resources and Environment (MNRE) and is being the Designated National Authority for CDM (DNA-CDM) in Thailand. According to this documentation, this grid emission factor was determined based on the data given in the "*Electricity Report 2007 – 2009*" and along with the procedure stipulated in latest methodological tool "*Tool to calculate the emission factor for an electricity system (version 02.2.1)*" (hereinafter referred to as the "EF Tool")

This methodological EF Tool determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the operating margin (OM), the build margin (BM) as well as the combined margin (CM), as follows:

Step 1: Identify the relevant electricity systems

Consistent with the requirements stipulated in the EF Tool, the delineations of the project electricity system and connected electricity systems that were published by the host country DNA, TGO, are applied. Following the Thai DNA delineation, the relevant electric power system of the project activity is Thailand's national grid. It is because the electricity transmission system of Thailand is considered as a single system since the transmission lines are networked throughout the country and owned by the Electricity Generating Authority of Thailand (EGAT). EGAT is the authority that controls electricity generation and distribution in Thailand, whereas the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) are the authorities that supply the electricity to the users in Bangkok and provinces, respectively.

The quantity of electricity generated and delivered to the national grid can be obtained from the *"Electricity Report 2007 – 2009"* published by EGAT. Data are categorized by electricity generation system, type of power plant and quantity of electricity generated by LC/MR and Non LC/MR power plants. Type of power plant includes the power plant of the EGAT, Independent Power Producers (IPPs), Small Power Producers (SPPs) and imported electricity from neighbouring countries.

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)

Project participant chosen Option I as provided in Step 2 of the EF Tool, where, only grid power plants are included in the calculation. It is because in Thailand the generated electricity that is transferred to the national grid is the only available data. Thus, it is impossible to obtain off-grid electricity generation data.

Step 3: Select a method to determine the operating margin (OM)

The EF Tool offers four methods for the calculation of operating margin emission factor ($EF_{grid,OM,y}$), which include:
(a) Simple OM;
(b) Simple adjusted OM;

[3] Data source: http://www.tgo.or.th/download/publication/GEFReport_EN.pdf.

(c) Dispatch data analysis OM; or
(d) Average OM.

Out of the four methods, the simple OM method (Option a) is used, as low-cost/must-run (LC/MR) resources of the national grid was determined to be 6.49% of the total grid generation in average of the five most recent years, which constitute less than threshold limit of 50%, as shown in Table A1 below.

Table A1: National grid generation in Thailand from 2005 to 2009

Generation System	Grid Generation (GWh)				Percentage
	EGAT	IPP	SPP	Total	
(2009)					
Total	66,488.10	64,840.72	13,971.37	145,300.19	-
- Non LC/MR	59,541.66	64,840.72	11,811.42	136,193.80	-
- LC/MR[4]	6,946.44	0.00	2,159.95	9,106.39	6.27%
(2008)					
Total	63,719.02	67,420.14	14,092.83	145,232.00	-
- Non LC/MR	56,791.19	67,420.14	11,904.81	136,116.14	-
- LC/MR	6,927.83	0.00	2,188.03	9,115.86	6.28%
(2007)					
Total	67,704.95	62,233.44	14,426.00	144,364.39	-
- Non LC/MR	59,765.33	62,233.44	11,982.99	133,981.76	-
- LC/MR	7,939.62	0.00	2,443.02	10,382.64	7.19%
(2006)[5]					
Total	70,409.11	55,360.65	13,652.19	139,421.94	-
- Non LC/MR	62,480.23	55,360.65	11,619.95	129,460.82	-
- LC/MR	7,928.88	0.00	2,032.23	9,961.12	7.14%
(2005)[24]					
Total	66,650.81	51,989.60	13,571.59	132,212.00	-
- Non LC/MR	60,999.89	51,989.60	11,814.22	124,830.70	-
- LC/MR	5,650.93	0.00	1,730.37	7,381.30	5.58%
Average 5 year of LC/MR					**6.49%**

Between the *Ex-ante* and *Ex-post* options of the data vintages, the *Ex-post* option is chosen for the project activity. The simple OM emission factor is determined in the year in which the project activity displaces grid electricity, requiring the emission to be updated annually during the monitoring period.

Step 4: Calculate the operating margin emission factor according to the selected method

The simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system, not including LC/MR power plants/units. Option B, which is based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel

[4] LC/MR power plants include hydropower and renewable energy (including biomass, solar and geothermal power).

[5] Grid generation data of 2005 and 2006 is received from Department of Power Control System, EGAT.

consumption of the project electricity system, provided in Step 4 of the EF Tool was chosen with the following reasons:

(a) The necessary data for Option A is not available (Net electricity generation and a CO_2 emission factor of each power plant unit);
(b) Only nuclear and renewable power generation are considered as LC/MR power sources and quantity of electricity supplied to the grid by these sources is known; and
(c) Off-grid power plants are not included in the calculation, as per reason provided in Step 2 that off-grid data in Thailand is not available.

Therefore, the simple OM emission factor ($EF_{grid,OMsimple,y}$) is calculated based on the net electricity supplied to the grid by all power plants serving the system, excluding LC/MR power plants/units and including electricity imports, and based on the fuel type(s) and total fuel consumption of the project electricity system, as follow:

$$EF_{grid,OMsimple,y} = \frac{\sum_i (FC_{i,y}\ x\ NCV_{i,y}\ x\ EF_{CO2,i,y})}{EG_y}$$

Where:

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$FC_{i,y}$	=	Amount of fossil fuel type *i* consumed in the project electricity system in year y (mass or volume unit)
$NCV_{i,y}$	=	Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
EG_y	=	Net electricity generated and delivered to the grid by all power sources serving the system, not including LC/MR power plants/units, in year *y* (MWh)
i	=	All fossil fuel types combusted in power sources in the project electricity system in year *y*
y	=	The relevant year as per the data vintage chosen in Step 3

The values of CO_2 emission from combustion of fossil fuel (per unit of fossil fuel) are shown in Table A2. Net Calorific Value (NCV) is obtained from data provided by the Department of Alternative Energy Department and Efficiency (DEDE), Ministry of Energy. The CO_2 Emission Factor of fossil fuel follows IPCC default values as specified in the *"2006 IPCC Guidelines for National Greenhouse Gas Inventories"*.

Table A2: Net Calorific Values ($NCV_{i,y}$) and CO_2 emission per unit of each type of fossil fuel ($EF_{CO2,i,y}$)

Fuel type[6]	**Unit**	**Net Calorific Value**[7]	**CO_2 Emission Factor**[8]	**CO_2 Emission**
		(MJ/Unit)	**(tCO_2/TJ)**	**($kgCO_2$/Unit)**
Natural Gas	scf.	1.02	54.30	0.055
Lignite	ton	10,470.00	90.90	951.723
Bituminous	ton	26,370.00	89.50	2,360.115
Bunker	liter	39.77	75.50	3.003

[6] See Table A3: Comparison of the name of fuel type sourced from different report

[7] Electric Power in Thailand 2008/Department of Alternative Energy Development and Efficiency, Ministry of Energy

[8] IPCC default values at the lower limit as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guideline for National Greenhouse Gas Inventories

Diesel	liter	36.42	72.60	2.644

Table A3: Comparison of the name of fuel type sourced from different reports

The Study[9]	DEDE[10] (Thailand)	IPCC[11]
Natural Gas	Natural Gas (Dry)	Natural Gas
Lignite	Lignite (Mae Moh)	Lignite
Bituminous	Coal Import	Other Bituminous Coal
Bunker	Fuel Oil	Residual Fuel Oil
Diesel	Diesel	Diesel Oil

The quantity of electricity generated and delivered to the national grid can be obtained from the *"Electricity Report 2009"*, as shown in Table A4. Data are categorized by electricity generation system, type of power plant and quantity of electricity generated by non LC/MR power plants. Type of power plant includes the power plant of the EGAT, IPPs and SPPs. Quantity and type of fossil fuel consumed in electricity generation are also obtained from the *"Electricity Report 2009"*, as shown in Table A5.

Table A4: Quantity of electricity generated and delivered to the national grid[12] (excluding LC/MR power plants/units), EG_y

Generation System	Electricity Generated and Delivered to the Grid (EG_y, GWh)			
	EGAT	IPP	SPP	Total
(2009)				
Total non LC/MR	**59,541.66**	**64,840.72**	**11,811.42**	**136,193.80**
Thermal	23,463.69	12,388.03	2,225.63	38,077.35
Combined-Cycle	33,164.46	52,452.69	8,752.19	94,369.35
Gas Turbine	309.63	-	833.60	1,143.23
Diesel Engine	1.44	-	-	1.44
Electricity Import	2,602.43	-	-	2,602.43

Table A5: Amount of fossil fuel consumed by power plants[13] (excluding LC/MR power plants/units), $FC_{i,y}$

Fuel Type	Unit	Fuel Consumption			
		EGAT	IPP	SPP	Total
(2009)					
Natural Gas	scf.	369,146,214,392	459,228,417,361	140,550,086,056	968,924,717,809
Lignite	ton	15,818,265	-	-	15,818,265
Bituminous	ton	-	3,645,721	1,840,527	5,486,248
Bunker	liter	111,039,065	38,180,874	8,797,506	158,017,445
Diesel	liter	12,140,891	-	1,685,046	13,825,937

Table A6 summarizes the calculated CO_2 emissions from electricity generation in the years 2009 categorized by fuel types. The total emissions during the 2009 period were 82,178,673 tCO_2. The results in Table A6 show that the simple OM emission factor is 0.6034 tCO_2/MWh.

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[9] The Study of emission factor for an electricity system in Thailand 2009

[10] Electric Power in Thailand 2008/ Department of Alternative Energy and Efficiency, Ministry of Energy

[11] 2006 IPCC Guideline for National Greenhouse Gas Inventories

[12] Electricity report 2009/ Electricity Generating Authority of Thailand (EGAT)

[13] Electricity report 2009/ Electricity Generating Authority of Thailand (EGAT)

Table A6: Determination of the simple OM emission factor, $EF_{grid,OMsimple,y}$

Fuel type	Fuel Consumption ($FC_{i,y}$)		NCV of fossil fuels, $NCV_{i,y}$ (MJ/Unit)	CO_2 Emission Factor of Fossil Fuel, $EF_{CO2i,y}$ (tCO_2/TJ)	Electricity Generated and Delivered to Grid, EG_y (MWh)	CO_2 Emissions (tCO_2)	OM Emission Factor (tCO_2/MWh)
	Unit	Volume/mass					
(2009)							
Total					**136,193,800**	**82,178,673**	**0.6034**
Natural Gas	scf.	968,924,717,809	1.02	54.3	136,193,800	53,664,864	
Lignite	ton	15,818,265	10,470	90.9		15,054,607	
Bituminous	ton	5,486,248	26,370	89.5		12,948,176	
Bunker	liter	158,017,445	39.8	75.5		474,469	
Diesel	liter	13,825,937	36.4	72.6		36,557	
Average simple OM Emission Factor, $EF_{grid,OMsimple,y}$, during 2009							**0.6034**

Step 5: Calculate the build margin (BM) emission factor

The build margin is calculated as the generation-weighted average emission factor of a sample group of power plants. The sample group of power units *m* used to calculate the build margin consists of either:

(a) The set of five power units that have been built most recently; or

(b) The set of power capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

From these two options, the sample group that comprises the larger annual generation is to be chosen. In the case of the Thailand's national grid, the annual electricity generation estimated under Option (a) equals to 28,305,630 MWh, whereas that under Option (b) equals to 38,323,760MWh, which is equivalent to 26.38% of the total national grid generation in 2009 (145,300,180 MWh). Therefore, Option (b) is chosen.

Table A7: Annual electricity generation of the set of five power units in Option (a)

Power Unit	Commissioning Date	Grid Generation (MWh)[14]
1. Bangpakong Power Plant (Unit 05)	16-Sep-09	1,918,110
2. South Bangkok Power Plant (Unit 03)	1-Mar-09	4,745,320
3. Chana Power Plant (Unit 01)	15-Jul-08	4,150,260
4. Ratchaburi Power Company Limited (RPCL) (Unit 1&2)	1-Jul-08	8,153,260
5. Gulf Power Generation Co., Ltd. (Unit 1&2)	1-Mar-08	9,338,680
Total annual electricity generation from five most recently built power plants	-	**28,305,630**

Table A8: Annual electricity generation of the set of power units in Option (b)

Power Unit	Commissioning Date	Grid Generation (MWh)[15]	Accumulated MWh	Accumulated % as of total grid generation in 2009
1. Bangpakong Power Plant (Unit 05)	16-Sep-09	1,918,110	1,918,110	1.32%
2. South Bangkok Power Plant (Unit 03)	1-Mar-09	4,745,320	6,663,430	4.59%

[14] Electricity Report 2009/Electricity Generating Authority of Thailand

[15] Electricity Report 2009/ Electricity Generating Authority of Thailand

3. Chana Power Plant (Unit 01)	15-Jul-08	4,150,260	10,813,690	7.44%
4. Ratchaburi Power Company Limited (RPCL) (Unit 1&2)	1-Jul-08	8,153,260	18,966,950	13.05%
5. Gulf Power Generation Co., Ltd. (Unit 1&2)	1-Mar-08	9,338,680	28,305,630	19.48%
6. BLCP Power Co., Ltd. (Unit 1&2)	1-Feb-07	10,018,130	**38,323,760**	**26.38%**[16]

Between the *Ex-ante* and *Ex-post* options of the data vintages, the *Ex-ante* option is chosen for the project activity. For the first crediting period, the BM emission factor is calculated *ex-ante* based on the most recent information available on units already built for sample group *m* at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the BM emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the BM emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

The build margin emission factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units *m* during the most recent year y for which power generation data is available. As represented in above, the six power plants listed in Table A8: comprise 26.38% of total national grid generation system in 2009, which has the larger generation than the group of power plants listed in Table A7:. Therefore, the group of power plants in Option (b) of Step 5 is chosen and used for build margin emission factor calculation.

The same calculation method for the operating emission factor in Option A1 of Step 4 as provided in the EF Tool is applied as follows:

$$EF_{grid,BM,y} = \frac{\sum_i (FC_{i,m,y}\ x\ NCV_{i,y}\ x\ EF_{CO2,i,y})}{EG_{m,y}}$$

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$FC_{i,m,y}$	=	Amount of fossil fuel type *i* consumed by power plant/unit *m* in year *y* (mass or volume unit)
$NCV_{i,y}$	=	Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
$EG_{m,y}$	=	Net electricity generated and delivered to the grid by power plant/unit *m* serving the system, not including LC/MR power plants/units, in year *y* (MWh)
i	=	All fossil fuel types combusted in power unit *m* in year *y*
y	=	The relevant year as per the data vintage chosen in Step 5

[16] As per footnote 7 of the EF Tool, *"if 20% on part capacity of a unit, that unit is fully included in the calculation"*, therefore, electricity generation from BLCP Co., Ltd (Unit 1&2) was included in the calculation.

Table A9: Build margin emission factor ($EF_{grid,BM,y}$) in 2009

Fuel type	Fuel Consumption,[17] $FC_{i,m,y}$		NCV of fossil fuels, $NCV_{i,y}$ (MJ/Unit)	CO_2 Emission Factor of Fossil Fuel, $EF_{CO2i,y}$ (tCO_2/TJ)	Electricity Generated and Delivered to Grid, $EG_{m,y}$ (MWh)	CO_2 Emissions (tCO_2)
	Unit	Volume/ mass				
Natural Gas	scf.	223,467,679,056	1.02	54.3	38,323,760	12,376,981
Bituminous	ton	3,645,721	26,370	89.5		8,604,321
Diesel	liter	3,929,038	36.4	72.6		10,389
Total					38,323,760	20,991,690
BM Emission Factor, $EF_{grid,BM,y}$ (tCO_2/MWh)					**0.5477**	

Based on the above calculation, the resultant build margin (BM) emission factor is 0.5477 tCO_2/MWh.

Step 6: Calculate the combined margin emission factor

The combined margin emission factor ($EF_{grid,CM,y}$) is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \ x \ W_{OM} + EF_{grid,BM,y} \ x \ W_{BM}$$

Where:

$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
W_{OM} = Weighting of operating margin emission factor (%)
W_{BM} = Weighting of build margin emission factor (%)

As per the EF Tool, the weightings of OM and BM emission factors for all other projects that are not solar or wind power generation are 0.50 and 0.50 respectively for the crediting period. Table A10: demonstrates that the resultant combined margin (CM) CO_2 emission factor of Thailand's national grid is 0.5756 tCO_2/MWh, for all other project.

Table A10: Baseline emission factor of Thailand's national grid in 2009

Parameters	Other projects
OM emission factor, $EF_{grid,OM,y}$ (tCO_2/MWh)	0.6034
Weighting of OM, W_{OM} (tCO_2/MWh)	0.50
BM emission factor, $EF_{grid,BM,y}$ (tCO_2/MWh)	0.5477
Weighting of BM, W_{BM} (tCO_2/MWh)	0.50
CM emission factor, $EF_{grid,CM,y}$ (tCO_2/MWh)	**0.5756**

[17] Fuel consumptions of the most recently built power plants as listed in Table 8 are sourced from Electricity Report 2009/ Electricity Generating Authority of Thailand.

Appendix III

Calibration of magnetic flow meter

Calibration:

DOE comment: Magnetic feed flow meter calibration was performed internally. The project proponent is required to demonstrate that the calibration was conducted in accordance to appropriate industry/international standards.

SQS has, with its sister company SMS, more than 25 years of experience with using flow meters for all aspects of the starch process including measuring waste water streams. A magnetic flow meter was chosen to measure the feed flow as it is the best flow meter design for the service in terms of being readily available in large sizes for high flows and also because, from SQS's experience, it is a particularly stable design in terms of the accuracy obtained as there is nothing in the flow stream which can deteriorate through wear or corrosion. The sensor accuracy obtained by the supplier in the initial calibration is +/-0.25%.

Calibration has been an issue for SQS during the past more than 25 years as, in Thailand, there has been no means available of carrying out full, bench-test calibrations such as the supplier would carry out other than sending the meter in question back to the supplier overseas for re-calibration. SQS, in developing a calibration system for ISO 9000 standards throughout the 1990's, has sent relevant officers to various seminars and training sessions organized by suppliers or semi-government institutions such as the Technology Promotion Association (Thailand-Japan) as well as working in cooperation with its then joint venture partner AVEBE bv, a potato starch manufacturer based in the Netherlands who was also the consultant to SQS and SMS in developing the ISO 9000 systems.

The calibration method which was developed for field calibrations of flow meters, and which has been accredited as part of SQS's ISO 9001 system, consists of the calibration of a "master" flow meter by comparison with dead weights which can then be compared in series with the flow meter to be field calibrated. A number of standard 20 kg test weights are sent for calibration at a calibration laboratory, NEC Corporation (Thailand) Ltd., to accuracies of +/- 10 g at the frequency of two years specified by the Ministry of Commerce. These weights are then used to calibrate a weight scale which can also be adjusted to +/- 10 g. A quantity of water weighed on this scale can then be passed through a mass flow meter which can be adjusted to read the same as the weight scale by the use of a K factor to an accuracy of +/- 0.1%. This is the flow meter used as the "master". It is a very accurate, coriolis type, mass flow meter with 1 ½" diameter inlet and outlet, and is suitable for a calibration flow of about 10 cubic meters per hour.

For field calibrations of meters with similar flow parameters, the field calibrations can be carried out to achieve the accuracy required by the starch production process or, if that is not available, the name plate accuracy specified by the supplier. For larger meters, however, the relatively small flow possible through the "master" may not be within the flow range that the larger meter can produce the accuracy specified, perhaps from 10% to 90% of full flow for example. In this case, the method used is to carry out an initial field calibration on the newly-installed, larger flow meter to compare the readings obtained from the "master" to the supplier's bench calibration. The readings obtained from the "master" then form the basis for establishing the expected accuracy limits to be specified in the ISO 9001 calibration system. Subsequent calibrations comparing the field flow meter with the calibrated "master" at intervals specified in the ISO 9001 calibration system can then determine whether the field instrument has deviated from the supplier's bench calibration. If the "master" flow meter readings show that the field instrument has deviated more than the limits of accuracy specified, then the field instrument must be send to the supplier for recalibration.

In the case of the feed water flow meter in question, it is a 250 mm diameter, magnetic flow meter sized to handle the anticipated maximum feed flow of 300 cubic meters per hour in the position it is installed. The sensor accuracy specified by the supplier is +/- 0.25%. Initial calibration readings at approximately 10 cubic meters per hour flow rate, or 3% of the anticipated full flow, produce readings of the order of +/- 1.5% deviation from the “master” flow meter. An accuracy of +/- 2.5% was adopted for subsequent calibrations, reasoning by inference that this would show no more than +/- 0.5% true accuracy of the field instrument at full-flow conditions, and this is considered sufficient accuracy for this process flow.

Appendix IV

Track Record of COD against Starch Production Rates

In section B.7.1 of the registered PDD, there is a QA/QC procedure for cross checking the measurement of "flow rate of wastewater fed into/discharge out of the digester ($F_{digester}$/$F_{dig\_out,m}$)". It can be cross-checked by the product of the measured flow rate and the measured COD load against the factory's starch production records. This calculation is used to observe the variation in amount of COD produced per ton starch generated from the factory, where, the variation of this parameter should not be significant when considering that the production process of the SQS's factory is maintained the same throughout the monitoring period. This parameter has been computed and expressed in the following figure;

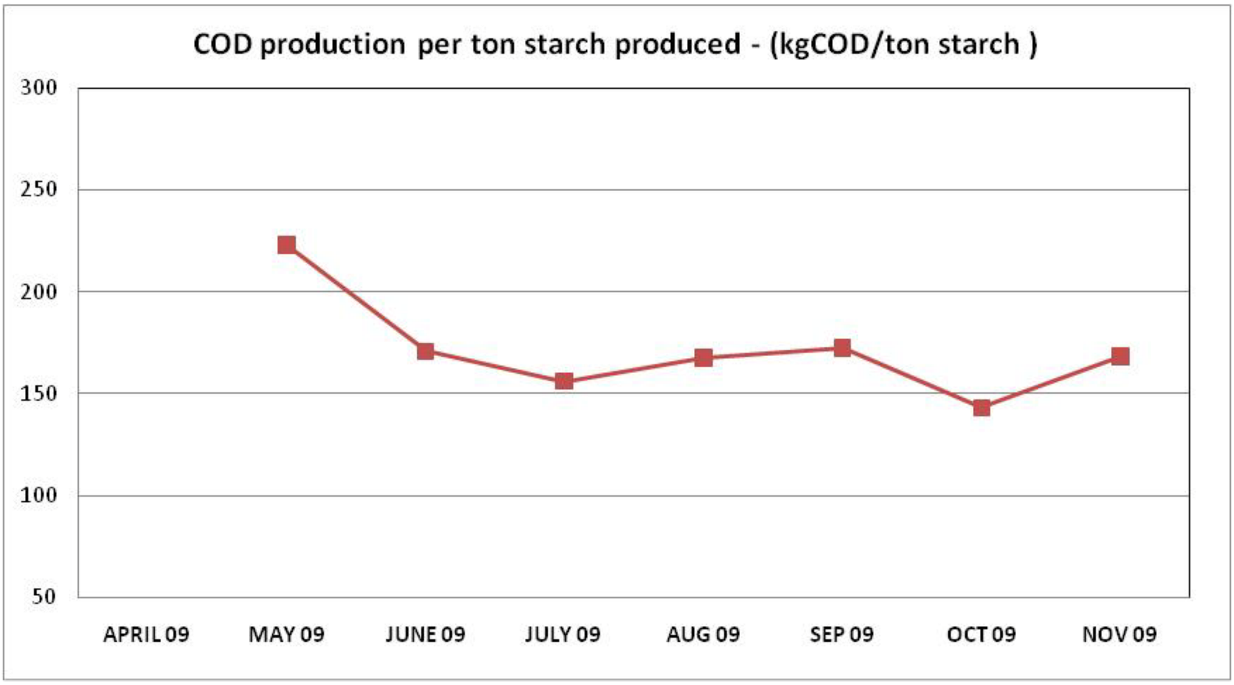

Figure 5: track record of monthly COD loading production rates

Figure 5 represented the monthly COD production per ton starch produced from SQS's factories in this monitoring period. It can be observed from the figure that most of the monthly COD production per ton starch produced monitored in this monitoring period is considerably stable, while, a slightly deviation found in May 2009 is thought to be due to the factory shutdown between April 9, 2009 (prior to the registration date) and May 11, 2009. During the start up period (May 12 to 31, 2009), the factories were operated at low capacity and not continuously (e.g. starts and stops for every 3 hours) due to the shortage in the supply of cassava roots. A shortage in supply is a normal circumstance for SQS at the time SQS's factory is restarted up, after the plant is shutdown for a month (SQS stops procuring/stocking cassava roots at the factory).

As the production process could not be run continuously and normal practice of SQS is to keep washing the production line at every time when the production process is stopped, thus, a lot of wastewater is produced during the time no starch is produced. Thus, this circumstance is the cause of the increasing in amount of COD production per ton starch produced during the start up period in May 2009.

History of the document

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