

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



Document Prepared By South Pole Carbon Asset Management Ltd.

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Table of Contents

1	Project Details	3
1.1	Summary Description of Project	3
1.2	Sectoral Scope and Project Type	4
1.3	Project Proponent	4
1.4	Other Entities Involved in the Project	5
1.5	Project Start Date	5
1.6	Project Crediting Period	5
1.7	Project Location	6
1.8	Title and Reference of Methodology	7
2	Implementation Status	7
2.1	Implementation Status of the Project Activity	7
2.2	Deviations from the Monitoring Plan	8
2.3	Grouped Project	15
3	Data and Parameters	15
3.1	Data and Parameters Available at Validation	15
3.2	Data and Parameters Monitored	22
3.3	Description of the Monitoring Plan	30
4	Quantification of GHG Emission Reductions and Removals	31
4.1	Baseline Emissions	31
4.2	Project Emissions	34
4.3	Leakage	35
4.4	Summary of GHG Emission Reductions and Removals	35
5	Additional Information	38

1 PROJECT DETAILS

1.1 Summary Description of Project

Chol Charoen Group Wastewater Treatment with Biogas System I (Khonkaen), hereafter, 'the project activity', involves the installation and operation of a methane recovery and utilisation system (an open anaerobic effluent treatment system) at Kean Charoen (1) Co., Ltd., a tapioca starch factory in Khonkaen, Thailand. The system has been in operation since 2nd October 2006 (project start date). The starch factory has a mean daily production capacity of 175 tonnes of dried starch, generating 2,000 m³ of wastewater per operational day.

Table 1 : Summary of baseline and project conditions

Project/Baseline Component	Brief Description
Lagoon system	11 lagoons, commissioned along with the operation start date of starch plant in 1988. The approximate retention time of the open lagoon system is around 200 days
Covered lagoons	Two covered lagoons have been converted from existing open lagoons. Typically, the COD removal efficiency of this system is around 80%. The hydraulic retention time is approximately 90 days. The covered lagoon system started operation in October 2006 (first month of biogas usage).
Boiler	There are two dual-fired boilers with a thermal capacity of 4.070 MW _{th} and 3.78 MW _{th} respectively. The first boiler, which previously capacity of 3.488 MW _{th} , has been replaced by the new one with capacity 4.070 MW _{th} in year 2010. The reason for replacement is to increase the biogas utilization capacity of boiler. The new burner can operate with only biogas (100%) instead of oil-biogas mixed fuel. ¹
Gas engines	There are two electricity generation sets, with capacity of 952 kW _e ² each. The new generator sets (no.3 rd and 4 th) with capacity of 450 kW _e each are not included in this project boundary.
Flare	An open flare system is available at the plant. This is an automatic flare system that will operate when pressure is higher than 3 mbar. There is also a flame arrester to ensure the safe operation of the flare system.
Capacity of auxiliary drives	Total capacity of the auxiliary drives is 458 kW; the same can be referred in the GHG calculation sheet as well as in the document submitted during validation.

¹ The yearly report to Safety Technology Office of Department of Industrial Work for the old and new boilers are provided.

² The technical specification document is provided.

This monitoring report is for the 1st verification of this project. Further background information on this project activity can be found in the VCS website :

<https://vcsprojectdatabase1.apx.com/mymodule/ProjectDoc/EditProjectDoc.asp?id1=427>

1.2 Sectoral Scope and Project Type

The project activity involves recovery of biogas from wastewater that is released from a tapioca starch processing plant. The recovered biogas is used in a boiler to generate heat for the starch-drying process and to generate electricity in order to meet the power requirement of the starch processing plant; it may later be supplied to the national grid. After satisfying the above demands, surplus biogas is flared for safety purposes. The project has a total electrical generation capacity of less than 15 MWel, thermal generation capacity of less than 45 MWth, and will generate emission reductions of 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 follows:

Methane avoidance component:

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

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)

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)

1.3 Project Proponent

Role	Project owner (responsible for implementation and operation of the project activity)
Organization:	Kaen Charoen Co., Ltd.
Address:	1004/201 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
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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
Country:	Switzerland
E-Mail:	i.puhl@southpolecarbon.com
URL:	www.southpolecarbon.com
Represented	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 2nd October 2006. On this date the hot oil boiler became operational and the biogas began to be utilized.

1.6 Project Crediting Period

Crediting period start date: 15th July 2009. Due to insufficiency of monitoring equipment, the operational period from 15th July 2009, which is the starting date mentioned in registered PD, till 2nd December 2009 will be neglected from our claim of emission reduction.

The project activity is estimated to last 15 years³. After the initial crediting period of ten years, subsequent renewals of the crediting time may be considered depending on the status of the project activity and baseline revision at that time.

According to gas engine lifetime confirmations from individual technology providers, a lifetime of 15 years is assumed.

³ Average operation period of a cover lagoon wastewater treatment system in Thailand is 15 years, <http://teenet.chiangmai.ac.th/btc/introbiogas02.php>

The lifetime of each boiler can be assumed as 25 years for the default value, and the boiler nameplates show the boiler manufacturing years as 1999 and 2002. It can be assumed that the boilers shall function normally during the first crediting period.⁴

1.7 Project Location

The proposed project activity is located at Kean Charoen (1) Co., Ltd, in Kranuan district, Khonkaen province, situated in the northeast region of Thailand, approximately 450 km from Bangkok. The project activity location is depicted in Figure 1 and Figure 2.

Street address: 261 Moo 4, Huanakhum, Kranuan, Khonkaen, 40170, THAILAND

Geographical coordinates: 16° 48.498'N Latitude 103° 05.148'E Longitude



Figure 1: Location map

⁴ http://cdm.unfccc.int/EB/050/eb50_repan15.pdf - Tool to determine the remaining lifetime of equipment.



Figure 2: Project activity boundaries

1.8 Title and Reference of Methodology

VCS Program approved methodologies are used to monitor the emissions reductions. AMS III.H., “Methane Recovery in Wastewater Treatment” (version 13), is applied to the proposed project activity for the methane avoidance components. The AMS I.C. “Thermal energy production with or without electricity” (version 15) and AMS I.D. “Grid connected renewable electricity generation” (version 14) are applied for thermal energy and electricity components accordingly. These methodology choices have already been justified in section 2.2 of registered PD.

AMS. III.H., refers to:

“Tool to determine project emissions from flaring gases containing methane”, Annex 13 of EB28.

AMS.I.C., refers to:

- “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion” version 1.2.
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” version 1.0;

AMS.I.D., refers to:

“Tool to calculate the emission factor for an electricity system” version 1.1.

These methodologies and tools can be found on the UNFCCC's website at the following address:

<http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html>

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

After the commissioning of wastewater treatment process was finished in the mid of year 2009 , the project has been fully utilized, and the stability of the biogas system has been maintained. .

The monitoring program has been setup since the commissioning phase of the project activity. But because the monitored data from the initial phase was incomplete then it was decided to exclude from the monitoring period. The monitoring period has been started after the improvement of monitoring program at the end of year 2009.

- The reducing of the starch yield due to the smaller size of cassava root, as well as the higher water consumption per ton starch are the main reasons for the raising up of emission reduction achieved in this monitoring period.
- The average biogas production rate from two covered lagoons is 1,430 Nm³/h for this monitoring period. This figure is changed from 208 Nm³/h in registered PD because of same reason above.
- The new generators have been installed due to excess biogas production. These two generators are not included in the project boundary.
- The cover sheet of the covered lagoon no.2 leaked. This covered lagoon has been shutdown for repairing during May'2010 to June'2010.

2.2 Deviations from the Monitoring Plan

1) *Deviations from methodologies which 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) can 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 of VCS version 3 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 (39.6 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.

2) Deviations from monitoring plan indicated in the registered PD

Deviation 1

Explanation of the deviation

The methane content in biogas is monitored by inline gas analyser attached with generator set. This equipment can measure when the generators are in operation. In case of all generators stop, there is no monitored data although the boilers are in operation.

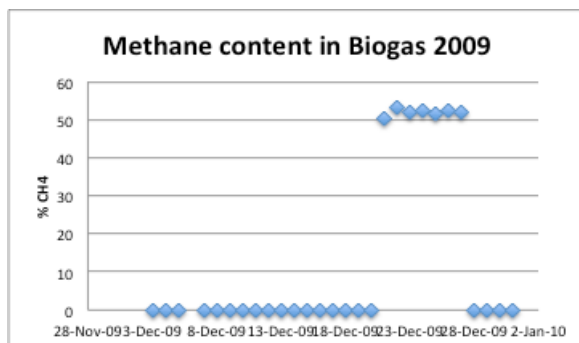
Compliance with the deviation

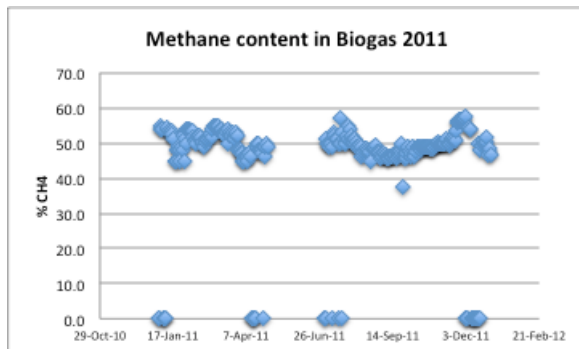
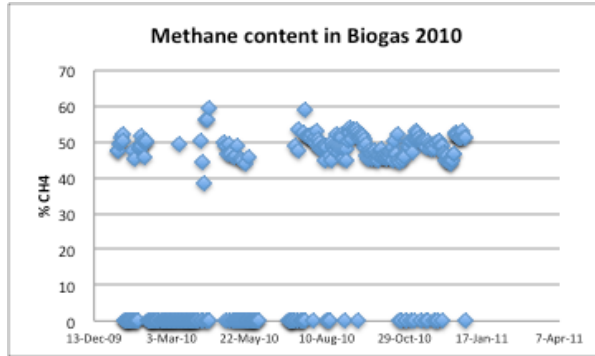
The deviated approach is adopted with referring to Annex 30 of EB 50, to be applied for this monitoring period.

It is indicated in the section 3.3 registered PD that *In the case of breakdown of the inline gas analyzer, periodic measurements will be done using portable gas analyzers at 95% confidence level.* Then this approach is justified, can be applied for this case.

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 acceptable 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 to estimate the 95% confidence interval for the W_{CH_4} values for year 2009 , 2010 and 2011. The lowest bound of the interval shall be used for the baseline emissions and highest bound is used for project emissions as a conservative approach.

Theory of used approach : In case there are infinite number 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- α)%. 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.⁵

⁵ 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>

Approach applied to the project activity:

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 $\bar{X} - \left(A * s/\sqrt{n} \right)$ and $\bar{X} + \left(A * s/\sqrt{n} \right)$. The value of A depends on degrees of freedom i.e. n-1. Higher the value of n, lower the value of A.

W_{CH_4}	2009	2010	2011
$\bar{X}$	51.99	48.87	49.95
s	0.90	2.95	2.96
n	7	188	274
A	2.365	1.969	1.969
X_{lower}	51.2	48.4	49.6
X_{upper}	52.8	49.3	50.3

The above values of lower and upper bound of intervals are used for W_{CH_4} in baseline and project emission reductions calculation respectively, for conservative estimation of Emission Reductions.

Deviation 2

Explanation of the deviation

The first hot oil boiler has been replaced by the new bigger one. The capacity of thermal energy output has been changed from 3.488 to 4.070 MW_{th}. As per description in FAR M3 of the validation report, if existing boiler is replaced with a new one during any verification no emission reduction shall be granted for heat displacement. Hence the heat displacement at this boiler is neglected from the emission reductions.

Compliance with the deviation

The deviated approach is adopted by considering only the thermal energy supplied from the 2nd hot oil boiler for the thermal energy displacement of AMS I.C.

This is the conservative approach as per VCS guidelines because the emission reductions achieved from AMS I.C is reduced.

Description of deviation

The thermal energy supplied and displacement at the hot oil boiler no.2 is calculated as per steps below. This information is included in the emission reduction calculation spread sheet.

1. Determine the fuel oil consumption of each boilers in litres

Fuel oil usage	2009	2010	2011
Boiler 1	26,400	275,199	68,360
Boiler 2	15,495	229,249	83,080
Total	41,895	504,448	151,440

2. Determine the biogas consumption of each boilers in Nm³

Biogas usage	2009	2010	2011
Boiler 1	182,290	1,223,151	1,431,884
Boiler 2	93,390	1,039,873	1,428,479

3. Calculate the thermal energy supplied from each boilers in GJ

Thermal energy (GJ)	2009	2010	2011
Boiler 1	4,865	36,544	32,688
Boiler 2	2,571	30,881	33,202
Total	7,436	67,425	65,890

4. Calculate the percentage of thermal energy supplied from each boilers

Percentage	2009	2010	2011
Boiler 1	65%	54%	50%
Boiler 2	35%	46%	50%

5. The BE_{thermal} calculation as per description in deviation 1.1 is changed for exclusion of boiler no.1. Then the equation for deviation 1.1 is revised to ,

$$BE_{thermal,CO2y} = (Q_{starch} * Q_{FO,starch} * \% B2 - q_{FO,y,Boiler2}) * D_{FO} * NCV_{FO} * EF_{CO2}/10^6$$

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,boiler2}	Quantity of fossil fuel consumed by hot oil boiler no.2 in year “y” (litres)
D _{FO}	Density of fossil fuel (kg/litre)
NCV _{FO}	Net Calorific value of the fuel oil (TJ/ton)
%B2	The percentage of thermal energy supplied from boiler no.2 from step

	4 above
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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, lagoon}
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, CL}
Data unit:	Fraction
Description:	Methane correction factor for project wastewater treatment system covered lagoon equipped with biogas recovery
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:	$MCF_{ww, treatment, PJ, lagoon}$
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-baseline
Data unit:	%
Description:	COD removal efficiency of baseline wastewater treatment system
Source of data:	Measured – Colorimetric analysis
Value applied:	87.16%
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

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

Data Unit / Parameter:	EF _{CO2}
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:	-
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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:	

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:	Historical data
Value applied:	39.6
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}
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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:	50%
Purpose of the data:	Project emission calculation
Any comment:	Default value for open flare 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:	-

Data Unit / Parameter:	P _{el}
Data unit:	kW
Description:	Total electrical capacity of the equipments installed

	in the project activity																																																																																																																								
Source of data:	List of electrical consumption from name plates of installed motors <table><tr><th>Tag</th><th>Description</th><th>Motor (HP)</th></tr><tr><td>ST1</td><td>Stirrer - NaoH Tank</td><td>3</td></tr><tr><td>ST2</td><td>Stirrer - Mixing tank</td><td>3</td></tr><tr><td>ST3</td><td>Stirrer - Pump sump</td><td>20</td></tr><tr><td>Bi1</td><td>WW Feed pump</td><td>40</td></tr><tr><td>Bi2</td><td>WW Feed pump</td><td>40</td></tr><tr><td>Bi3</td><td>WW recycle pump</td><td>25</td></tr><tr><td>Bi4</td><td>Sludge recycle pump 1</td><td>15</td></tr><tr><td>Bi5</td><td>Sludge recycle pump 2</td><td>15</td></tr><tr><td>Bi6</td><td>Reuse water pump</td><td>75</td></tr><tr><td>Bi7</td><td>Reuse water pump</td><td>40</td></tr><tr><td>Bi8</td><td>Reuse water pump</td><td>40</td></tr><tr><td>OG</td><td>Oxygen pumpfor Bio-scrubber</td><td>0.25</td></tr><tr><td>SP</td><td>Super pump for gas washer</td><td>1</td></tr><tr><td>FL</td><td>Flare</td><td>0.25</td></tr><tr><td>CH 1</td><td>Chiller No. 1</td><td>12.68</td></tr><tr><td>CH 2</td><td>Chiller No. 2</td><td>12.68</td></tr><tr><td>CH 3</td><td>Chiller No. 3</td><td>12.68</td></tr><tr><td>CH 4</td><td>Chiller No. 4</td><td>12.68</td></tr><tr><td>CH 5</td><td>Chiller No. 5</td><td>12.68</td></tr><tr><td>CLP1</td><td>Water pump - CT1</td><td>15</td></tr><tr><td>CLP2</td><td>Water pump - CT2</td><td>15</td></tr><tr><td>CLP3</td><td>Water pump - CT3</td><td>15</td></tr><tr><td>FBC1</td><td>Fan Blower of Cooling Tower 1</td><td>5</td></tr><tr><td>FBC2</td><td>Fan Blower of Cooling Tower 2</td><td>5</td></tr><tr><td>FB1</td><td>Fan Blower No. 1</td><td>0.5</td></tr><tr><td>FB2</td><td>Fan Blower No. 2</td><td>0.5</td></tr><tr><td>FB3</td><td>Fan Blower No. 3</td><td>1</td></tr><tr><td>FB4</td><td>Fan Blower No. 4</td><td>1</td></tr><tr><td>BA1</td><td>Blower air No. 1</td><td>5</td></tr><tr><td>BA2</td><td>Blower air No. 2</td><td>5</td></tr><tr><td>BL 1</td><td>Gas Blower No. 1</td><td>30</td></tr><tr><td>BL 2</td><td>Gas Blower No. 2</td><td>30</td></tr><tr><td>BL 3</td><td>Gas Blower No. 3</td><td>30</td></tr><tr><td>BL 4</td><td>Gas Blower No. 4</td><td>30</td></tr><tr><td>BL 5</td><td>Gas Blower No. 5</td><td>30</td></tr><tr><td>BP1</td><td>Spray pump</td><td>7.5</td></tr><tr><td>BP2</td><td>Spray pump</td><td>7.5</td></tr><tr><td colspan="2">Total - HP</td><td>614</td></tr><tr><td colspan="2">Total - kW</td><td>458</td></tr></table>	Tag	Description	Motor (HP)	ST1	Stirrer - NaoH Tank	3	ST2	Stirrer - Mixing tank	3	ST3	Stirrer - Pump sump	20	Bi1	WW Feed pump	40	Bi2	WW Feed pump	40	Bi3	WW recycle pump	25	Bi4	Sludge recycle pump 1	15	Bi5	Sludge recycle pump 2	15	Bi6	Reuse water pump	75	Bi7	Reuse water pump	40	Bi8	Reuse water pump	40	OG	Oxygen pumpfor Bio-scrubber	0.25	SP	Super pump for gas washer	1	FL	Flare	0.25	CH 1	Chiller No. 1	12.68	CH 2	Chiller No. 2	12.68	CH 3	Chiller No. 3	12.68	CH 4	Chiller No. 4	12.68	CH 5	Chiller No. 5	12.68	CLP1	Water pump - CT1	15	CLP2	Water pump - CT2	15	CLP3	Water pump - CT3	15	FBC1	Fan Blower of Cooling Tower 1	5	FBC2	Fan Blower of Cooling Tower 2	5	FB1	Fan Blower No. 1	0.5	FB2	Fan Blower No. 2	0.5	FB3	Fan Blower No. 3	1	FB4	Fan Blower No. 4	1	BA1	Blower air No. 1	5	BA2	Blower air No. 2	5	BL 1	Gas Blower No. 1	30	BL 2	Gas Blower No. 2	30	BL 3	Gas Blower No. 3	30	BL 4	Gas Blower No. 4	30	BL 5	Gas Blower No. 5	30	BP1	Spray pump	7.5	BP2	Spray pump	7.5	Total - HP		614	Total - kW		458
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Total - HP		614																																																																																																																							
Total - kW		458																																																																																																																							
Value applied:	458 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:	$Q_{y,ww}$						
Data unit:	m^3						
Description:	Volume of wastewater treated in the year y						
Source of data:	Volumetric flow meter : FM1						
Description of measurement methods and procedures to be applied:	The electromagnetic volumetric flow is installed at the plant.						
Frequency of monitoring/recording:	Continuous monitoring with daily recording						
Value monitored:	<table border="1"> <tr> <td>Dec'09</td><td>60,950</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>572,311</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>1,073,649</td></tr> </table>	Dec'09	60,950	Jan'10 – Dec'10	572,311	Jan'11 – Dec'11	1,073,649
Dec'09	60,950						
Jan'10 – Dec'10	572,311						
Jan'11 – Dec'11	1,073,649						
Monitoring equipment:	FM1 as per detail in Table 7						
QA/QC procedures to be applied:	The flow meter is calibrated at least every 3 years.						
Calculation method:	During the monitoring period of 03-Dec-09 to 14-Dec-10, the wastewater flow counted by FM1 was included with the recycle water, which is pumped from open lagoon no.2 for pH adjustment of raw wastewater. The total flow from FM1 was deducted by 2,004 m^3/d ($83.5^6 m^3/h * 24 hrs$) on the days that the pump is in operation. After the flow meter relocation , the readings from						

⁶ The capacity of pump is 83.5 m^3/h . The capacity test was done on 15'Nov'11 , the reference document will be provided.

	FM1 are only for raw wastewater from 15-Dec-10 onwards.
Any comment:	-

Data Unit / Parameter:	COD _{ww, untreated, y}						
Data unit:	mg/l						
Description:	COD of wastewater entering the covered lagoon reactor system						
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 tests are carried out in every operational day.						
Value monitored:	<table> <tr> <td>Dec'09</td><td>19,288</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>18,303</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>20,647</td></tr> </table>	Dec'09	19,288	Jan'10 – Dec'10	18,303	Jan'11 – Dec'11	20,647
Dec'09	19,288						
Jan'10 – Dec'10	18,303						
Jan'11 – Dec'11	20,647						
Monitoring equipment:	Spectrophotometer as per detail in Table 7						
QA/QC procedures to be applied:	The spectrophotometer is calibrated at least once every 3 years.						
Calculation method:	-						
Any comment:	-						

Data Unit / Parameter:	COD _{out, lagoon, PJ, y}						
Data unit:	tonnes/m ³						
Description:	COD of water coming out of the last lagoon						
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 tests are carried out in every operational day.						
Value monitored:	<table> <tr> <td>Dec'09</td><td>0.00145</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>0.00108</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>0.00129</td></tr> </table>	Dec'09	0.00145	Jan'10 – Dec'10	0.00108	Jan'11 – Dec'11	0.00129
Dec'09	0.00145						
Jan'10 – Dec'10	0.00108						
Jan'11 – Dec'11	0.00129						
Monitoring equipment:	Spectrophotometer as per detail in Table 7						

QA/QC procedures to be applied:	The spectrophotometer is calibrated at least once every 3 years.
Calculation method:	-
Any comment:	-

Data Unit / Parameter:	COD _{out,CL,y}						
Data unit:	tonnes/m ³						
Description:	COD of water coming out of the covered lagoon						
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 tests are carried out in every operational day.						
Value monitored:	<table border="1"> <tr> <td>Dec'09</td><td>0.017</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>0.017</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>0.019</td></tr> </table>	Dec'09	0.017	Jan'10 – Dec'10	0.017	Jan'11 – Dec'11	0.019
Dec'09	0.017						
Jan'10 – Dec'10	0.017						
Jan'11 – Dec'11	0.019						
Monitoring equipment:	Spectrophotometer as per detail in Table 7						
QA/QC procedures to be applied:	The spectrophotometer is calibrated at least once every 3 years.						
Calculation method:	-						
Any comment:	There are two measurements: - one after Cover lagoon 1 - one after Cover lagoon 2 The average of the two measurements is used.						

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 boilers, 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 daily recording		
Value monitored:	<table border="1"> <tr> <td>Dec'09</td><td>410,311</td></tr> </table>	Dec'09	410,311
Dec'09	410,311		

	Jan'10 – Dec'10	3,989,845
	Jan'11 – Dec'11	7,101,503
Monitoring equipment:	GM1 , GM3 and GM4 as per detail in Table 7	
QA/QC procedures to be applied:	The flow meters are calibrated at least once every 3 years.	
Calculation method:	The summation from GM1, GM3 and GM4 is calculated.	
Any comment:	-	

Data Unit / Parameter:	W _{CH4}														
Data unit:	%														
Description:	Methane content in biogas														
Source of data:	Measured – Gas analyzer system to monitor % of methane in biogas														
Description of measurement methods and procedures to be applied:	Inline gas analyzers attached with generators are installed for continuously monitoring.														
Frequency of monitoring/recording:	The methane content in biogas is continuously measured. The average value is calculated on daily basis.														
Value monitored:	<table><tr><td></td><td>Upper</td><td>Lower</td></tr><tr><td>Dec'09</td><td>52.8</td><td>51.2</td></tr><tr><td>Jan'10 – Dec'10</td><td>49.3</td><td>48.4</td></tr><tr><td>Jan'11 – Dec'11</td><td>50.3</td><td>49.6</td></tr></table>				Upper	Lower	Dec'09	52.8	51.2	Jan'10 – Dec'10	49.3	48.4	Jan'11 – Dec'11	50.3	49.6
	Upper	Lower													
Dec'09	52.8	51.2													
Jan'10 – Dec'10	49.3	48.4													
Jan'11 – Dec'11	50.3	49.6													
Monitoring equipment:	Inline gas analyzer as per detail in Table 7														
QA/QC procedures to be applied:	The gas analyzers are calibrated at least once every 3 years.														
Calculation method:	-														
Any comment:	• Since the quality of biogas sent to generator no.1 and 2 should be the equal, the daily average of methane content from the gas analyzer at 1st generator is used in ER calculation. • The monitored values are adjusted as per description in deviation 2.1.														

Data Unit / Parameter:	$BG_{TOFlare, y}$
Data unit:	Nm ³

Description:	Amount of biogas flared						
Source of data:	Measured using biogas flow meter : GM2						
Description of measurement methods and procedures to be applied:	The gas flow meter is installed at the plant.						
Frequency of monitoring/recording:	Continuous monitoring with daily recording						
Value monitored:	<table border="1"> <tr> <td>Dec'09</td><td>70,729</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>1,528,550</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>46,808</td></tr> </table>	Dec'09	70,729	Jan'10 – Dec'10	1,528,550	Jan'11 – Dec'11	46,808
Dec'09	70,729						
Jan'10 – Dec'10	1,528,550						
Jan'11 – Dec'11	46,808						
Monitoring equipment:	GM2 as per detail in Table 7						
QA/QC procedures to be applied:	The flow meter is calibrated at least once every 3 years.						
Calculation method:	-						
Any comment:	-						

Data Unit / Parameter:	$Q_{FO, y}$						
Data unit:	Litres						
Description:	Quantity of fossil fuel used in boiler in year y.						
Source of data:	Usage data (monitored from boiler panel). Value is used for conservative estimation of biogas / methane used in replacement of fossil fuel during year y.						
Description of measurement methods and procedures to be applied:	Fuel oil meters are incorporated to the hot oil boiler.						
Frequency of monitoring/recording:	Continuous monitoring with daily recording						
Value monitored:	<table border="1"> <tr> <td>Dec'09</td><td>15,495</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>229,248</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>83,080</td></tr> </table>	Dec'09	15,495	Jan'10 – Dec'10	229,248	Jan'11 – Dec'11	83,080
Dec'09	15,495						
Jan'10 – Dec'10	229,248						
Jan'11 – Dec'11	83,080						
Monitoring equipment:	Fuel oil flow meters as per detail in Table 7						
QA/QC procedures to be applied:	The liquid flow meters are calibrated at least once every 3 years.						
Calculation method:	-						
Any comment:	Since the boiler no.1 is the new replacement. Then this boiler is not taken into account of emission reduction claimed in this monitoring period , please refer to deviation 2.2.						

Data Unit / Parameter:	$Q_{\text{starch}, y}$						
Data unit:	Tonnes						
Description:	Quantity of dry starch produced						
Source of data:	Based on operational log sheet at the plant						
Description of measurement methods and procedures to be applied:	A proper record of all starch produced shall be maintained at the project site.						
Frequency of monitoring/recording:	Daily recording						
Value monitored:	<table border="1"> <tr> <td>Dec'09</td><td>4,330</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>51,043</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>62,419</td></tr> </table>	Dec'09	4,330	Jan'10 – Dec'10	51,043	Jan'11 – Dec'11	62,419
Dec'09	4,330						
Jan'10 – Dec'10	51,043						
Jan'11 – Dec'11	62,419						
Monitoring equipment:	-						
QA/QC procedures to be applied:	The production data is cross-checked with sales records, 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:	Measured – Electricity meters installed at the generation sets						
Description of measurement methods and procedures to be applied:	Measured electronically on a continuous basis						
Frequency of monitoring/recording:	Continuous monitoring with daily recording						
Value monitored:	<table border="1"> <tr> <td>Dec'09</td><td>201</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>3,281</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>5,369</td></tr> </table>	Dec'09	201	Jan'10 – Dec'10	3,281	Jan'11 – Dec'11	5,369
Dec'09	201						
Jan'10 – Dec'10	3,281						
Jan'11 – Dec'11	5,369						
Monitoring equipment:	Power meters, EM1 and EM2 as per detail in Table 7						
QA/QC procedures to be applied:	The power meters are calibrated at least once every 3 years.						

Calculation method:	-
Any comment:	- The meters were not calibrated since the installation in year 2008 , the accuracy of -0.5% is applied for conservativeness as per EB 52 Annex 60. - The electricity supplied from new generators (no.3 and 4) are not included in this calculation since they are the additional equipment installed after project implementation

Data Unit / Parameter:	EC _y						
Data unit:	MWh/y						
Description:	Electricity consumption by wastewater treatment plant in year y						
Source of data:	Maximum rated consumption is calculated by multiplying total electrical capacity with operational hour with 10% additional factor to be conservative.						
Description of measurement methods and procedures to be applied:	-						
Frequency of monitoring/recording:	-						
Value monitored:	<table border="1"> <tr> <td>Dec'09</td><td>339</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>4,413</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>4,413</td></tr> </table>	Dec'09	339	Jan'10 – Dec'10	4,413	Jan'11 – Dec'11	4,413
Dec'09	339						
Jan'10 – Dec'10	4,413						
Jan'11 – Dec'11	4,413						
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 the site are used.

Description of measurement methods and procedures to be applied:	Proper log records is maintained for sludge removal and disposal at the project site.
Frequency of monitoring/recording:	Recorded every time sludge is removed from the system
Value monitored:	0
Monitoring equipment:	-
QA/QC procedures to be applied:	Calibration of weighbridge is done on a once in three year basis.
Calculation method:	-
Any comment:	This parameter is included in the unlikely event that the sludge is removed from the covered lagoons.

Data Unit / Parameter:	$\eta_{\text{flare,h}}$
Data unit:	%
Description:	Flare efficiency
Source of data:	"Tool to determine project emissions from flaring gases containing methane"
Description of measurement methods and procedures to be applied:	The efficiency of the flaring process is defined as 50% based on the default factor for open flares.
Frequency of monitoring/recording:	-
Value monitored:	0
Monitoring equipment:	-
QA/QC procedures to be applied:	Maintenance of the flare system shall be conducted periodically as per supplier's specifications to ensure optimal operation.
Calculation method:	-
Any comment:	Since this parameter is not monitored as per monitoring plan in the registered PD then the efficiency of 0% is applied for conservativeness.

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:	Biogas flow meter , GM2 is used.
Description of measurement methods and procedures to be applied:	Log record shall be maintained on an hourly basis to ascertain net amount of biogas has gone to flare unit during a particular hour.

Frequency of monitoring/recording:	-						
Value monitored:	No monitored value in this unit. The same value of of BG_{TOFlare, y} in Nm³/d is used. <table border="1"> <tr> <td>Dec'09</td><td>70,729</td></tr> <tr> <td>Jan'10 – Dec'10</td><td>1,528,550</td></tr> <tr> <td>Jan'11 – Dec'11</td><td>46,808</td></tr> </table>	Dec'09	70,729	Jan'10 – Dec'10	1,528,550	Jan'11 – Dec'11	46,808
Dec'09	70,729						
Jan'10 – Dec'10	1,528,550						
Jan'11 – Dec'11	46,808						
Monitoring equipment:	GM2 , as per detail in table 7.						
QA/QC procedures to be applied:	The biogas flow meter is calibrated at least once every three years.						
Calculation method:	-						
Any comment:	-						

3.3 Description of the Monitoring Plan

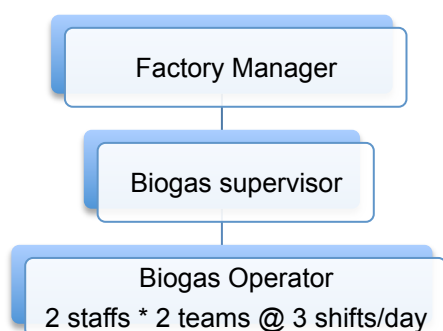
The monitoring plan is as described in section 3.4 of the registered PD. The daily operation data recording and laboratory analysis is carried out by plant operators. The reports will be checked and approved by the biogas plant supervisor. All equipment calibrations are controlled by the biogas plant supervisor.

The biogas plant supervisor will collect all information and submit it to a consultant for emission calculation.

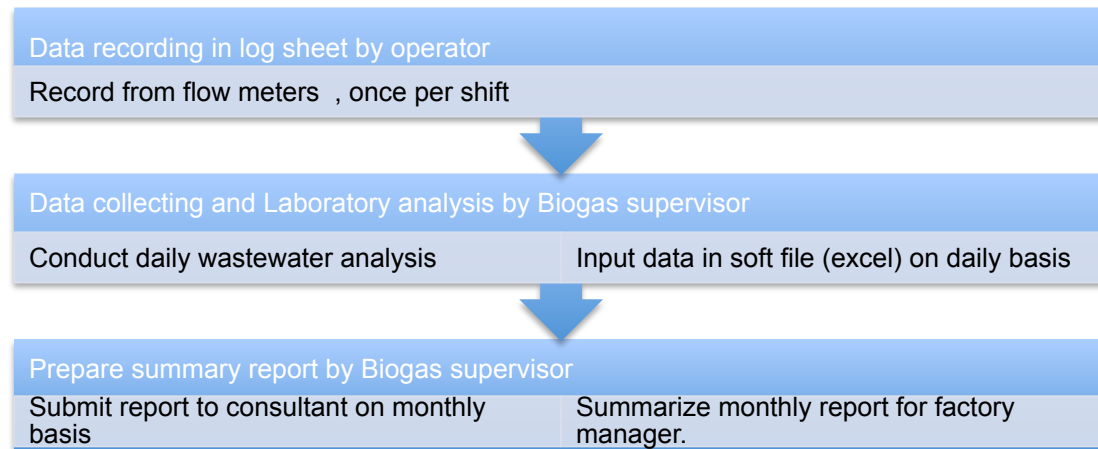
All monitoring data is available in an Excel spreadsheet. This spreadsheet consists of:

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 production office by biogas supervisor.
- The data in excel format is saved in computer at biogas control room and backup into computer at production office every month by biogas supervisor.
- 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 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)
$BE_{ww,}$	Baseline emissions of the wastewater treatment systems affected by

treatment, y	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).

In the baseline scenario, treated wastewater is not discharged into sea/lake/river, therefore methane emissions from degradable organic carbon in treated wastewater discharged (BE_{ww, discharge, y}) is taken as zero.

The generated sludge in the baseline scenario is close to null in which it is anyway used aerobically for soil application. There is no sludge treatment system. Therefore baseline methane emissions from sludge treatment and anaerobic decay of the final sludge (BE_{s, treatment, y} and BE_{s, final, y}) produced are neglected from baseline emissions.

Baseline Emissions for AMS ID

Baseline emissions from electricity generation (BE_{gen,y})

As per AMS I. D., paragraph 10, 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
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_{heat, 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 and 10 of the methodology.

$$BE_{\text{thermal,CO}_2,y} = (EG_{\text{thermal,y}} / \eta_{\text{BL,thermal}}) * EF_{\text{CO}_2} \quad \text{Equation 3}$$

Where:

Parameter	Details
EG_{thermal}	The net quantity of steam/heat supplied by the project activity during the year y (TJ)
$\eta_{\text{BL, thermal}}$	The efficiency of the plant using fossil fuel that would have been used in the absence of the project activity.
EF_{CO_2}	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.

Since the boiler no.1 has been replaced and the thermal capacity has been increased. The deviation 2.2 is established based on conservative approach for the emission reduction of heat component.

Table 2 : Summary of baseline emission calculation

AMS III. H.				
Parameter	2009	2010	2011	Unit
$BE_{\text{ww, treatment, y}}$	3,376	30,683	63,490	tCO ₂ e
$BE_{\text{power, y}}$	0	0	0	tCO ₂ e
$BE_{\text{s, treatment, y}}$	0	0	0	tCO ₂ e
$BE_{\text{ww, discharge, y}}$	0	0	0	tCO ₂ e
$BE_{\text{s, final, y}}$	0	0	0	tCO ₂ e
$BE_{\text{y, ex post}}$	3,376	30,683	63,490	tCO₂e

Parameter	2009	2010	2011	Unit
MD_y	3,157	29,063	52,959	tCO₂e

AMS I. C.				
Parameter	2009	2010	2011	Unit
$BE_{\text{thermal, CO}_2, y} = ER_{\text{heat, y}}$	137	2,156	3,548	tCO₂e

AMS I. D.				
Parameter	2009	2010	2011	Unit
$BE_{\text{gen, y}} = ER_{\text{power, y}}$	101	1,659	2,714	tCO₂e

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 3 : Summary of project emission calculation

Parameter	2009	2010	2011	Unit
PE _{power, y}	171	2,232	2,232	tCO ₂ e
PE _{ww, treatment, y}	331	2,309	5,197	tCO ₂ e
PE _{s, treatment, y}	0	0	0	tCO ₂ e
PE _{ww, discharge, y}	0	0	0	tCO ₂ e
PE _{s, final, y}	0	0	0	tCO ₂ e
PE _{fugitive, y}	396	3,669	7,487	tCO ₂ e
PE _{fugitive, s, y}	0	0	1	tCO ₂ e
PE _{fugitive, ww, y}	396	3,669	7,486	tCO ₂ e
PE _{flaring, y}	561	11,329	354	tCO ₂ e
PE _{biomass, y}	0	0	0	tCO ₂ e
PE _{y, ex post}	1,460	19,539	15,271	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.

Table 4 : Summary of leakage emissions

Leakage				
Parameter	2009	2010	2011	Unit
LE _y	0	0	0	tCO ₂ e

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
$ER_{y, \text{expost}}$	Emission reductions achieved by the project activity based on monitored values for year y (tCO ₂ e)
$BE_{y, \text{expost}}$	Baseline emissions calculated as per paragraph 4.1 <i>ex post</i> monitored values
$PE_{y, \text{expost}}$	Project emissions calculated as per paragraph 4.2 <i>ex post</i> monitored values
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:

$$MD_y = BG_{\text{burnt},y} * w_{CH_4,y} * D_{CH_4} * FE * GWP_{CH_4} \quad \text{Equation 6}$$

Where:

Parameter	Details
$BG_{\text{burnt},y}$	Biogas flared/combusted in year y (m ³)
W_{CH_4}	Methane content in the biogas in the year y (mass fraction)
D_{CH_4}	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)

Based on the description of deviation 1.2 , the alternative MD_y value is deviated from the approved methodology and can be calculated as follows:

$$MD_y = W_{CH_4} * D_{CH_4} * GWP_{CH_4} * [(BG_{TOFlare,y} * FE) + (BG_{\text{combusted},y} * DE)] \quad \text{Deviation 1.1}$$

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)

Table 5 : Summary of emission reductions calculation

	Parameter	2009	2010	2011	Unit
AMS III. H.	ER - approach 1 (COD)	1,915	11,144	48,219	tCO ₂ e
	ER - approach 1 (MD _y)	2,986	26,831	50,727	tCO ₂ e
	ER _{ww, y}	1,915	11,144	48,219	tCO ₂ e
AMS I. C.	ER _{heat, y}	137	2,156	3,548	tCO ₂ e
AMS I. D.	ER _{power, y}	101	1,659	2,714	tCO ₂ e
ER for the project activity		2,153	14,959	54,481	tCO ₂ e
Total ER for 1st verification		71,593 tCO ₂ e			

Justification for the significant increasing of emission reductions in 2011

In year 2011, the actual emission reductions from project activity are higher than ex-ante figure. As per information in section 2.1, the reducing in starch yield of raw cassava root from 28% in 2010 to 25% in 2011, has a direct effect on the changing of quantity and quality (COD) of the wastewater.

When comparing the actual monitored data with the ex-ante figures, most of figures are increased. The explanation is as below:

- Ton of starch production: The starch production capacity has not changed. The higher amount is from the higher utilization of starch factory.
- Wastewater volume: The water factor of 2011 is 17.2 m³/t starch which is higher than 11.4 assumed for ex-ante calculation. The figure of 17.2 is still lower than the average figure from starch factory in Thailand of 23 m³/t.⁷
- Biogas production volume: The actual COD removal efficiency for the covered lagoon system is 90% approximately. While the figure of 80% is applied in ex-ante calculation. This further explains the increased biogas production.

The above changes are out of the control of the project proponent. At the time of PD development and validation, conservative values were used and verified by the validating DOE. The quality of raw material has a direct impact on the starch output and resulting wastewater generation. This is dependent on the crop and is subject to seasonal variations. Therefore, the assumptions made at the time of validation were based on sound judgment and sources but may change during the course of operation of the project. It may happen that due to the variation in the raw material, the wastewater generation volume may change again in the future.

⁷ <http://www.kmutt.ac.th/rippc/best73e.htm>

5 ADDITIONAL INFORMATION

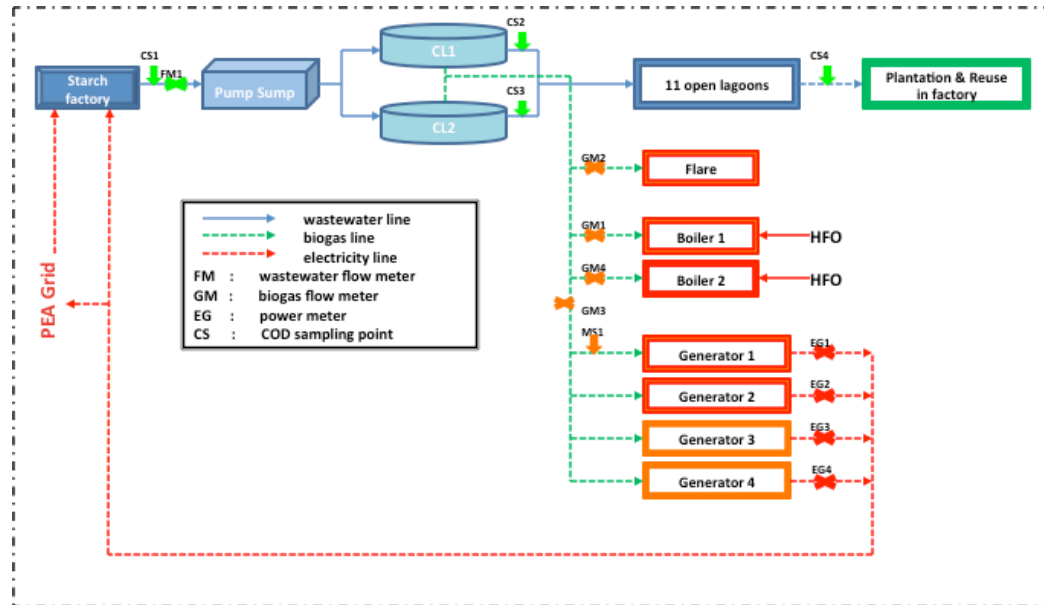


Figure 3 : Monitoring diagram

Table 6 : Summary of monitored data

Parameter	Unit	2009	2010	2011
Q _{ww, y}	m ³	60,950	572,311	1,073,649
COD _{ww, untreated, y}	mg/L	19,288	18,303	20,647
COD _{out, CL, y}	mg/L	1,803	1,417	1,791
COD _{out, lagoon, PJ, y}	mg/L	332	335	515
COD _{load, ww, untreated, y}	Tonnes	1,168.02	10,615.35	21,965.11
COD _{load, out, CL, y}	Tonnes	108.52	804.95	1946.17
COD _{load, out, lagoon, y}	Tonnes	19.89	187.60	556.39
COD _{removed, i, y}	tonnes/m ³	0.017	0.016	0.018
COD _{out, CL, y}	tonne/m ³	0.017	0.017	0.019
COD _{out, lagoon, PJ, y}	tonne/m ³	0.00145	0.00108	0.00129
MEP _{ww, treatment, y}	tonnes	189	1,747	3,565
BG _{combusted, y}	m ³	410,311	3,989,845	7,101,503
BG _{TOFlare, y}	m ³	70,729	1,528,550	46,808
W _{CH4}	%	52.0%	49.1%	50.4%
W _{CH4 - lower}	%	51.2%	48.4%	49.6%
W _{CH4 - upper}	%	52.8%	49.3%	50.3%
q _{FO, y}	Litres	15,495	229,249	83,080
Q _{starch, y}	Tonnes	4,330	51,043	62,419
EG _y	MWh	201	3,281	5,369
EC _y	MWh	339	4,413	4,413
Sludge removed	Tonnes	0	0	0

Table 7 : Information of monitoring equipment

Tag	Brand	Model	S/N	Accuracy	Calibration Date		
					Bef. 2010	2010	2011
FM1	Euromag	MUT 1000EL	ZAP0573	0.20%	20-May-09	8-Apr-10	29-Nov-11
GM1	Siemens	7MF4433-1BA22-1AC96-Z	N1-TD02-9544958	0.075%	25-Sep-09	25-Jun-10	30-Nov-11
GM2	FOX	FT2-12I	7568	1%R + 0.2%FS	28-May-09		29-Nov-11
GM3	FOX	FT2-06I	7569	1%R + 0.2%FS	28-May-09		29-Nov-11
GM4	Siemens	7MF4433-1BA22-1AC96-Z	N1-T905-9663007	0.075%	25-Sep-09	25-Jun-10	
MS	JE	JE CH4	27391	1%	15-Dec-09		14-Mar-11
EM1	CARLO GAVAZZI	WM3-06	62560 1 00N0030	0.50%	Not calibrated		
EM2	CARLO GAVAZZI	WM3-06	62560 1 00N0034	0.50%	Not calibrated		
CS	Hanna	HI 83214	HI19945I	10 mg/l (HR) 1 mg/l (LR)	18-Mar-08	14-Jul-10	
OM1	CONTOIL	VZO 20 FL130/25	4546871	1%			29-Nov-11
OM2	CONTOIL	VZO 20 FL130/25	4126168	1%			29-Nov-11