MONITORING REPORT OF CHOL CHAROEN GROUP WASTEWATER TREATMENT WITH BIOGAS SYSTEM I (CHOLBURI)

Document Prepared By South Pole Carbon Asset Management Ltd.

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

Chol Charoen Group Wastewater Treatment with Biogas System I (Cholburi), hereafter 'the project activity', involves the installation and operation of a biogas recovery and utilization system (an open anaerobic effluent treatment system) at Chol Charoen Co. Ltd., a tapioca starch factory in Cholburi, Thailand. The system has been in operation since 7th January 2006 (project start date).

This starch factory has a design daily production capacity of 240 tonnes of dried starch, generating 2,400 m^3 of wastewater per operational day. Under the previous system, wastewater released from the plant was treated in 13, cascading, open anaerobic lagoons. With the depth of these ponds being greater than 2 m from the water surface, and the mean temperature of the area being in the region of 29°C, there is a suitable anaerobic environment within the ponds. Anaerobic bacteria in the ponds break down organic compounds in the wastewater, resulting in the release of biogas. The resulting biogas is characterized by the chemical oxygen demand or COD of the wastewater.

The project activity involves modification of the existing open anaerobic lagoon-based process into a closed anaerobic system for treatment of high organic matter wastewater. This is based on Anaerobic Fixed Film Reactor (AFFR) technology, which is a technology derived from joint research between King Mongkut's University of Technology Thonburi (KMUTT) and the National Centre for Genetic Engineering and Biotechnology (BIOTEC). In addition, three open lagoons at the outlet of the AFFRs were redesigned and converted to covered lagoons in order to 1) increase gas-storage capacity and 2) serve an as an emergency wastewater treatment system in case the AFFR system malfunctions.

The implementation of AFFR system enables the recovery of biogas that would have been released to the atmosphere and the utilization of the recovered biogas for thermal and electricity generation. Excess biogas (if any) is sent to the enclosed flare system. The hot oil boiler in the existing plant was originally designed to burn fuel oil for heat generation. Under the project activity, the burner is retrofitted with a combination fuel burner, which allows the boiler to be co-fired using both fuel oil and the biogas collected from the reactors. The power produced by the captured biogas augments the electricity requirement of the plant and may, in the future, be fed to the national grid, under the pending power purchase agreement with the Provincial Electricity Authority (PEA). With such utilization of biogas, the project activity achieves GHG emission reduction through avoidance of methane being released to the atmosphere, and also through reduction of fossil fuel consumption (with fuel oil and grid electricity being displaced).

As per the VCS's guideline, the project is verified against the VCS standard. Further background information on the project activity can be found in the VCS Project Design Document (PDD), which has been registered and available on the V-C-S under project number 430 as well as the combined Voluntary Validation and Verification:

https://vcsprojectdatabase1.apx.com/mymodule/ProjectDoc/EditProjectDoc.asp?id1=430.

This is the 5th verification of the project. Details of previous monitoring periods are listed below. All monitoring and verification reports are available on the VCS registry.

- 1st monitoring period : 01-01-07 to 31-12-08 ; verification report issued 18-11-10
- 2nd monitoring period: 01-01-09 to 30-09-10 ; verification report issued 13-04-11
- 3rd monitoring period: 01-10-10 to 31-12-11 ; verification report issued 05-03-12
- 4th monitoring period: 01-01-12 to 31-07-14 ; verification report issued 10-10-14

1.2 Sectoral Scope and Project Type

The project activity involves recovery of biogas from the wastewater released from tapioca starch processing plant. The recovered biogas is used in a boiler to generate heat for the starch drying process and used to generate electricity in order to meet the power requirement of the starch processing plant and supplied to national-owned grid. After satisfying the above demands, surplus biogas is flared for safety purpose. The project has a total electrical generation capacity of less than 15 MW_{el}, thermal generation capacity less than 45 MW_{th} and will generate emission reductions less than 60 $ktCO_2e$ per year. The type/category of the project is thus according to Appendix B, *Simplified Modalities and Procedures for Small-Scale CDM Project Activities*, as follow:

Methane avoidance component:

Type III:	Other project activities
Category III.H:	Methane Recovery in Wastewater Treatment
Sectoral Scope 13:	Waste handling and disposal
Version:	13

Electricity generation component:

Type I:	Renewable energy projects
Category I.D:	Grid connected renewable electricity generation
Sectoral Scope 1:	Energy industries (renewable/non-renewable sources)
Version:	14

Fuel replacement component

Type I:	Renewable energy projects
Category I.C:	Thermal energy production with or without electricity
Sectoral Scope 1:	Energy industries (renewable/non-renewable sources)
Version:	15

1.3 Project Proponent

Organization name	Chol Charoen Co.,Ltd
Contact person	Ung Mengchua
Title	Mr.
Address	1004/200 Rama3 Road , Bangpongpang , Yannawa Bangkok 10120
Telephone	+66 2 294 5315-6
Email	-

1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon Asset Management Ltd.
Role in the project	Carbon consultant
Contact person	Ingo Puhl
Title	Mr.
Address	Technoparkstrasse 1 , Zurich , Switzerland 8005
Telephone	+66 2 678 8979
Email	i.puhl@southpolecarbon.com

1.5 Project Start Date

The project activity began on 7th January 2006.

1.6 Project Crediting Period

The project proponent has chosen a ten-year crediting period for the project activity: from 2007 to 2016.

Crediting period start date: 1st January 2007. Due to insufficiency of monitoring equipment, the operational period in the year 2006 was neglected from our claim of emission reductions. This is in line with the principle of conservativeness as per VCS version 3.

1.7 Project Location

The proposed project activity is located at Chol Charoen Co., Ltd., in Banbung district, Cholburi province. It is approximately 250 km away from Bangkok. The project activity location is depicted in **Figure 1** and **Figure 2**

Street address: 204 Moo 3 Nongchak, Banbung, Cholburi, 20170, Thailand.

Geographic coordinates: 13° 17.736'N latitude 101° 09.108'E longitude

Figure 1 : Project Location

Figure 2 : Project Boundary

1.8 Title and Reference of Methodology

The approved CDM methodologies are applied to this project activity. According to Appendix B of the *Simplified Modalities and Procedures for Small-Scale CDM Project Activities*, the Project type and category are defined as follows:

Methane avoidance component:

Type III:	Other project activities
Category III.H:	Methane Recovery in Wastewater Treatment
Sectoral Scope 13:	Waste handling and disposal
Version:	13

Electricity generation component:

Type I:	Renewable energy projects
Category I.D:	Grid connected renewable electricity generation
Sectoral Scope 1:	Energy industries (renewable /non-renewable sources)
Version:	14

Fuel replacement component:

Type I:	Renewable energy projects
Category I.C:	Thermal energy production with or without electricity
Sectoral Scope 1:	Energy industries (renewable /non-renewable sources)
Version:	15

1.9 Other Programs

N/A

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The monitoring period for this report is from 1st August 2014 to 14th September 2014 , both days are included.

- The increasing in achieved emission reductions in this monitoring period is because of the improving of AFFR performance as well as the raising of the starch production quantity.
- From the higher quantity of biogas produced , the excess electricity generated from internal consumption is exported to national grid.
- There is no monitored data during the yearly shutdown period of the starch factory. The shutdown schedule is dependent on the situation of cassava roots supply.
- The new boiler has been installed at the project site as a spare for the old boiler. The biogas consumed by this new boiler is not counted for emission reduction calculation.
- There is no change or modification in biogas plant occurred in this monitoring period.

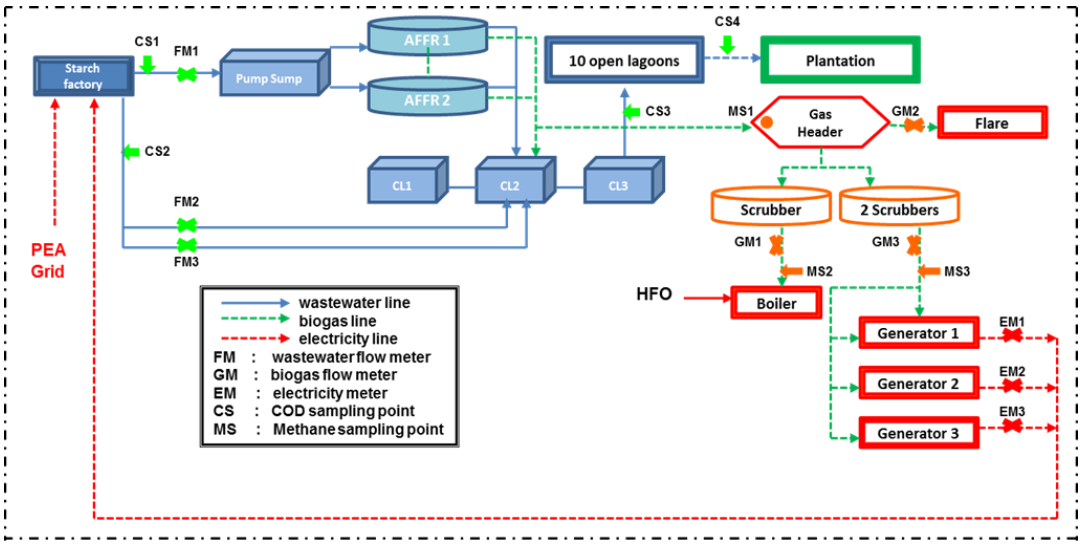


Figure 3 : Monitoring diagram of this period

2.2 Deviations

2.2.1 Methodology Deviations

There are methodology deviations stated in the registered PD , to be applied for the whole crediting period.

Deviation 1

Explanation of the deviation

Since the complete monitoring mechanism is not available for the measurement of baseline input/output thermal energy, a conservative approach has been adopted as explained in the validated PD.

Compliance with the deviation

For verification, with a quantity of dry starch that is produced during a particular year, a minimum required quantity of fossil fuel (fuel oil) could be estimated from quantity of fossil fuel used per unit of dry starch historically. For the same year, if the data for fossil fuel consumed is available, then the remaining energy must be supplied by biogas. This is a conservative approach to estimate the fuel oil that, in the absence of the project activity, would be used in the starch drying process.

The deviation takes into account the baseline efficiencies. A simplified approach is explained here to estimate the baseline emissions. The approach is based on historical consumption of fuel oil per tonne of starch generation. The deviation addresses the coherence with §15, & 10 of the methodology.

It must be noted that the efficiency of the boiler when used in dual-fuel mode is lower than at regular, single-fuel conditions (HFO only). This drop in efficiency leads to a lower biogas to HFO displacement rate. Based on the arguments listed below (provided by technical experts on the subject) and energy balance comparisons based on data available before and after

implementation of the dual-fuel mode in such boiler systems, an efficiency drop resulting in 10% less HFO displacement (than under theoretical conditions) is a conservative approximation. This can be substantiated based on following arguments:

- **Higher hydro/moisture loss makes boiler efficiency lower with biogas** - The efficiency of heating equipment depends on several factors; one of the important ones being the C:H ratio in the fuel, which is higher for fuel oil and lower for biogas. Lower C:H ratio leads to higher quantity of H2O as combustion product, which decreases the thermal efficiency of the boiler. This is typically called "hydrogen loss". In addition, the biogas has a much higher moisture percentage as compared to fuel oil, thus increasing the moisture losses from the equipment, making it a less efficient fuel for burning. The hydrogen sulphide content in the biogas adds to the hydrogen loss.

- **Higher dry flue gas loss reduces boiler efficiency in dual fuel firing mode** - Air in excess of the theoretical calculations (called excess air) is always added for proper and complete combustion. In case of dual fuel firing, due to the different mixing properties of the fuel with the air, this quantity of excess air added is always higher due to the reduced probability of achieving proper air-fuel mixing due to varying fuel properties. At the end of the combustion process, the quantity of unused air is exhausted through the flue gases thus removing away unusable heat in the boiler, such a loss being partly accounted in the dry flue gas loss (the rest is the unusable heat from the high temperature flue gas itself). This can be understood by the fact that the air enters the furnace at ambient temperature but the flue gases are typically at a much higher temperature, 200-300 deg.C for most low-pressure boiler systems. Thus, if the quantity of excess air pumped into the furnace is higher, which is the case for most dual fuel fired systems, the dry flue gas loss is also higher, bringing down the efficiency of the boiler. The excess air quantity adjustment is a matter of experience, and over a period of time boiler operators do understand how to do this and achieve better efficiencies than what they start with. Thus it is expected that during the initial stages of operation, this loss is higher.

- **Variation in biogas quality and quantity influences the air regulation mechanism**, thus lowering the efficiency of the system - The varying quantity and quality of biogas influences the air regulation mechanism continuously, never allowing it to achieve a steady state operation, thus lowering the efficiency of the system.

The statements above can be confirmed through interview with technical experts and details of same can be provided. In addition, the energy balance for a particular year, considering amount of biogas and fossil fuel used, would easily justify the assumption that energy input required in a dual fuel system is higher than in the baseline system. From this, the deviation can be considered as justifiable as it conforms with the requirements as per paragraph 5.3, page 13 of VCS 2007.1 that it does not impact negatively on the conservativeness of the emission reduction calculation or the additionality of the project.

Starch production are multiplied by this default factor (34.3 litres per tonne) to get minimum fuel oil consumption for each year. For the same year, subtracting actual amount of fuel oil used, we estimate the amount of thermal energy supplied by biogas and consequently amount of GHG emission reductions made from the project as per AMS I. C., version 15, component.

Deviation 2

Explanation of the deviation

As per answers to authors of query by the SSC WG "*in the case that the biogas is combusted for a gainful use of the released energy as in an engine or a power plant, a destruction efficiency of 100% can be used for the portion of biogas that is combusted when applying AMS III. H., i.e. use a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use*". Based on this, the calculation approach of MD_y has been deviated from the methodology as justified and accepted in the validation report.

Compliance with the deviation

A destruction efficiency of 100% is used for the portion of biogas that is combusted for gainful use i.e. in boiler and gas engines. For the portion of biogas that is sent to flare, a flare efficiency of 0% has been adopted for the current monitoring period to account for non-operation of the flare system due to unavailability of excess biogas.

Deviation 3

Explanation of the deviation

Based on paragraph 36 of AMS III.H., version 13, volume of gas has to be estimated in Nm^3 from the volume of gas available in m^3. However, due to the unavailability of regular measurement of pressure and temperature values, a conversion of biogas from measured conditions (m^3) to normal conditions (Nm^3) has been done using a conservative factor as elaborated in the validated PD.

Compliance with the deviation

The deviated approach has been adopted for the first monitoring period. The approach assumes that no pressure measurement is done in the supply pipe, thus pressure difference is assumed to be zero, estimating the volume in Nm^3 to be on a lower side. Temperature for ambient conditions around the year as per validated PD is used to calculate a conservative factor in the estimation of biogas volume at normal conditions. Note that the calculated volume of biogas at normal conditions is found to be at an approximate of 90.4% of the measured conditions (m^3), resulting in a lower estimation of methane destructed through combustion of biogas. The approach is explained in detail below this table

Description of deviation

As per the gas equation: $P_1 \times V_1 / T_1 = P_2 \times V_2 / T_2$;

Where 1 represents parameters at measured conditions and 2 refers to parameters at normal conditions. Now for each of these parameters, an explanation of range is shown below.

P1 would always be higher than 1 atm pressure so that there is a positive gauge pressure and gas can flow from gas storage to boiler and gas engines. Let's assume the same to be (1+x) atm where x is a positive number.

P2 = 1 atm as per normal conditions of temperature and pressure.

Since the gas is generated, stored and sent to boiler and gas engines at ambient conditions T1 (average temperature of 29 C as per meteorological data) and normal conditions as 0 C.

So if V1 represents volume in m^3 and V2 represents volume in Nm^3, we have the following situation.

$$V_2(Nm3) = (1+x)X\,V_1(m3)X\,\frac{273}{273+29}$$

If we assume x = 0, we get a conservative factor of 0.904 to be multiplied by gas volume in m3 to get biogas volume in Nm^3 on a conservative basis.

The approach assumes that no pressure measurement is done in the supply pipe and thereby pressure difference is assumed to be zero, estimating the volume in Nm^3 to be on a lower side.

The ambient temperature conditions around the year are available and a conservative value is used to calculate a factor used in estimation of volume at normal conditions. The approach is thus considered as conservative, and it meets the deviation requirements as per paragraph 5.3, page 13 of VCS 2007.1.

The following deviated approach has been adopted and accepted in the previous verifications.

Deviation 4

Description of deviation

It is indicated in the registered PD that the online gas analyser will be installed later (after the first monitoring period) for continuous monitoring. Although the gas analyser has been installed together with generator no.1, the performance of the analyser is not stable. The readings are not consistent. The readings from the portable gas analyser are more reliable.

As per the above reason , the monitoring of this parameter is the periodic measurement by portable gas analyser at 95% confidential level. The measuring is conducted at three locations (header , boiler and generator biogas pipeline) every four hours

Period of deviation

This deviated approach is applied for the whole motoring period.

Deviated approach

The data is periodically measured on hourly basis before entering the boilers and gas engines. The daily average value is calculated. The monitored data is adjusted for 95% confidence level as described in the following steps.

1) Calculate sample mean (μ).

$$\mu_{WCH4,y} = \sum_{m=1}^{n_m} W_{CH4,m,y} \Big/ n_m$$

Where :

$\mu_{WCH4,y}$ = Mean of the fraction of methane in the biogas in year *y* (%)

$W_{CH4,m,y}$ = Monitored fraction of methane in biogas in measurement m in year y (%)

nm = Number of measurements *m* in year *y* (minimum is 4)

2) Calculate the sample standard deviation (σ).

$$\sigma_{WCH4,y} = \sqrt{\sum_{m=1}^{n_m} \left(W_{CH4,m,y} - \mu_{CH4,y}\right)^2 \Big/ (n_m - 1)}$$

Where :

$\sigma_{WCH4,y}$ = Standard deviation of the fraction of methane in biogas in year y (%)

3) Calculate the 95% confidence interval.

$$\mu_{WCH4,y} - t * {}^{\sigma_{WCH4,y}}\Big/_{\sqrt{n_m}} \leq W_{CH4,y} \leq \mu_{WCH4,y} + t * {}^{\sigma_{WCH4,y}}\Big/_{\sqrt{n_m}}$$

Where :

t = Value from standard t distribution for a confidence level of 95% with degrees of freedom n_m-1[1]

4) Use the lower bound of the 95% confidence interval obtained above for BE calculation and the upper bound one for PE calculation to ensure conservativeness.

The above calculating is performed in the ER calculation spreadsheet , monitored parameter adjusting section.

Justification for deviated approach

This approach is according to item.36 of AMS III.H version 13 that *"The fraction of methane in the gas should be measured with a continuous gas analyzer , or , alternatively, with periodically measurement at 95% confidence level"* To be inline with conservative principle , the upper bound value is used for project emission calculation. While the lower bound value is used for baseline emission calculation.

Deviation 5

Description of deviation

The $COD_{ww,untreated,y}$, $COD_{out,CL}$, and $COD_{out,lagoon,PJ}$ were not measured on daily basis which required by the methodology.

Period of deviation

This deviated approach is applied for the whole monitoring period.

Deviated approach

The wastewater analysis of the all wastewater samples was carried out , but not on every operational days. Refer to table III.H.2 of AMS III.H version16 , for COD parameters : *Average value may be used through sampling with the confidence/precision level 90/10* . The standard statistical calculation is applied as per following steps.

[1] http://www.stat.tamu.edu/~lzhou/stat302/T-Table.pdf

1) Calculate sample mean (μ).

$$\mu_{COD,x} = \sum_{m=1}^{n_m} COD_x \Big/ n_m$$

Where :

$\mu_{COD,x}$ = Mean of the COD_x in year *y* (mg/l)

COD_x = Monitored COD_x in measurement m in year y (mg/l)

n_m = Number of measurements *m* in year *y* (minimum is 4)

2) Calculate the sample standard deviation (σ).

$$\sigma_{COD,x} = \sqrt{\sum_{m=1}^{n_m} \left(COD_x - \mu_{COD,x}\right)^2 \Big/ (n_m - 1)}$$

Where :

$\sigma_{COD,x}$ = Standard deviation of COD_x the in year y

3) Calculate the 95% confidence interval.

$$\mu_{COD,x} - t * {}^{\sigma_{COD,x}}\Big/_{\sqrt{n_m}} \leq COD_x \leq \mu_{COD,x} + t * {}^{\sigma_{COD,x}}\Big/_{\sqrt{n_m}}$$

Where :

t = Value from standard t distribution for a confidence level of 95% with degrees of freedom n_m-1[2]

4) Use the lower and upper bound of the 95% confidence interval obtained above for BE and PE calculation respectively to ensure conservativeness.

The above calculating is performed in the ER calculation spreadsheet , monitored parameter adjusting section.

<u>Justification for deviated approach</u>

This approach is in line with conservative principle , the upper bound value is used for project emission calculation to achieve the lower emission reductions

2.2.2 Project Description Deviations

There is no PD deviations proposed in this monitoring period.

[2] http://www.stat.tamu.edu/~lzhou/stat302/T-Table.pdf

2.3 Grouped Project

This project is not a grouped project.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	GWP_{CH4}
Data unit	-
Description	Global warming potential of methane gas
Source of data	Default value from AMS III.H.
Value applied:	21
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	$B_{o,ww}$
Data unit	kg CH_4/kg COD
Description	Methane producing capacity of the COD in wastewater
Source of data	IPCC default value, corrected as per methodology AMS III.H., is used for estimation
Value applied:	0.21
Justification of choice of data or description of measurement methods and procedures applied	IPCC adjusted value
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	UF_{BL}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS III.H., Version 13
Value applied:	0.94
Justification of choice of	According to the AMS III.H., correction factor will be used for

data or description of measurement methods and procedures applied	estimation of baseline emissions.
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	UF_{PJ}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS III.H., Version 13
Value applied:	1.06
Justification of choice of data or description of measurement methods and procedures applied	According to the AMS III.H., correction factor will be used for estimation of baseline emissions.
Purpose of the data	Calculation of project emissions
Comments	-

Data / Parameter	$MCF_{ww,treatment,BL,i}$
Data unit	Fraction
Description	Methane correction factor for the baseline anaerobic wastewater treatment systems
Source of data	Table III.H.1. of AMS III.H., Version 13 page no 6
Value applied:	0.8
Justification of choice of data or description of measurement methods and procedures applied	The baseline wastewater treatment system consists in a succession of deep lagoons (depth more than 2 metres) therefore MCF value is chosen as 0.8.
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	$MCF_{ww,treatment,PJ,k}$
Data unit	Fraction
Description	Methane correction factor for the baseline anaerobic wastewater treatment systems
Source of data	Table III.H.1. of AMS III.H., Version 13 page no 6
Value applied:	0.8
Justification of choice of data or description of measurement methods	The project wastewater treatment system without biogas recovery (secondary treatment) consists in a succession of deep lagoons, with depth more than 2 metres, so the value of 0.8 has been

and procedures applied	chosen.
Purpose of the data	Calculation of project emissions
Comments	-

Data / Parameter	COD removal efficiency
Data unit	%
Description	COD removal efficiency of baseline wastewater treatment system
Source of data	Measured – Colorimetric analysis
Value applied:	87%
Justification of choice of data or description of measurement methods and procedures applied	The COD removal efficiency is based, on COD values for baseline system before implementation of project activity. The COD reduction across the baseline treatment system is multiplied by a factor of 0.89 for conservative estimation of baseline emissions. Actual reduction across the system is approximately 98.1%[3].
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	CFE_{ww}
Data unit	Fraction
Description	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems.
Source of data	Equation 10 in AMS III.H, Version 13 methodology (page 11)
Value applied:	0.9
Justification of choice of data or description of measurement methods and procedures applied	Default value as per AMS III.H.
Purpose of the data	Calculation of project emissions
Comments	-

Data / Parameter	EF_y
Data unit	t CO_2/MWh
Description	CO_2 emission factor for grid power
Source of data	"The calculation of emission factor for an electricity system in Thailand 2007" , DEDE
Value applied:	0.5057
Justification of choice of	EF_y is calculated according to the "Tool to calculate the emission

[3] COD measurement records can be used to substantiate this value. Water analysis reports showing the quality of treated wastewater during pre-project scenario has been submitted to the DOE.

data or description of measurement methods and procedures applied	factor for an electricity system" as determined in the respective small-scale methodology for grid connected electricity generation (AMS I.D version 14).
Purpose of the data	Calculation of baseline emissions
Comments	Conservative choice and publically available data during validation.

Data / Parameter	EF_{CO2}
Data unit	EF_{CO2}
Description	tCO_2/TJ
Source of data	Emission factor of fossil fuel replaced – Residual Fuel oil
Value applied:	IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23
Justification of choice of data or description of measurement methods and procedures applied	IPCC default values used for unavailability of national data. In pre project scenario the residual fuel oil has been main source of thermal energy for the processes.
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	NCV_{FO}
Data unit	GJ/tonne
Description	NCV of fuel oil i.e. fossil fuel displaced by biogas
Source of data	"Thailand Energy Situation 2005"
Value applied:	42.76
Justification of choice of data or description of measurement methods and procedures applied	Default value from official source in Thailand.
Purpose of the data	Calculation of baseline emissions
Comments	Conservative choice and publically available data during validation.

Data / Parameter	NCV_{biogas}
Data unit	MJ/Nm^3
Description	NCV of biogas
Source of data	"Thailand Energy Situation 2005"
Value applied:	20.93
Justification of choice of data or description of measurement methods and procedures applied	Default value from official source in Thailand.

Purpose of the data	Calculation of baseline emissions
Comments	Conservative choice and publically available data during validation.

Data / Parameter	$q_{FO,starch}$
Data unit	litres/tonne
Description	Litres of fossil fuel required per tonne of dry starch historically
Source of data	Historic data
Value applied:	34.3
Justification of choice of data or description of measurement methods and procedures applied	Based on average values compiled from receipts in 2002, 2003, and 2005 2002 = 34.01 litres/tonne 2003 = 34.38 litres/tonne 2005 = 34.39 litres/tonne
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	D_{CH4}
Data unit	Kg/m^3
Description	Density of methane at normal conditions
Source of data	Tool to determine project emissions from flaring gases containing methane.
Value applied:	0.716
Justification of choice of data or description of measurement methods and procedures applied	CDM EB as per EB28 Meeting report (Annex 13).
Purpose of the data	Calculation of project emissions
Comments	-

Data / Parameter	D_{FO}
Data unit	Kg/litre
Description	Density of fuel oil
Source of data	http://www.engineeringtoolbox.com/fuels-densities-specific-volumes-d_166.html
Value applied:	0.93
Justification of choice of data or description of measurement methods	Publically available information

and procedures applied	
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	FE
Data unit	%
Description	Flare efficiency
Source of data	Tool to determine project emissions from flaring gases containing methane.
Value applied:	90%
Justification of choice of data or description of measurement methods and procedures applied	Default value for enclosed as per Tool to determine project emissions from flaring gases containing methane has been applied.
Purpose of the data	Calculation of project emissions
Comments	Default value for enclosed as per Tool to determine project emissions from flaring gases containing methane has been applied

Data / Parameter	DE
Data unit	%
Description	Destruction efficiency of the electricity generator
Source of data	SSC WG
Value applied:	100%
Justification of choice of data or description of measurement methods and procedures applied	According to clarification from SSC WG "*in the case that the biogas is combusted for a gainful use of the released energy as in an engine or a power plant, a destruction efficiency of 100% can be used for the portion of biogas that is combusted when applying AMS III.H., i.e. use a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use*"[4]
Purpose of the data	Calculation of project emissions
Comments	As per description of deviation 2.

Data / Parameter	P_{el}
Data unit	kW
Description	Total electrical capacity of the equipment installed in the project activity
Source of data	

[4] http://cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKUHEF5LB07QICT1P

Item	Equipment	rated power (kW)	Number	Total power	Unit
1	Pump	7.5	2	15	kW
2	Pump - covered lagoon	11	1	11	kW
3	Subemersible pump	7.5	1	7.5	kW
4	Blower to burner	22	1	22	kW
5	Blower to generator	22	1	22	kW
	Blower to generator	7.5	2	15	kW
6	pump-Scrubber for burner	4	1	4	kW
7	pump-Bio scrubber	4	4	16	kW
	pump-Bio scrubber	5.5	1	5.5	kW
8	pump-Scrubber for generator	4	1	4	kW
9	Chiller	0.375	2	0.75	kW
10	feed pump	5.5	3	16.5	kW
				139.25	**kW**

Value applied:	139.25 kW
Justification of choice of data or description of measurement methods and procedures applied	Extract from nameplate of the electrical equipment.
Purpose of the data	Calculation of project emissions
Comments	The rated power consumption of the equipment is updated according to the nameplate of the existing equipment. The total power consumption is higher than identified value in PD. This is the conservativeness approach for higher project emission, which can reduce the emission reduction.

3.2 Data and Parameters Monitored

Data / Parameter	$Q_{ww,y}$
Data unit	m^3
Description	Volume of wastewater treated in the year y
Source of data	Measured continuously using volumetric flow meter
Description of measurement methods and procedures to be applied	The volumetric flow meters are installed at the plant.
Frequency of monitoring/recording	Continuous monitoring with recording on daily basis.
Value monitored:	157,801
Monitoring equipment	This information is provided in Table 4 : Summary of monitoring equipment data and calibration.
QA/QC procedures to be applied	The flow meters are calibrated at least once every 3 years.
Purpose of the data	Calculation of baseline and project emissions
Calculation method	-
Comments	-

Data / Parameter	$COD_{ww,untreated,y}$
Data unit	mg/l
Description	COD of wastewater entering the treatment plant
Source of data	Measured – Colorimetric analysis
Description of measurement methods and procedures to be applied	The COD content will be analyzed using a colorimetric method in the on-site laboratory of the treatment plant.
Frequency of monitoring/recording	The analysis is carried out in every operational day.
Value monitored:	28,634
Monitoring equipment	This information is provided in Table 4 : Summary of monitoring equipment data and calibration.
QA/QC procedures to be applied	The spectrophotometer is calibrated at least once every 3 years.
Purpose of the data	Calculation of baseline and project emissions
Calculation method	-
Comments	The monitored values are adjusted as per deviated approach no. 5.

Data / Parameter	$COD_{removed,PJ,k,y}$
Data unit	tonnes/m^3
Description	COD of water exiting the AFFR and Covered Lagoon treatment process
Source of data	Measured as the difference between inflow COD and the outflow COD of the AFFR and CL system – Colorimetric analysis
Description of measurement methods and procedures to be applied	The COD content will be analyzed using a colorimetric method in the on-site laboratory of the treatment plant.
Frequency of monitoring/recording	The analysis is carried out in every operational day.
Value monitored:	0.027
Monitoring equipment	This information is provided in Table 4 : Summary of monitoring equipment data and calibration.
QA/QC procedures to be applied	The spectrophotometer is calibrated at least once every 3 years.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$BG_{combusted,y}$
Data unit	Nm^3

Description	Amount of biogas combusted for gainful use
Source of data	Calculated from a summation of total biogas utilized in boiler and generation sets.
Description of measurement methods and procedures to be applied	$BG_{combusted, y}$ is estimated by summing the volume of biogas sent to the boiler and generation sets.
Frequency of monitoring/recording	Continuous monitoring with recording on daily basis.
Value monitored:	985,604
Monitoring equipment	This information is provided in Table 4 : Summary of monitoring equipment data and calibration.
QA/QC procedures to be applied	The flow meters are calibrated at least once every 3 years.
Purpose of the data	Calculation of baseline emissions
Calculation method	For GM1, the correction factor applied to adjust temperature difference between Nm^3 conditions and m^3 is done conservatively as explained in Deviation 3.
Comments	-

Data / Parameter	$BG_{TOFlare,y}$
Data unit	Nm^3
Description	Amount of biogas flared
Source of data	Measured using gas flow meter
Description of measurement methods and procedures to be applied	The gas flow meter is at the plant.
Frequency of monitoring/recording	Continuous monitoring with recording on daily basis.
Value monitored:	0
Monitoring equipment	This information is provided in Table 4 : Summary of monitoring equipment data and calibration.
QA/QC procedures to be applied	The flow meter is calibrated at least once every 3 years.
Purpose of the data	Calculation of project emissions
Calculation method	The correction factor applied to adjust temperature difference between Nm^3 conditions and m^3 is done conservatively as explained in Deviation 3.
Comments	The gas flare station is always shutoff. No biogas was sent to the flare in this monitoring period.

Data / Parameter	W_{CH4}
Data unit	%

Description	Methane content in biogas
Source of data	Measured by portable gas analyzer and adjusted for 95% of confidence level
Description of measurement methods and procedures to be applied	The methane content in biogas is measured by the portable gas analyzer.
Frequency of monitoring/recording	Reading is taken by the plant's operators every four hours at three locations i.e. at common gas header before cleansing, before the boiler and before the gas engines in every operational day of the machines.
Value monitored:	48.9%
Monitoring equipment	This information is provided in Table 4 : Summary of monitoring equipment data and calibration.
QA/QC procedures to be applied	The gas analyzer is calibrated at least once every 3 years.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	The monitored values are adjusted as per deviated approach no. 4.

Data / Parameter	$Q_{FO,y}$
Data unit	Litres
Description	Quantity of fossil fuel used in boiler in year y.
Source of data	Fuel oil flow meter
Description of measurement methods and procedures to be applied	The flow meter is installed for continuous measuring the fuel quantity sent to boiler.
Frequency of monitoring/recording	Continuous monitoring with recording
Value monitored:	0
Monitoring equipment	This information is provided in Table 4 : Summary of monitoring equipment data and calibration.
QA/QC procedures to be applied	The flow meter is calibrated at least once every 3 years.
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	$Q_{starch,y}$
Data unit	Tonnes

Description	Quantity of dry starch produced
Source of data	Starch production report
Description of measurement methods and procedures to be applied	The starch production quantities are recorded by operators on daily basis.
Frequency of monitoring/recording	Daily recording
Value monitored:	10,171
Monitoring equipment	-
QA/QC procedures to be applied	The production data can be cross-checked with sales record if necessary.
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	EG_y
Data unit	MWh/y
Description	Net electricity production by the generators during year y
Source of data	Electricity meter built into the generator sets[5]
Description of measurement methods and procedures to be applied	The power monitoring equipment are installed for continuous measuring of electricity produced from each generator.
Frequency of monitoring/recording	Continuous monitoring with daily recording
Value monitored:	895 - after applying 1% of error is 886
Monitoring equipment	This information is provided in Table 4 : Summary of monitoring equipment data and calibration.
QA/QC procedures to be applied	The power meter (EM1) is calibrated at least once every 3 years.
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	The monitored values are adjusted by applying the maximum error of 1% as a result of calibration delay as per EB 52 Annex 60.

Data / Parameter	EC_y

[5] The electricity supplied from 4th generator is not included in this calculation since it is the additional equipment after project implementation which is not indicated in registered PD

Data unit	Electricity consumption by wastewater treatment plant in year y
Description	Calculated from rated power consumption of motors installed in wastewater treatment plant
Source of data	Electricity consumption by wastewater treatment plant in year y
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	-
Value monitored:	162
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	Calculation based on maximum rated consumption is conducted in a conservative manner (as per paragraph 35 in AMS III. H., version 13).
Comments	-

Data / Parameter	Sludge removal and its application
Data unit	Tonnes / type of application
Description	The quantity of organic material / sludge removed from treatment plant and its application
Source of data	Weighing equipment available at site is used.
Description of measurement methods and procedures to be applied	The records weight of sludge transferred from project site are kept. The destination and disposal method should be identified in this record.
Frequency of monitoring/recording	Plant operators record every sludge removal trips.
Value monitored:	0
Monitoring equipment	-
QA/QC procedures to be applied	The records should be approved by factory manager.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$Q_{biogas,flare,h}$
Data unit	Nm^3/hr
Description	Biogas sent to flare during a particular hour h
Source of data	Log record shall be maintained on an hourly basis to ascertain net amount of biogas has gone to flare unit

	during a particular hour.
Description of measurement methods and procedures to be applied	Biogas flow meter is used.
Frequency of monitoring/recording	Continuous monitoring
Value monitored:	There is no monitored value since the flare has never been operated.
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$T_{flare,h}$
Data unit	Deg C
Description	Temperature at the flame of flare
Source of data	The temperature sensor is installed at flare.
Description of measurement methods and procedures to be applied	The temperature sensor is installed at flare. Flame detection shall be logged from measurements by a Type N (or its equivalent) thermocouple
Frequency of monitoring/recording	Continuous monitoring
Value monitored:	There is no monitored value since the flare has never been operated.
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

3.3 Monitoring Plan

The monitoring plan is described in section 3.4 of the registered PD. The documented procedure for VCS monitoring program has been established and implemented. This document describes about the scope of VCS project , responsibility of concerned person , job description and scope ,and emergency preparedness & response.

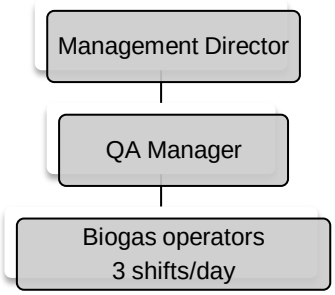
The daily operation data recording and laboratory analysis is carried out by plant operator. The report will be checked and approved by QA manager. The QA manager controls all equipment calibrations.

The QA manager will collect all information and submit to the consultant for emission calculation.

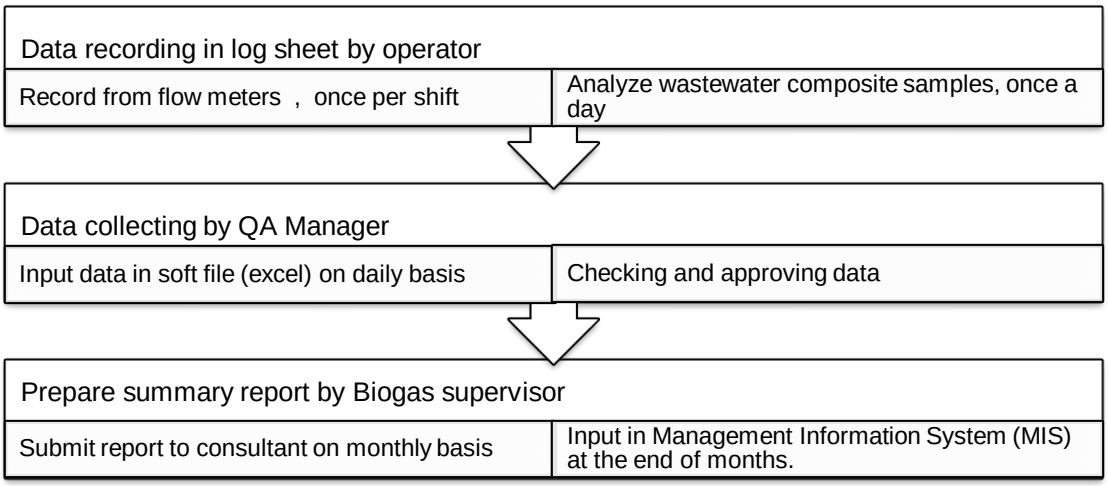
All monitoring data is available in an excel spreadsheet. This spreadsheet consists of:

1. A summary worksheet containing the results of the monitoring for every day of the monitoring period on a yearly basis;
2. The monitored parameters during the monitoring period

Organization structure



Data Collection and management system



Data storage and backup

- The original log sheets are collected and stored at starch operation office by QA Manager.
- The excel spreadsheet is stored in QA manager's computer and backup into external or portable hard disk at least once a month.
- The data stored in MIS report is backup via Chol Charoen's server.
- The excel spreadsheet submitted to consultant is stored and backup via consultant's internal server on monthly basis.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

Baseline emissions for the systems affected by the project activity may consist of:

Baseline Emissions for AMS III.H

$$BE_y = \{BE_{power,y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{s,final,y}\}$$ **Equation 1**

Where:

Parameter	Details
BE_y	Baseline emissions in year y (tCO_2e)
$BE_{power,y}$	Baseline emissions from electricity or fuel consumption in year y (tCO_2e)
$BE_{ww,treatment,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO_2e)
$BE_{s,treatment,y}$	Baseline emissions of the sludge treatment systems affected by the project activity in year y (tCO_2e)
$BE_{ww,discharge,y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y (tCO_2e).
$BE_{s,final,y}$	Baseline methane emissions from anaerobic decay of the final sludge produced in year y (tCO_2e).

Baseline Emissions for AMS I.D.

Baseline emissions from electricity generation (BE_y)

As per AMS I. D., paragraph 9, the baseline is the MWh produced by the renewable generating unit multiplied by an emission coefficient as follows:

$$BE_y = BE_{gen,y} = EF_y * EG_y$$ **Equation 2**

Where:

Parameter	Details
BE_y	Baseline emissions from electricity generation referred as $BE_{gen,y}$ hereafter
EG_y	The quantity of electricity supplied by the project activity during the year "y" (MWh)
EF_y	Thailand National Grid emission factor (tCO_{2e}/MWh)

Baseline Emissions for AMS IC

Emissions from steam/heat displacement by the project activity ($BE_{thermal,CO2,y}$)

According to paragraph 15 of AMS I.C., the baseline emissions are estimated based on the amount of heat/steam delivered by the equipment (as per equation below).

The deviation explained in later section of the PD takes into account the baseline efficiencies and a simplified approach is explained here to estimate the baseline emissions, the approach is based on historical consumption of fuel oil per tonne of starch generation. The deviation addresses the coherence with §15, & 10 of the methodology.

$$BE_{thermal,CO2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{CO2}$$ **Equation 3**

Where:

Parameter	Details
$EG_{thermal}$	The net quantity of steam/heat supplied by the project activity during the year y (TJ)

$\eta_{BL,\ thermal}$	The efficiency of the plant using fossil fuel that would have been used in the absence of the project activity.
EF_{CO2}	The CO_2 emission factor per unit of energy of the fuel that would have been used in the baseline plant in (tCO_2 / TJ), obtained from reliable local or national data if available, otherwise, IPCC default emission factors are used.

$$BE_{thermalCO2,y} = ER_{heat,y} = (Q_{starch,y} * Q_{FO,starch} - q_{FO,y}) * D_{FO} * NCV_{FO} * EF_{co2} / 10^6$$

Deviation 1

Where:

Parameter	Details
$Q_{starch,\ y}$	Quantity of dry starch produced in year "y" (tonnes)
$Q_{FO,\ starch}$	Quantity of fossil fuel per unit of dry starch (liter/tonne)
$q_{FO,\ y}$	Quantity of fossil fuel consumed at the project site in year "y (litres)
D_{FO}	Density of fossil fuel (kg/litre)
NCV_{FO}	Net Calorific value of the fuel oil (TJ/ton)

The detail of this deviation in described in section 2.2. It must be noted that the deviation does not only estimates baseline emissions on the amount of heat/steam generated by the boiler, it also take into account CO_2 emissions from on-site consumption of fossil fuels due to the project activity. In other words, it represents the emission reduction from the heat generation component.

Table 1 : Summary of baseline emissions calculation

BE - AMS III. H.		
Parameter	**2014**	**Unit**
$BE_{ww,\ treatment,\ y}$	13,037	tCO_2e
$BE_{power,\ y}$	0	tCO_2e
$BE_{s,\ treatment,\ y}$	0	tCO_2e
$BE_{ww,\ discharge,\ y}$	0	tCO_2e
$BE_{s,\ final,\ y}$	0	tCO_2e
$BE_{y,\ ex\ post}$	**13,036**	**tCO_2e**
MD_y	**7,247**	**tCO_2e**

BE - AMS I. C.		
Parameter	**2014**	**Unit**
$BE_{thermal,\ CO2,\ y}$	**1,074**	**tCO_2e**

BE - AMS I. D.		
Parameter	**2014**	**Unit**
$BE_{gen,\ y}$ =	**448**	**tCO_2e**

4.2 Project Emissions

Project activity emissions for AMS III.H

$$PE_y = \begin{Bmatrix} PE_{power,y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + \\ PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y} \end{Bmatrix}$$ **Equation 4**

Where:

Parameter	Details
PE_y	Project activity emissions in the year *y* (tCO_2e)
$PE_{power,y}$	Emissions from electricity or fuel consumption in the year *y* (tCO_2e).
$PE_{ww,treatment,y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year *y* (tCO_2e).
$PE_{s,treatment,y}$	Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year *y* (tCO_2e).
$PE_{y,ww,discharge}$	Methane emissions from degradable organic carbon in treated wastewater in year *y* (tCO_2e).
$PE_{s,final,y}$	Methane emissions from anaerobic decay of the final sludge produced in year *y* (tCO_2e).
$PE_{fugitive,y}$	Methane emissions from biogas release in capture systems in year *y*
$PE_{flaring,y}$	Methane emissions due to incomplete flaring in year *y*
$PE_{biomass,y}$	Methane emissions from biomass stored under anaerobic conditions.

Table 2 : Summary of project emissions calculation

PE		
Parameter	**2014**	**Unit**
$PE_{power,y}$	*82*	tCO_2e
$PE_{ww,treatment,y}$	*1,773*	tCO_2e
$PE_{s,treatment,y}$	*0*	tCO_2e
$PE_{ww,discharge,y}$	*0*	tCO_2e
$PE_{s,final,y}$	*0*	tCO_2e
$PE_{fugitive,y}$	*1,611*	tCO_2e
$PE_{fugitive,s,y}$	0	tCO_2e
$PE_{fugitive,ww,y}$	1,611	tCO_2e
$PE_{flaring,y}$	*0*	tCO_2e
$PE_{biomass,y}$	*0*	tCO_2e
$PE_{y,ex\ post}$	**3,466**	**tCO_2e**

4.3 Leakage

The used technology is not equipment transferred from another activity, therefore according to the AMS.III.H, there is no leakage to be considered. All the equipment used in the project activity for power and heat generation is either already existing or brought for purpose of project activity and there is no shifting of old equipment takes place. Therefore, there is no leakage as per AMS.I.C and AMS.I.D.

4.4 Net GHG Emission Reductions and Removals

According to the paragraph 31 AMS III.H., emission reduction achieved by the project activity is limited to the ex-post calculated baseline emissions minus project emissions using the actual monitored data for the project activity. Emission reductions achieved on any year are the lowest value of the following;

$$ER_{y,ex\ post} = \min((BE_{y,ex\ post} - PE_{y,ex\ post} - LE_{y,ex\ post}), (MD_y - PE_{power,y} - PE_{biomass,y} - LE_{y,ex\ post})) \quad \textbf{Equation 5}$$

Where:

Parameter	Details
$ER_{y,\ expost}$	Emission reductions achieved by the project activity based on monitored values for year *y* (tCO2e)
$BE_{y,\ expost}$	Baseline emissions calculated as per Equation 1
$PE_{y,\ expost}$	Project emissions calculated as per Equation 6
MD_y	Methane captured and destroyed/gainfully used by the project activity in the year y

Year	Baseline emissions or removals (tCO_2e)	Project emissions or removals (tCO_2e)	Leakage emissions (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
Year 2014	8,768	82	0	8,686
Total	**8,768**	**82**	**0**	**8,686**

.

APPENDIX 1 : ADDITIONAL INFORMATION

Table 3 : Summary of monitored parameter

Parameter	Unit	2014
$Q_{ww, y}$	m^3	157,801
$COD_{ww, untreated,y}$	mg/L	28,634
$COD_{out, CL}$	mg/L	1,336
$COD_{out,lagoon.PJ}$	mg/L	705
$COD_{load,ww, untreated, y}$	Tonnes	4,519
$COD_{load, out, CL}$	Tonnes	211
$COD_{load, out, lagoon, PJ}$	Tonnes	111
$COD_{removed, i, y}$	Tonnes	3,931
$COD_{removed, PJ,AFFR+CL,y}$	Tonnes	4,308
	Tonnes/m3	0.027
$COD_{y,removed, PJ,Lagoon, y}$	Tonnes	100
	Tonnes/m3	0.00063
$MEP_{ww, treatment, y}$	tonnes	767
$BG_{combusted, y}$	Nm^3	985,604
$BG_{TOFlare, y}$	Nm^3	0
$W_{CH4 - lower}$	%	48.9%
$q_{FO, y}$	Litres	-
$Q_{starch, y}$	Tonnes	10,171
EG_{y}	MWh	886
EC_{y}	MWh	162
Sludge removed	Tonnes	0

Table 4 : Summary of monitoring equipment data and calibration

Meter	Location	Brand	Model	S/N	Accuracy	Remark	Calibration record				
							2012	2013	2014	2015	2016
FM1	AFFR	Euromag	MUT 1000EL	YAL1623	0.2%			21-May-13	21-Jun-14	22-Jun-15	18-Jun-16
FM2	CL2	Euromag	MUT 1000EL	YAL1624	0.2%			17-May-13	21-Jun-14	22-Jun-15	18-Jun-16
FM3	CL2	Euromag	MUT 1000EL	YAL1625	0.2%			17-May-13	21-Jun-14	22-Jun-15	18-Jun-16
GM1	Boiler	Veris detector	Verabar	V9107-03.1	1.0%				27-Jun-14	18-Jun-15	16-Jun-16
GM2	*Flare*	*Veris detector*	*Verabar*	*V10S08-01.1*	*1.0%*	*Old*		15-May-13			
GM2	Flare	Veris detector	Verabar	V21059-01.1	1.0%	New				18-Jun-15	16-Jun-16
GM3	Gen set	FOX	FT2A-09I	20880	1%	New			10-Jul-14	18-Jun-15	16-Jun-16
GM3	*Gen set*	*FOX*	*FT2A-09I*	*7565*	*1%*	*Old*		13-May-13			
EM1	Gen1	Carlo Gavazzi	WM3-96	61580000N0050	1%		23-May-12				
EM2	Gen2	Huatong	PDM-803AC-M4	HT08051884	0.5%						
EM3	Gen3	Huatong	PDM-803AC-M5	HT09050004	0.5%						
MS	*Portable*	*Gas Data*	*GFM series*	*11824*	*3%*	*Old*		16-Apr-13			
MS	Portable	Gas Data		12368		New				4-Mar-15	
CS		*HACH*	*DR/2700*	*1422847*		*Old*		3-Jun-13	5-Jun-14		
CS		HACH	DR900	HAC160600001037		New					29-Feb-16
OM	Boiler	Aquametro	Contoil VZ	20320	1%			22-May-13	24-Jun-14	29-Jun-15	20-Jun-16