

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



Document Prepared By South Pole Carbon Asset Management Ltd.

Project Title	Chol Charoen Group Wastewater Treatment with Biogas System I (Cholburi)
Version	04
Date of Issue	04-May-2012
Project ID	430
Monitoring Period	01-October-2010 to 31-December-2011
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1 PROJECT DETAILS

1.1 Summary Description of 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 m³ 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 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).

This monitoring report is for the 3rd verification of this project. The 1st and 2nd verification reports were issued on 18th November 2010 and 13th April 2011 respectively.

Further background information on this project activity can be found in the VCS website : <https://vcsprojectdatabase1.apx.com/mymodule/ProjectDoc/EditProjectDoc.asp?id1=430>.

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 ktCO₂e 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

Role	Project owner (Responsible for implementation and operation of the project activity)
Organization:	Chol Charoen Co., Ltd.
Address:	1004/200 Rama 3 Road, Bangpongpan, Yannawa, 10120
City:	Bangkok
Country:	Thailand
Telephone:	+66 2 294 5315-6, 2945646
FAX:	+66 2 294 3215
Represented	Ung Mengchua
Title:	Mr.
Salutation:	President

Role	Carbon consultant (responsible for development of emission reductions through the Voluntary Carbon Standard)
Organization:	South Pole Carbon Asset Management Ltd.
Street/P.O.Box:	Technoparkstrasse 1
City:	Zurich
Postfix/ZIP:	8005
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Represented by:	Ingo Puhl
Title:	Mr.
Salutation:	Managing Partner.
Mobile:	+ 66 86 778 2869
Direct tel:	+ 66 2 678 8979

1.4 Other Entities Involved in the Project

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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 will be neglected from our claim of emission reduction. 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

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

This is the 3rd monitoring period of the project activity. The monitoring period is from 1st October 2010 to 31st December 2011, 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 depended on the situation of cassava roots supply. It can be referred the letter to Provincial Electricity Authority (PEA)¹ to inform about zero and partial electricity consumption.
- There is no change or modification in biogas plant occurred in this monitoring period.

¹ Memos to PEA are provided as reference document.

2.2 Deviations from the Monitoring Plan

1) *Deviations from methodologies stated in the registered PD*

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 Nm³ from the volume of gas available in m³. However, due to the unavailability of regular measurement of pressure and temperature values, a conversion of biogas from measured conditions (m³) to normal conditions (Nm³) 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 Nm³ 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 (m³), resulting in a lower estimation of methane destructured 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 m³ and V2 represents volume in Nm³, we have the following situation.

$$V_2 (Nm^3) = (1 + x) \times V_1 (m^3) \times \frac{273}{273 + 29}$$

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 Nm³ 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 Nm³ 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.

2) *Deviations from monitoring plan indicated in the registered PD*

Deviation 1

Explanation of the deviation

The monitoring of methane content in biogas is not monitored by online gas analyser. 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.

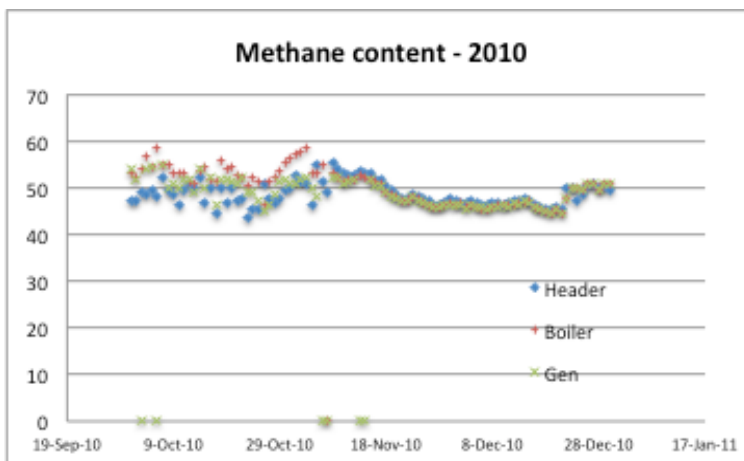
Compliance with the deviation

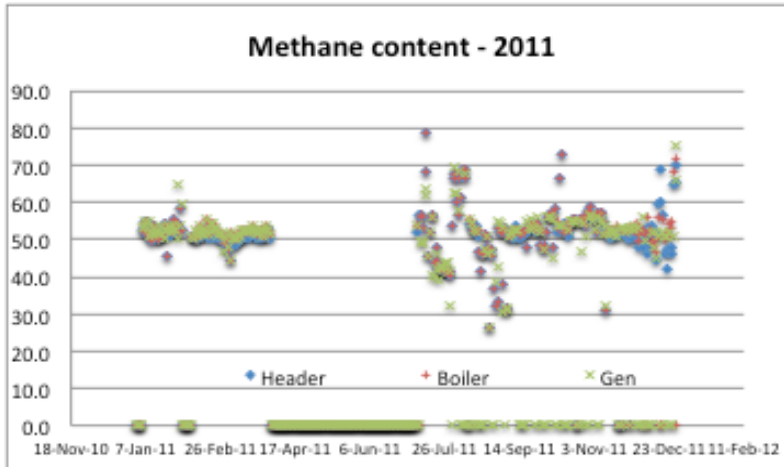
The deviated approach has been adopted during validation which referred to EB 50 , Annex 30 , and was applied and accepted in the first and second monitoring periods.

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.

Description of deviation

The measured values of W_{CH_4} parameter when plotted against time of year show no clear change or dependency of W_{CH_4} on time of year. It should be reasonable to assume that w_{CH_4} readings represent a normal distribution over a year, which means that for most days, the value of w_{CH_4} is close to the mean, while for fewer days, the W_{CH_4} value is higher or smaller than the average. This is well represented on the following graph.





The approach is aimed at estimating the 95% confidence interval for the W_{CH_4} values for year 2010 and 2011. The lower bound of the interval will be used for the baseline emissions and higher bound will be used for project emissions as a conservative approach.

Theory of used approach: In case there are infinite numbers of data samples available, true mean and true standard deviation can be established for the normally distributed data. On the other hand when number of samples is low, Student-t distribution approach is used. The approach of student-t distribution is explained below.

$\bar{X}$ = Average of the n number of sample readings available.

μ = is the mean of normally distributed data if large number of readings are available.

s = standard deviation of the sample readings.

n = number of sample readings.

n-1 = degrees of freedom, the scores which are free to vary.

A = Factor applied to the calculation term based on standard tables. The value of A is inversely proportional to the value of n. If more number of samples is available, the value of A is lower, whereby the range of confidence interval is low making the estimate more precise.

TABLE of CRITICAL VALUES for STUDENT'S t DISTRIBUTIONS

Column headings denote probabilities (α) above tabulated values.

d.f.	0.40	0.25	0.10	0.05	0.04	0.025	0.02	0.01	0.005	0.0025	0.001	0.0005
1	0.325	1.000	3.078	6.314	7.916	12.706	15.894	31.821	63.656	127.321	318.289	636.578
2	0.289	0.816	1.886	2.920	3.320	4.303	4.849	6.965	9.925	14.089	22.328	31.600
3	0.277	0.765	1.638	2.353	2.605	3.182	3.482	4.541	5.841	7.453	10.214	12.924
4	0.271	0.741	1.533	2.132	2.333	2.776	2.999	3.747	4.604	5.598	7.173	8.610
5	0.267	0.727	1.476	2.015	2.191	2.571	2.757	3.365	4.032	4.773	5.894	6.869
6	0.265	0.718	1.440	1.943	2.104	2.447	2.612	3.143	3.707	4.317	5.208	5.959
7	0.263	0.711	1.415	1.895	2.046	2.365	2.517	2.998	3.499	4.029	4.785	5.408
8	0.262	0.706	1.397	1.860	2.004	2.306	2.449	2.896	3.355	3.833	4.501	5.041
9	0.261	0.703	1.383	1.833	1.973	2.262	2.398	2.821	3.250	3.690	4.297	4.781
10	0.260	0.700	1.372	1.812	1.948	2.228	2.359	2.764	3.169	3.581	4.144	4.587
11	0.260	0.697	1.363	1.796	1.928	2.201	2.328	2.718	3.106	3.497	4.025	4.437
12	0.259	0.695	1.356	1.782	1.912	2.179	2.303	2.681	3.055	3.428	3.930	4.318
13	0.259	0.694	1.350	1.771	1.899	2.160	2.282	2.650	3.012	3.372	3.852	4.221
14	0.258	0.692	1.345	1.761	1.887	2.145	2.264	2.624	2.977	3.326	3.787	4.140
15	0.258	0.691	1.341	1.753	1.878	2.131	2.249	2.602	2.947	3.286	3.733	4.073
16	0.258	0.690	1.337	1.746	1.869	2.120	2.235	2.583	2.921	3.252	3.686	4.015
17	0.257	0.689	1.333	1.740	1.862	2.110	2.224	2.567	2.898	3.222	3.646	3.965
18	0.257	0.688	1.330	1.734	1.855	2.101	2.214	2.552	2.878	3.197	3.610	3.922
19	0.257	0.688	1.328	1.729	1.850	2.093	2.205	2.539	2.861	3.174	3.579	3.883
20	0.257	0.687	1.325	1.725	1.844	2.086	2.197	2.528	2.845	3.153	3.552	3.850
21	0.257	0.686	1.323	1.721	1.840	2.080	2.189	2.518	2.831	3.135	3.527	3.819
22	0.256	0.686	1.321	1.717	1.835	2.074	2.183	2.508	2.819	3.119	3.505	3.792
23	0.256	0.685	1.319	1.714	1.832	2.069	2.177	2.500	2.807	3.104	3.485	3.768
24	0.256	0.685	1.318	1.711	1.828	2.064	2.172	2.492	2.797	3.091	3.467	3.745
25	0.256	0.684	1.316	1.708	1.825	2.060	2.167	2.485	2.787	3.078	3.450	3.725
26	0.256	0.684	1.315	1.706	1.822	2.056	2.162	2.479	2.779	3.067	3.435	3.707
27	0.256	0.684	1.314	1.703	1.819	2.052	2.158	2.473	2.771	3.057	3.421	3.689
28	0.256	0.683	1.313	1.701	1.817	2.048	2.154	2.467	2.763	3.047	3.408	3.674
29	0.256	0.683	1.311	1.699	1.814	2.045	2.150	2.462	2.756	3.038	3.396	3.660
30	0.256	0.683	1.310	1.697	1.812	2.042	2.147	2.457	2.750	3.030	3.385	3.646
31	0.256	0.682	1.309	1.696	1.810	2.040	2.144	2.453	2.744	3.022	3.375	3.633
32	0.255	0.682	1.309	1.694	1.808	2.037	2.141	2.449	2.738	3.015	3.365	3.622
33	0.255	0.682	1.308	1.692	1.806	2.035	2.138	2.445	2.733	3.008	3.356	3.611
34	0.255	0.682	1.307	1.691	1.805	2.032	2.136	2.441	2.728	3.002	3.348	3.601
35	0.255	0.682	1.306	1.690	1.803	2.030	2.133	2.438	2.724	2.996	3.340	3.591
36	0.255	0.681	1.306	1.688	1.802	2.028	2.131	2.434	2.719	2.990	3.333	3.582
37	0.255	0.681	1.305	1.687	1.800	2.026	2.129	2.431	2.715	2.985	3.326	3.574
38	0.255	0.681	1.304	1.686	1.799	2.024	2.127	2.429	2.712	2.980	3.319	3.566
39	0.255	0.681	1.304	1.685	1.798	2.023	2.125	2.426	2.708	2.976	3.313	3.558
40	0.255	0.681	1.303	1.684	1.796	2.021	2.123	2.423	2.704	2.971	3.307	3.551
60	0.254	0.679	1.296	1.671	1.781	2.000	2.099	2.390	2.660	2.915	3.232	3.460
80	0.254	0.678	1.292	1.664	1.773	1.990	2.088	2.374	2.639	2.887	3.195	3.416
100	0.254	0.677	1.290	1.660	1.769	1.984	2.081	2.364	2.626	2.871	3.174	3.390
120	0.254	0.677	1.289	1.658	1.766	1.980	2.076	2.358	2.617	2.860	3.160	3.373
140	0.254	0.676	1.288	1.656	1.763	1.977	2.073	2.353	2.611	2.852	3.149	3.361
160	0.254	0.676	1.287	1.654	1.762	1.975	2.071	2.350	2.607	2.847	3.142	3.352
180	0.254	0.676	1.286	1.653	1.761	1.973	2.069	2.347	2.603	2.842	3.136	3.345
200	0.254	0.676	1.286	1.653	1.760	1.972	2.067	2.345	2.601	2.838	3.131	3.340
250	0.254	0.675	1.285	1.651	1.758	1.969	2.065	2.341	2.596	2.832	3.123	3.330
inf	0.253	0.674	1.282	1.645	1.751	1.960	2.054	2.326	2.576	2.807	3.090	3.290

In such cases the confidence intervals is defined, in which the value μ would lie with a probability of $(100-\alpha)\%$. So in this case we select $\alpha = 0.05$ (for both sides of the curve contributing 0.025 on each end of the curve is curtailed), the interval is defined as $[\bar{X} - (A * s / \sqrt{n}), \bar{X} + (A * s / \sqrt{n})]$. Here A is dependent on the number of sample readings available. The value is available in standard tables on many sources.

More specifically, probability $(\bar{X} - (A * s / \sqrt{n}) \leq \mu \leq \bar{X} + (A * s / \sqrt{n})) = 0.95$

So the lower limit of established intervals is used for baseline emissions and upper limit is used for project emissions. ²

Approach applied to the project activity:

² Student-t distribution theory: http://www.wikidoc.org/index.php/Student's_t-distribution

Confidence Interval theory: http://www.wikidoc.org/index.php/Confidence_interval

Distribution Tables: <http://www.statsoft.com/textbook/distribution-tables/>

Statistic Tutorials: <http://stattrek.com/Lesson3/TDistribution.aspx?Tutorial=AP>

Common terms used:

$\bar{X}$ = average of the parameter, COD in this case

s = standard deviation of the data set

n = number of sample readings

$s/\sqrt{n}$ = standard error of the data

The 95% confidence interval is represented as $\bar{X} - (A * s/\sqrt{n})$ and $\bar{X} + (A * s/\sqrt{n})$. The value of A depends on degrees of freedom i.e. n-1. Higher the value of n, lower the value of A. For the range between 250 and infinity of n, the value of A is 1.969; which refers to the normal distribution.

W_{CH_4}	2010	2011
$\bar{X}$	49.11	51.88
s	4.32	6.32
n	267	684
A	1.969	1.969
X	48.6	51.4

The above values of lower of intervals are used for W_{CH_4} , for conservative estimation of Emission Reductions.

2.3 Grouped Project

The project activity is not a grouped project.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data Unit / Parameter:	GWP _{CH4}
Data unit:	-
Description:	Global warming potential of methane gas
Source of data:	Default value from AMS III.H.
Value applied:	21
Purpose of the data:	Baseline and project emission calculation
Any comment:	

Data Unit / 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
Purpose of the data:	Baseline emission calculation
Any comment:	

Data Unit / 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
Purpose of the data:	Baseline emission calculation
Any comment:	

Data Unit / 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
Purpose of the data:	Project emission calculation
Any comment:	

Data Unit / 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
Purpose of the data:	Baseline emission calculation
Any comment:	IPCC Default values from chapter 6 of volume 5 page no 6.21. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Data Unit / Parameter:	$MCF_{ww, treatment, PJ, k}$
Data unit:	Fraction
Description:	Methane correction factor for project wastewater treatment system k
Source of data:	Table III.H.1. of AMS III.H., Version 13 page no 6
Value applied:	0.8
Purpose of the data:	Project emission calculation
Any comment:	IPCC Default values from chapter 6 of volume 5 page no 6.21. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Data Unit / Parameter:	COD removal efficiency
------------------------	------------------------

Data unit:	%
Description:	COD removal efficiency of baseline wastewater treatment system
Source of data:	Measured – Colorimetric analysis
Value applied:	87%
Purpose of the data:	Baseline emission calculation
Any comment:	

Data Unit / 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
Purpose of the data:	Project emission calculation
Any comment:	

Data Unit / 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
Purpose of the data:	Baseline emission calculation
Any comment:	Conservative choice and publically available data during validation.

Data Unit / Parameter:	EF_{CO_2}
Data unit:	tCO ₂ /TJ

Description:	Emission factor of fossil fuel replaced – Residual Fuel oil
Source of data:	IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23
Value applied:	77.4
Purpose of the data:	Baseline emission calculation
Any comment:	-

Data Unit / 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
Purpose of the data:	Baseline emission calculation
Any comment:	Conservative choice and publically available data during validation.

Data Unit / Parameter:	NCV _{biogas}
Data unit:	MJ/Nm ³
Description:	NCV of biogas
Source of data:	“Thailand Energy Situation 2005”
Value applied:	20.93
Purpose of the data:	Baseline emission calculation
Any comment:	Conservative choice and publically available data during validation.

Data Unit / 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
Purpose of the data:	Baseline emission calculation
Any comment:	

Data Unit / 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
Purpose of the data:	Baseline emission calculation
Any comment:	CDM EB as per EB28 Meeting report (Annex 13)

Data Unit / 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
Purpose of the data:	Baseline emission calculation
Any comment:	

Data Unit / Parameter:	FE
Data unit:	%
Description:	Flare efficiency
Source of data:	Tool to determine project emissions from flaring gases containing methane.

Value applied:	90%
Purpose of the data:	Project emission calculation
Any comment:	Default value for enclosed as per Tool to determine project emissions from flaring gases containing methane has been applied

Data Unit / Parameter:	DE
Data unit:	%
Description:	Destruction efficiency of the electricity generator
Source of data:	SSC WG
Value applied:	100%
Purpose of the data:	Project emission calculation
Any comment:	As per deviation 2.

Data Unit / Parameter:	P _{el}																																																																																				
Data unit:	kW																																																																																				
Description:	Total electrical capacity of the equipments installed in the project activity																																																																																				
Source of data:	<table><tr><th>Item</th><th>Equipment</th><th>rated power (kW)</th><th>Number</th><th>Total power</th><th>Unit</th></tr><tr><td>1</td><td>Pump</td><td>7.5</td><td>2</td><td>15</td><td>kW</td></tr><tr><td>2</td><td>Pump - covered lagoon</td><td>11</td><td>1</td><td>11</td><td>kW</td></tr><tr><td>3</td><td>Submersible pump</td><td>7.5</td><td>1</td><td>7.5</td><td>kW</td></tr><tr><td>4</td><td>Blower to burner</td><td>22</td><td>1</td><td>22</td><td>kW</td></tr><tr><td>5</td><td>Blower to generator</td><td>22</td><td>1</td><td>22</td><td>kW</td></tr><tr><td></td><td>Blower to generator</td><td>7.5</td><td>2</td><td>15</td><td>kW</td></tr><tr><td>6</td><td>pump-Scrubber for burner</td><td>4</td><td>1</td><td>4</td><td>kW</td></tr><tr><td>7</td><td>pump-Bio scrubber</td><td>4</td><td>4</td><td>16</td><td>kW</td></tr><tr><td></td><td>pump-Bio scrubber</td><td>5.5</td><td>1</td><td>5.5</td><td>kW</td></tr><tr><td>8</td><td>pump-Scrubber for generator</td><td>4</td><td>1</td><td>4</td><td>kW</td></tr><tr><td>9</td><td>Chiller</td><td>0.375</td><td>2</td><td>0.75</td><td>kW</td></tr><tr><td>10</td><td>feed pump</td><td>5.5</td><td>3</td><td>16.5</td><td>kW</td></tr><tr><td colspan="4"></td><td>139.25</td><td>kW</td></tr></table>	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	Submersible 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
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	Submersible 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																																																																																				
Purpose of the data:	Project emission calculation																																																																																				
Any comment:	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 PDD. This is the conservativeness approach for higher project emission, which can reduce the emission reduction.
--	---

3.2 Data and Parameters Monitored

Data Unit / 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:	<table> <tr> <th>Period</th><th>Value</th></tr> <tr> <td>Oct'10 - Dec'10</td><td>266,510</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>794,473</td></tr> </table>	Period	Value	Oct'10 - Dec'10	266,510	Jan'11 - Dec'11	794,473
Period	Value						
Oct'10 - Dec'10	266,510						
Jan'11 - Dec'11	794,473						
Monitoring equipment:	FM1, FM2 , FM3 as per information in Table 5.						
QA/QC procedures to be applied:	The flow meters are calibrated at least once every 3 years.						
Calculation method:	-						
Any comment:	-						

Data Unit / 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:	<table> <tr> <th>Period</th><th>Value</th></tr> <tr> <td>Oct'10 - Dec'10</td><td>24,497</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>24,297</td></tr> </table>	Period	Value	Oct'10 - Dec'10	24,497	Jan'11 - Dec'11	24,297
Period	Value						
Oct'10 - Dec'10	24,497						
Jan'11 - Dec'11	24,297						
Monitoring equipment:	Spectrophotometer as per information in Table 5.						
QA/QC procedures to be applied:	The spectrophotometer is calibrated at least once every 3 years.						
Calculation method:	-						
Any comment:	-						

Data Unit / 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:	<table> <tr> <th>Period</th><th>Value</th></tr> <tr> <td>Oct'10 - Dec'10</td><td>0.0198</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>0.0223</td></tr> </table>	Period	Value	Oct'10 - Dec'10	0.0198	Jan'11 - Dec'11	0.0223
Period	Value						
Oct'10 - Dec'10	0.0198						
Jan'11 - Dec'11	0.0223						
Monitoring equipment:	Spectrophotometer as per information in Table 5.						
QA/QC procedures to be applied:	The spectrophotometer is calibrated at least once every 3 years.						
Calculation method:	-.						
Any comment:	-						

Data Unit / 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:	<table> <tr> <th>Period</th><th>Value</th></tr> <tr> <td>Oct'10 - Dec'10</td><td>1,419,613</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>5,491,749</td></tr> </table>	Period	Value	Oct'10 - Dec'10	1,419,613	Jan'11 - Dec'11	5,491,749
Period	Value						
Oct'10 - Dec'10	1,419,613						
Jan'11 - Dec'11	5,491,749						
Monitoring equipment:	GM1 and GM3 as per information in Table 5.						
QA/QC procedures to be applied:	The flow meters are calibrated at least once every 3 years.						
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 1.3.						
Any comment:	-						

Data Unit / 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:	<table> <tr> <th>Period</th><th>Value</th></tr> <tr> <td>Oct'10 - Dec'10</td><td>0</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>0</td></tr> </table>	Period	Value	Oct'10 - Dec'10	0	Jan'11 - Dec'11	0
Period	Value						
Oct'10 - Dec'10	0						
Jan'11 - Dec'11	0						
Monitoring equipment:	GM2 as per information in Table 5.						
QA/QC procedures to be applied:	The flow meter is calibrated at least once every 3 years.						
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.						
Any comment:	-						

Data Unit / Parameter:	W_{CH_4}						
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 , as per description of deviation 2.1 in section 2.2.						
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:	<table border="1"> <thead> <tr> <th>Period</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Oct'10 - Dec'10</td><td>48.59</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>51.40</td></tr> </tbody> </table>	Period	Value	Oct'10 - Dec'10	48.59	Jan'11 - Dec'11	51.40
Period	Value						
Oct'10 - Dec'10	48.59						
Jan'11 - Dec'11	51.40						
Monitoring equipment:	The gas analyzer as per information in Table 5.						
QA/QC procedures to be applied:	The gas analyzer is calibrated at least once every 3 years.						
Calculation method:	-						
Any comment:	To maintain the reliability of methane content result measured by portable analyzer , the maximum methane value of 80% ³ is considered as the upper bound of the possible methane range. The measured methane results over than 80% will be discarded from emission reductions calculation.						

Data Unit / 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

³ Same reference source for methane value applied during validation ,
<http://www.oregon.gov/ENERGY/RENEW/Biomass/biogas.shtml>

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:	<table> <tr> <th>Period</th><th>Value</th></tr> <tr> <td>Oct'10 - Dec'10</td><td>0</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>14,341</td></tr> </table>	Period	Value	Oct'10 - Dec'10	0	Jan'11 - Dec'11	14,341
Period	Value						
Oct'10 - Dec'10	0						
Jan'11 - Dec'11	14,341						
Monitoring equipment:	The liquid flow meter, OM as per information in Table 5.						
QA/QC procedures to be applied:	The flow meter is calibrated at least once every 3 years.						
Calculation method:	-						
Any comment:	The flow meter VZO type , S/N : 92049 , was replaced by new flow meter , S/N 4624027 , on 30 th August 2011..						

Data Unit / Parameter:	$Q_{\text{starch}, y}$						
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:	<table> <tr> <th>Period</th><th>Value</th></tr> <tr> <td>Oct'10 - Dec'10</td><td>21,814</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>53,572</td></tr> </table>	Period	Value	Oct'10 - Dec'10	21,814	Jan'11 - Dec'11	53,572
Period	Value						
Oct'10 - Dec'10	21,814						
Jan'11 - Dec'11	53,572						
Monitoring equipment:	-						
QA/QC procedures to be applied:	The production data can be cross-checked with sales record if necessary.						
Calculation method:	-						
Any comment:	-						

Data Unit / 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 ⁴						
Description of measurement methods and procedures to be applied:	The power monitoring equipments are installed for continuous measuring of electricity produced from each generator.						
Frequency of monitoring/recording:	Continuous monitoring with daily recording						
Value monitored:	<table border="1"> <thead> <tr> <th>Period</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Oct'10 - Dec'10</td><td>1,702</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>4,024</td></tr> </tbody> </table>	Period	Value	Oct'10 - Dec'10	1,702	Jan'11 - Dec'11	4,024
Period	Value						
Oct'10 - Dec'10	1,702						
Jan'11 - Dec'11	4,024						
Monitoring equipment:	EM1 , EM2 and EM3 as per information in Table 5.						
QA/QC procedures to be applied:	The power meters are calibrated as per manufacturer's recommendation.						
Calculation method:	-						
Any comment:	For period of 1-Oct-10 to 6-Nov-10 , the electricity generated from generator no.1 is deducted by 1% (the maximum error of the power meter) for the conservative approach due to the delay of calibration in accordance with EB 52 Annex 60.						

Data Unit / Parameter:	EC _y						
Data unit:	MWh/y						
Description:	Electricity consumption by wastewater treatment plant in year y						
Source of data:	Calculated from rated power consumption of motors installed in wastewater treatment plant						
Description of measurement methods and procedures to be applied:	-						
Frequency of monitoring/recording:	-						
Value monitored:	<table border="1"> <thead> <tr> <th>Period</th><th>Value</th></tr> </thead> <tbody> <tr> <td>Oct'10 - Dec'10</td><td>335</td></tr> <tr> <td>Jan'11 - Dec'11</td><td>1,342</td></tr> </tbody> </table>	Period	Value	Oct'10 - Dec'10	335	Jan'11 - Dec'11	1,342
Period	Value						
Oct'10 - Dec'10	335						
Jan'11 - Dec'11	1,342						

⁴ 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

Monitoring equipment:	-
QA/QC procedures to be applied:	-
Calculation method:	Calculation based on maximum rated consumption is conducted in a conservative manner (as per paragraph 35 in AMS III. H., version 13).
Any comment:	-

Data Unit / Parameter:	Sludge removed 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.
Calculation method:	-
Any comment:	-

Data Unit / Parameter:	$Q_{\text{biogas, flare, h}}$
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:	-

Calculation method:	-
Any comment:	

Data Unit / 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:	-
Calculation method:	-
Any comment:	

3.3 Description of the 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.

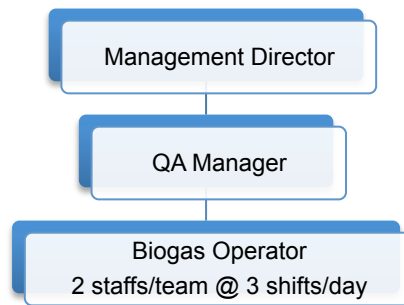
The daily operation data recording and laboratory analysis is carried out by plant operator. The report will be checked and approved by QA manager. The QA manager controls all equipment calibrations.

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

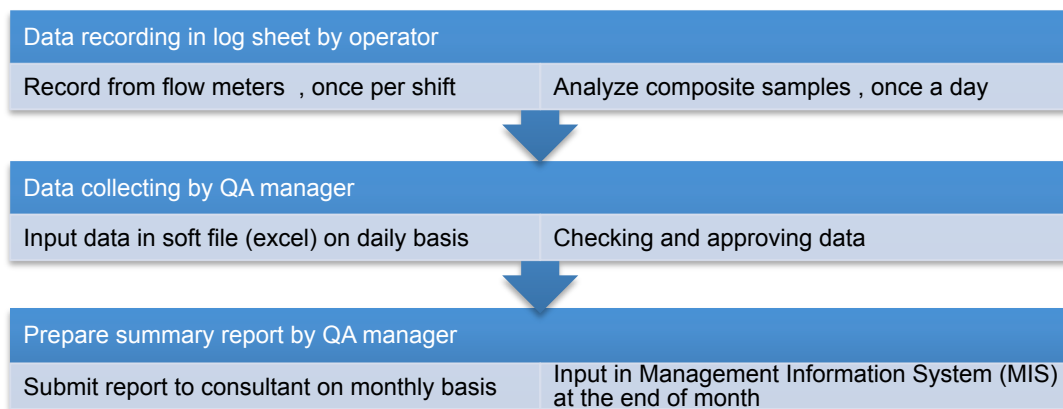
All monitoring data is available in an excel spreadsheet. This spreadsheet consists of:

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 in the starch operation office by QA manager.
- The excel spreadsheet is stored in QA manager's computer and backup into external or portable hddisk 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

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

Where:

Parameter	Details
BE_y	Baseline emissions in year y (tCO ₂ e)
$BE_{power,y}$	Baseline emissions from electricity or fuel consumption in year y (tCO ₂ e)
$BE_{ww,treatment,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO ₂ e)
$BE_{s,treatment,y}$	Baseline emissions of the sludge treatment systems affected by the project activity in year y (tCO ₂ e)
$BE_{ww,discharge,y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y (tCO ₂ e).
$BE_{s,final,y}$	Baseline methane emissions from anaerobic decay of the final sludge produced in year y (tCO ₂ e).

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:

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

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 ($BE_{thermal,CO_2,y}$)

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.

$$BE_{thermal,CO_2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{CO_2} \quad \text{Equation 3}$$

Where:

Parameter	Details
EG _{thermal}	The net quantity of steam/heat supplied by the project activity during the year y (TJ)
η _{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.

$$BE_{thermal,CO_2,y} = ER_{heat,y} = (Q_{starch,y} * Q_{FO,starch} - q_{FO,y}) * D_{FO} * NCV_{FO} * EF_{co_2} / 10^6 \quad \text{Deviation 1}$$

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)
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The detail of this deviation is described in section 2.2. It must be noted that the deviation does not only estimate baseline emissions on the amount of heat/steam generated by the boiler, it also takes into account CO₂ 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

AMS III. H. : Baseline emissions			
Parameter	2010	2011	Unit
BE _{ww, treatment, y}	16,130	54,150	tCO ₂ e
BE _{power, y}	0	0	tCO ₂ e
BE _{s, treatment, y}	0	0	tCO ₂ e
BE _{ww, discharge, y}	0	0	tCO ₂ e
BE _{s, final, y}	0	0	tCO ₂ e
BE _{y, ex post}	16,129	54,150	tCO ₂ e
MD _y	10,372	42,446	tCO ₂ e

AMS I. C.			
Parameter	2010	2011	Unit
BE _{thermal, CO2, y} = ER _{heat, y}	2,303	5,612	tCO ₂ e

AMS I. D.			
Parameter	2010	2011	Unit
BE _{gen, y} = ER _{power, y}	861	2,035	tCO ₂ e

4.2 Project Emissions

Project activity emissions for AMS III.H

$$PE_y = \left\{ \begin{array}{l} PE_{power,y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + \\ PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y} \end{array} \right\} \quad \text{Equation 4}$$

Where:

Parameter	Details
PE _y	Project activity emissions in the year y (tCO ₂ e)

$PE_{power,y}$	Emissions from electricity or fuel consumption in the year y (tCO ₂ e).
$PE_{ww,treatment,y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year y (tCO ₂ e).
$PE_{s,treatment,y}$	Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year y (tCO ₂ e).
$PE_{y,ww,discharge}$	Methane emissions from degradable organic carbon in treated wastewater in year y (tCO ₂ e).
$PE_{s,final,y}$	Methane emissions from anaerobic decay of the final sludge produced in year y (tCO ₂ e).
$PE_{fugitive,y}$	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

Project emissions			
Parameter	2010	2011	Unit
$PE_{power,y}$	169	679	tCO ₂ e
$PE_{ww,treatment,y}$	3,015	10,729	tCO ₂ e
$PE_{s,treatment,y}$	0	0	tCO ₂ e
$PE_{ww,discharge,y}$	0	0	tCO ₂ e
$PE_{s,final,y}$	0	0	tCO ₂ e
$PE_{fugitive,y}$	1,976	6,622	tCO ₂ e
$PE_{fugitive,s,y}$	0	0	tCO ₂ e
$PE_{fugitive,ww,y}$	1,976	6,622	tCO ₂ e
$PE_{flaring,y}$	0	0	tCO ₂ e
$PE_{biomass,y}$	0	0	tCO ₂ e
$PE_{y,ex\ post}$	5,160	18,031	tCO ₂ e
LE_y	0	0	tCO ₂ e

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 Summary of 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;

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

Equation 5

Where:

Parameter	Details
ER _{y, ex post}	Emission reductions achieved by the project activity based on monitored values for year y (tCO2e)
BE _{y, ex post}	Baseline emissions calculated as per Equation 1
PE _{y, ex post}	Project emissions calculated as per Equation 6
MD _y	Methane captured and destroyed/gainfully used by the project activity in the year y

As per paragraph 32 in AMS III.H., *in case of flaring/combustion MD_y will be measured using the conditions of the flaring process:*

$$MD_y = BG_{burnt,y} * w_{CH4,y} * D_{CH4} * FE * GWP_{CH4}$$

Equation 6

Where:

Parameter	Details
BG _{burnt, y}	Biogas flared/combusted in year y (m ³)
W _{CH4}	Methane content in the biogas in the year y (mass fraction)
D _{CH4}	Density of methane at the temperature and pressure of the biogas in the

	year y (tonnes/m ³)
FE	Flare efficiency in year y (fraction)

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”⁵. Based on this, the alternative MD_y value is deviated from the approved methodology and can be calculated as follows:

$$MD_y = W_{CH_4} * D_{CH_4} * GWP_{CH_4} * [(BG_{TOFlare,y} * FE) + (BG_{combusted,y} * DE)] \quad \text{Deviation 2}$$

Where:

Parameter	Details
BG _{TOFlare}	Biogas sent to flare in year y (Nm ³ /year)
FE	Flare efficiency (fraction)
BG _{combusted, y}	Biogas combusted for gainful use in year y (Nm ³ /year)
DE	Destruction efficiency of biogas combusted for a gainful use (fraction)

The clarification of this deviation is explained in section 2.2. With reference to the clarification made by the SSC WG, this approach can be considered as not impact negatively on the conservativeness of the applied methodology’s criteria and procedures to quantify data leading to GHG emission reductions or removals. The clarification from EB, as referenced above, can be used to substantiate this statement

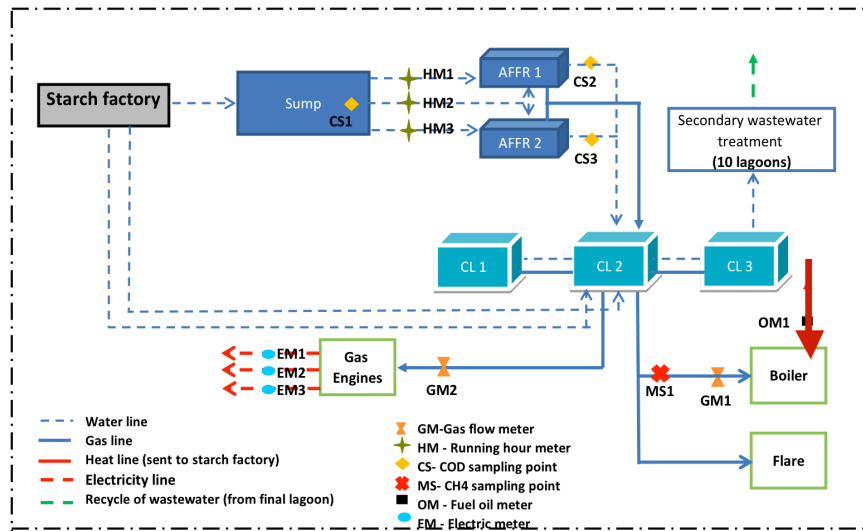
Table 3 : Emission reduction calculation

	Parameter	2010	2011	Unit
AMS III. H.	ER - approach 1 (COD)	10,968	36,119	tCO ₂ e
	ER - approach 1 (MD _y)	10,202	41,767	tCO ₂ e
	ER _{ww, y}	10,202	36,119	tCO ₂ e
AMS I. C.	ER _{heat, y}	2,303	5,612	tCO ₂ e
AMS I. D.	ER _{power, y}	861	2,035	tCO ₂ e
Total ER	57,130	13,365	43,765	tCO ₂ e

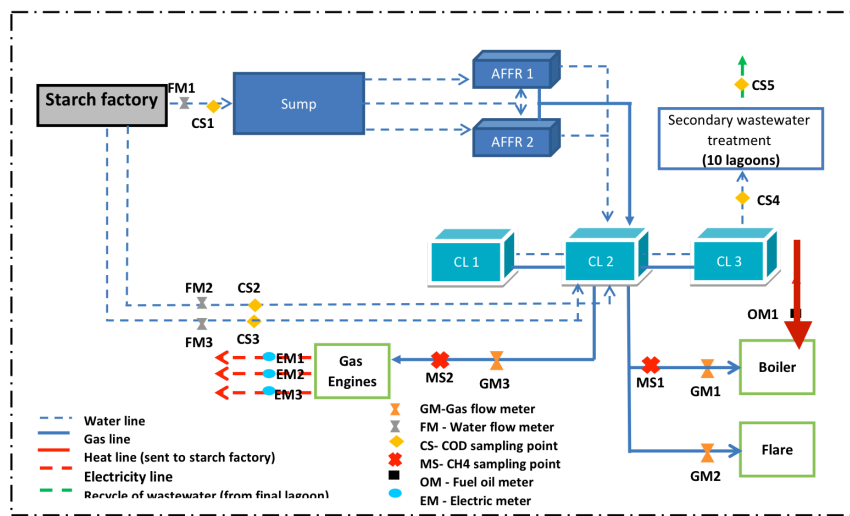
⁵ <http://cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKUHEF5LB07QICT1P>

Justification for the increasing of emission reductions in this monitoring period

In section 2.3 of registered PD , the project activity boundary for 1st verification period in figure 4 is used for emission reduction estimation or ex-ante calculation.



After the complete implementation of the project activity , the project boundary is switched to figure 5 in registered PD. Which is according to the present situation.



When comparing the above two diagrams, the amount of wastewater from starch factory to the 2nd covered lagoon is the extra part from ex-ante calculation.

Additionally, the ex-ante calculation considered only the biogas produced from the AFFR, by calculating from the COD removal efficiency of AFFR. Then the biogas production and COD

removal by three covered lagoons were not taken into account for ex-ante emission reduction calculation in the registered PD.

Hence , the figures of emission reduction in this monitoring period is applicable since it is in line with the monitoring plan determined in the registered PD.

5 ADDITIONAL INFORMATION

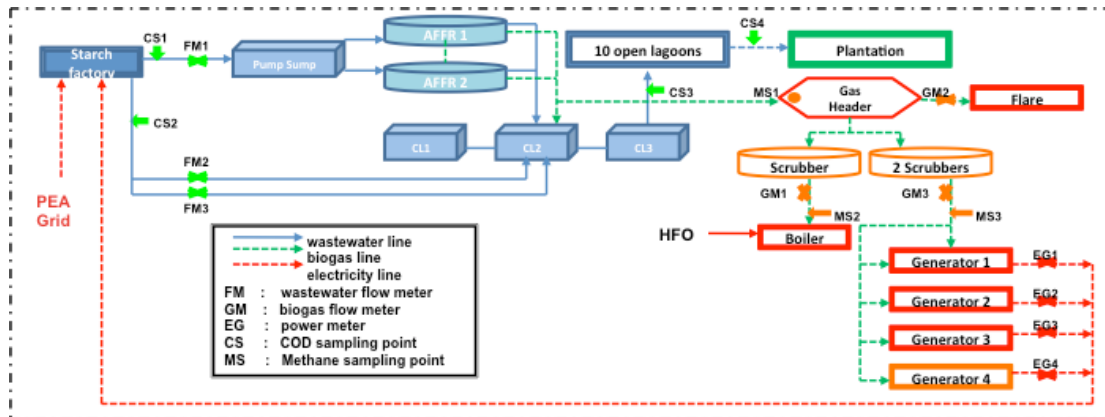


Figure 3 : Monitoring diagram

Table 4 : Monitored Data

Parameter	Unit	2010	2011
$Q_{ww, y}$	m ³	266,510	794,473
$COD_{ww, untreated, y}$	mg/L	24,497	24,297
$COD_{out, CL}$	mg/L	1,018	1,255
$COD_{out, lagoon, PJ}$	mg/L	595	717
$COD_{load, ww, untreated, y}$	Tonnes	5,590.49	18,768.31
$COD_{load, out, CL}$	Tonnes	307.59	1,059.71
$COD_{load, out, lagoon, PJ}$	Tonnes	138.27	457.20
$COD_{removed, i, y}$	Tonnes	4,864	16,328
$COD_{removed, PJ, AFR+CL, y}$	Tonnes	5,283	17,709
	Tonnes/m3	0.0198	0.0223
$COD_{y, removed, PJ, Lagoon, y}$	Tonnes	169	603
	Tonnes/m3	0.00064	0.00076
$MEP_{ww, treatment, y}$	tonnes	940.78	3,153.55
$BG_{combusted, y}$	Nm ³	1,419,613	5,491,749
$BG_{TOFlare, y}$	Nm ³	-	-
W_{CH4}	%	49.11%	51.86%
$W_{CH4} - adjusted$	%	48.59%	51.40%
$Q_{FO, y}$	Litres	0	14,341
$Q_{starch, y}$	Tonnes	21,814	53,572
EG_y	MWh	1,702	4,024
EC_y	MWh	335	1,342
Sludge removed	Tonnes	0	0

Table 5 : Information of monitoring equipment

Meter	Location	Brand	Model	S/N	Accuracy	Calibration Date		
						Bef. 2009	2010	2011
FM1	AFFR	Euromag	MUT 1000EL	YAL1623	0.2%	7-Sep-09	21-Oct-10	16-May-11
FM2	CL2	Euromag	MUT 1000EL	YAL1624	0.2%	7-Sep-09	21-Oct-10	15-May-11
FM3	CL2	Euromag	MUT 1000EL	YAL1625	0.2%	7-Sep-09	21-Oct-10	15-May-11
GM1	Boiler	Veris detector	Verabar	V9107-03.1	1.0%	10-Jun-09	12-Jan-10	23-May-11
GM2	Flare	Veris detector	Verabar	V10S08-01.1	1.0%	10-Jun-09	12-Jan-10	21-May-11
GM3	Gen set	FOX	FT2-09I	7565	1%	27-May-09	27-Oct-10	23-May-11
EM1	Gen1	Carlo Gavazzi	WM3-96	61580000N0050	1%		6-Nov-10	
EM2	Gen2	Huatong	PDM-803AC-M4	HT08051884	0.5%	3-Mar-06		
EM3	Gen3	Huatong	PDM-803AC-M5	HT09050004	0.5%	3-Mar-06		
MS	Portable	Messtechnik	VISIT 03	VI3-3005	2%	10-Sep-08	1-Sep-10	21-Dec-11
CS		HACH	DR/2400	50100006010	0.13%	4-Jun-09	14-May-10	12-May-11
OM	Boiler	Aquametro	Contoil VZ	92049 / 4624027 (new)	1%	10-Jul-09	4-Nov-10	16-May-11