WASTEWATER TREATMENT WITH BIOGAS SYSTEM IN PALM OIL MILL AT SAWI , CHUMPORN , THAILAND

south pole Carbon Asset Management Ltd.

Document Prepared By South Pole Carbon Asset Management Ltd.

Project Title	**Wastewater Treatment with Biogas System in Palm Oil Mill at Sawi, Chumporn, Thailand**
Version	03.1
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Monitoring Period	1st January 2009 to 31st May 2012
Prepared By	Nattaya Lonawan
Contact	South Pole Carbon Asset Management (Thailand) 2/22 Iyara Tower , 6th Floor Soi 2 , Chan Road , Thungwatdorn , Sathorn Bangkok 10120 , Thailand T +66 2 678 8977 , 9 E n.lonawan@southpolecarbon.com W http://www.southpolecarbon.com

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1 PROJECT DETAILS

1.1 Summary Description of Project

The project activity was implemented by The Natural Palm Group Co.,Ltd. , the new company of Natural Palm Oil (Chumporn) Co., Ltd. (NPO) , which was founded in 2002 and has been operating a palm oil factory since then. It has a capacity of 45-60 tons of fresh fruit bunches (FFB) per hour or 200 tons of palm oil per day. Prior to implementation of the project activity, the wastewater from the plant was treated through a system of 8 cascading lagoons. The average volume of wastewater is about 450 m^3/day which gives a retention time of approximately 289 days.

The project activity entails the installation of an anaerobic wastewater treatment facility, based on Complete Stirred Tank Reactor (CSTR) biogas reactor technology and anaerobic covered lagoon which is a newly built lagoon, at the existing crude palm mill that used to discharge to the open anaerobic lagoons before discharge to existing system.

- The mill first installed a 4800 m^3 capacity CSTR digester in 2005 together with a 1.064 MW gas engine and started to operate and exported electricity to the national grid in 2006.
- Later in 2007, the second gas engine 1.416 MW was installed in order to support the production of electricity to the grid.
- In 2008, 1800 m^3 capacity CSTR was installed together with one covered lagoon receiving treated wastewater from both CSTRs in order to treat more efficiently.
- At the end of 2008, some biogas is sent to replace heavy fuel oil in existing dual fuel fired boiler. The methane produced from CSTRs and the covered lagoon is delivered to both gas engines which generate electricity to be supplied to factory and exported to national grid. Any surplus biogas is sent to boiler or flare, which is an open flare.

Further background information on this project activity can be found in the VCS website :
https://vcsprojectdatabase2.apx.com/myModule/Interactive.asp?Tab=Projects&a=2&i=426&lat=10%2E2927&lon=99%2E0908&bp=1

1.2 Sectoral Scope and Project Type

The project activity involves recovery of fugitive biogas from the wastewater released from the palm oil mill factory using Complete Stirred Tank Reactor (CSTR) system together with anaerobic covered lagoon and utilizing the biogas to generate electricity.
The project has a total electrical generation capacity of 2.48 MW i.e. less than 15 MWel and emission reduction for methane avoidance part are less than 60 ktCO_2e per year. The type/category of the project activity 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

Electrical energy generation component:

Type I:	Renewable energy projects
Category: I.D:	Grid connected renewable electricity generation
Sectoral Scope 1:	Renewable Energy
Version:	14

1.3 Project Proponent

Role	Project owner (Responsible for implementation and operation of the project activity)
Organization:	The Natural Palm Group Co., Ltd.[1]
Address:	250 M.12 Petchkasem Road , Khron , Sawi
City:	Chumporn
Country:	Thailand
E-Mail:	kowit@naturalpalm.com
URL:	www.naturalplam.com
Telephone :	+ 66 77 557 170
Represented by:	Kowit Khuansongtham
Title:	Mr.
Salutation:	Director

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 by:	Ingo Puhl
Title:	Mr.
Salutation:	Managing Partner.
Mobile:	+ 66 86 778 2869
Direct tel:	+ 66 2 678 8979

[1] The project owner changed its company name from *Natural Palm Oil (Chumporn) Co.,Ltd.* to *The Natural Palm Group Co.Ltd.*. This new company is a combination of Natural Refinery Co.,Ltd. , Natural Palm Oil (Chumporn) Co.,Ltd. and Natural Electric (Chumporn) Co.,Ltd.. This new company was registered on 30th December 2009.

1.4 Other Entities Involved in the Project

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1.5 Project Start Date

Project start date: 15th May 2006, the date of first usage of biogas in gas engine to generate power i.e. destruction of captured biogas starts.

1.6 Project Crediting Period

Crediting period of this project is ten years , starts from 1st June 2006 to 31st May 2016.

The duration of the project activity is estimated to last 15 years[2]. After the initial crediting period of ten years, subsequent renewals of the crediting time might be considered according to the status of the project activity and baseline revision at that time

1.7 Project Location

The project site is located on the site of the Natural Palm Oil (Chumporn) factory, located at address: 250 M. 12 Petchkasem Rd, Khron, Sawi, Chumporn, about 530 km south of Bangkok.

The project coordinates are Lat 10°17"34'N and Long 99°5"27'E.

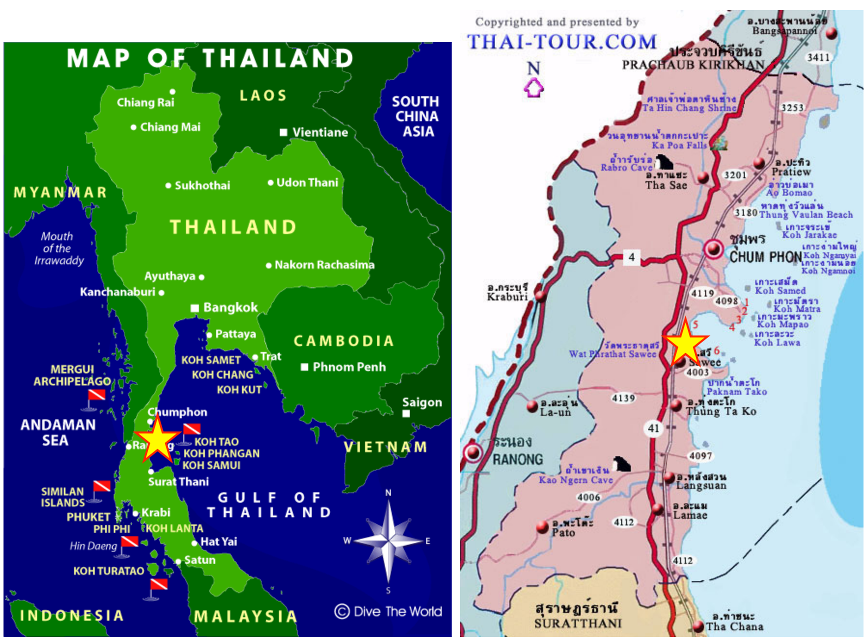

Figure 1 : Project Location

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[2] http://www.setatwork.eu/downloads/gp10%20Thailand_Chumporn.pdf

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 Project
Category I D:	Grid connected renewable electricity generation
Sectoral Scope 1:	Energy industries (renewable /non-renewable sources)
Version:	14

AMS-III.H refers to:

- “Tool to determine project emissions from flaring gases containing methane”, Annex 13, EB 28

AMS.I.D refers to:

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

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

This is the 1st monitoring period of this project activity. The monitoring period is from 1st January 2009 to 31st May 2012 , both days are included.

The emission reductions occurred before 1st January 2009 is not claimed due to the incompleteness of monitoring system.

The changings of project acivity in this monitoring period are listed below.

- The new open lagoon no.9 is the additional unit from baseline. However , there is no effect for emission reduction.
- The Equalization pond no.2 will be replaced by the new CSTR no.3. Now it is in construction process. The new CSTR will start the operation in the next monitoring period.

2.2 Deviations from the Monitoring Plan

Deviation 1

Approach in PDD

The methane content in biogas , W_{CH4} is continuously monitored using inline gas analyzer. In the case non-availability of the monitoring data (e.g. breakdown of equipment), lowest reported value of the third party reports will be used for estimation of baseline emissions.

Deviated approach

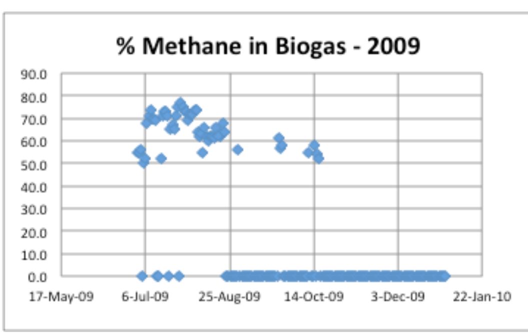
Althought the inline gas analyzer has been installed but the performance of this analyzer is not stable. The readings are not consistent and accurate. The readings from the portable gas analyser are more reliable. Hence , the source of methane data is from following sources.

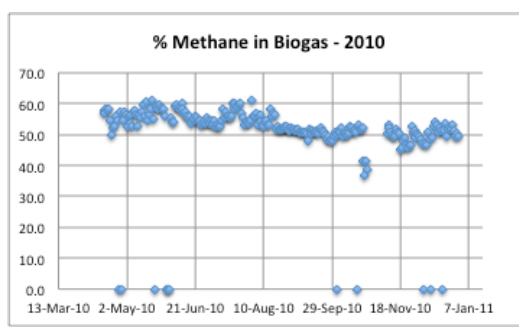
- Before 19-Aug-2010 ; the methane data was measured at the biogas supply line to generator by Gastec detector with RAE gas pump , measured once a day.
- 19-Aug-2010 onwards ; the methane data has been measured at the biogas supply line to generator by portable gas analyser , every 2 hours or 12 times per day.

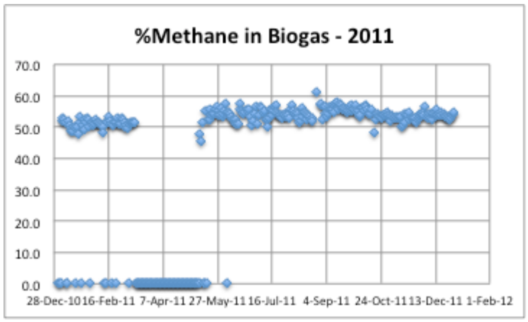
The deviated approach is adopted for this monitoring period in accordance with methodology for application of 95% confidential level and in line with conservativeness principle. This approach results in lower methane content which also affects the lowers baseline emission and achieved emission reduction.

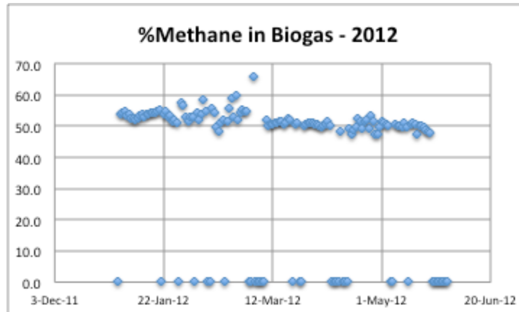
Justification for deviation

The measured values of W_{CH4} parameter when plotted against time of year shows no clear change or dependency of W_{CH4} on time of year. It should be reasonable to assume that W_{CH4} readings represent a normal distribution over a year, which means that for most days, the value of W_{CH4} is close to the mean, while for fewer days, the W_{CH4}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_{CH4} . 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.

Since the number readings in year 2009 is less than 50% of total operating days. As well as the average methane value of this year is above 60% which is the highest figure compared with other years. For conservativeness , for the application of 95% confidential level ,the minimum value is choosen for baseline emission calculation. The average value is selected for project emission calculation.

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-α)%. So in this case we select α =0.05 (for both sides of the curve contributing 0.025 on each end of the curve is curtailed), the interval is defined as [$\bar{X} - \left(A \bullet s/\sqrt{n}\right)$, $\bar{X} + \left(A \bullet s/\sqrt{n}\right)$]. Here A is dependent on the number of sample readings available. The value is available in standard tables on many sources.

More specifically, probability ($\bar{X} - \left(A \bullet s/\sqrt{n}\right) \le \mu \le \bar{X} + \left(A \bullet s/\sqrt{n}\right)$) = 0.95

So the lower limit of established intervals is used for baseline emissions and upper limit is used for project emissions. [3]

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

[3] 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

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

The 95% confidence interval is represented as $\bar{X} - \left(A \bullet s/\sqrt{n}\right)$ and $\bar{X} + \left(A \bullet s/\sqrt{n}\right)$. The value of A depends on degrees of freedom i.e. n-1. Higher the value of n, lower the value of A.

Parameter	2009	2010	2011	2012
$\bar{X}$	50.0 (BE) 64.6 (PE)	53.1	53.6	52.1
s	7.32	3.863	2.136	1.984
n	58	236	274	117
A	2.000	1.972	1.969	1.960
x – lower	48.04	52.60	53.37	51.69
x - upper	66.57	53.39	53.87	52.41

The above values of lower intervals are used for W_{CH4} in the basine emission calculation and the upper intervals are for project emission calculation , for conservative estimation of emission reductions.

Deviation 2

Approach in PDD

The amount of biogas combusted for gainful use , $BG_{combusted,y}$ is continuous monitored using gas flow meter in Nm^3 unit.

Deviated approach

The biogas flow meter installed at genertaor no.1 (GM2) is turbine type , without the temperature and pressure compensation. The flow is presented in m^3 unit. Hence , the unit conversion using a conservative factor for adjusting the temperature to normal conditions and project conditions is applied.

Justification for deviation

As per the gas equation: P_1 X V_1 / T_1 = P_2 X 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 as shown below.

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

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

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

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

$$V_2\ (Nm^3) = \ (1 + x) * V_1\ (m^3) * \ 273/(273 + 29)$$ **Deviation 2**

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

The approach assumes that no pressure measurement is done in the supply pipe and thereby pressure difference is assumed to be zero, estimating the volume in Nm^3 to be on a lower side. Temperature for ambient conditions around the year is available and same 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 of VCS 2007.3.

Deviation 3

Approach in PDD

The monitoring description for $BG_{TOFlare,y}$ is described below ,

- Monitoring: Gas flow meter at the flare system.
- Data type: Records in both hard and soft files.
- Frequency: Continuous measurements.
- Recording: Daily records.
- Archiving policy: The data shall be stored electronically and available up to two years after the end of the crediting period.
- Responsibility: The results will be logged by the operator in the plant operation report. The plant manager is responsible for data check and transfer of soft files to carbon consultant.
- Calibration frequency: Generally once every three years. Accuracy: Meters with accuracy level of +/- 1 % of the reading are installed.

Deviated approach

The biogas flow meter has been installed on 23-Feb-2010. But this meter was removed on 11-Jun-11 . During the meter was in place , the inspection and totalized recording was carried out on weekly basis because the flare is not supposed to operate.

For the ex-ante estimation in the registered PD , the amount of biogas generation is 259,200 Nm^3/y or 864 Nm^3/d (at 300 operating days) or 36 Nm^3/h. While the biogas consumption is 532 , 563 and 235.84 Nm^3/h for two generators and boiler accordingly or 1,330,84 Nm^3/h in total . The biogas production rate is less than the consumption rate. This is the safety factor for preventing the biogas loss to flare when maintenance or shutdown of biogas using machines.

From the monitored data , the boiler can use biogas only 91 days maximum in year 2011. It shows that this boiler mainly use the fuel oil because the biogas production is not sufficient.

It can be concluded that the chance that there is the excess biogas sent to flare is very low. Additionally , the biogas operating team has the instruction for managing the biogas production to optimize between biogas demand and supply. In order to serve the over-demand and shortage supply, two biogas storage balloons are installed to ensure that no biogas loss when producing rate is higher than consuming rate and smooth running of generators and boiler.

Thus , the flare should not operate. The installed flow meter always shows zero reading since no biogas sent to flare.

However , since the biogas flow meter for flare is not monitored properly before 23-Feb10 and after 11-Jun-11. The un-balance between the amount of biogas production and consumption is considered as flare volume. The amount of biogas produced from CSTRs and covered lagoon is continouously monitored by biogas flow meters , GM1 and GM5. The project emission calculation is based on 0% of flare efficiency. This approach increases the project emission from flare. The reduction of the final emission reductions is according to conservative principle.

Justification for deviation

In the ER calculation sheet , the daily biogas production volume from CSTRs and CL is added. The calculation to find the difference between the total biogas production and $BG_{combusted,y}$ is done. The total difference is used in the emission calculation as $BG_{TOFlare,y}$.

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.

Value applied:	0.21
Purpose of the data:	Baseline emission calculation
Any comment:	

Data Unit / Parameter:	$MCF_{ww, treatment,BL,lagoon}$
Data unit:	Fraction
Description:	Methane correction factor for the existing anaerobic wastewater treatment systems
Source of data:	Table III.H.1. of AMS III.H. v.13
Value applied:	0.8
Purpose of the data:	Baseline emission calculation
Any comment:	The original source of data can be checked for IPCC default value, as per Volume 5 Chapter 6, page 6.21. 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 equipped with biogas recovery
Source of data:	Table III.H.1. of AMS III.H. v.13
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:	$MCF_{ww, treatment, PJ,CSTR}$
Data unit:	Fraction
Description:	Methane correction factor for project wastewater treatment system k

Source of data:	Table III.H.1. of AMS III.H. v.13
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 not equipped with biogas recovery
Source of data:	Table III.H.1. of AMS III.H. v.13
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:	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:	CFE_{ww}
Data unit:	Fraction
Description:	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems.

Source of data:	Equation 12 in AMS III.H v.13
Value applied:	0.9
Purpose of the data:	Project emission calculation
Any comment:	

Data Unit / Parameter:	COD removal efficiency - baseline
Data unit:	%
Description:	Chemical oxygen demand removal efficiency of baseline treatment system
Source of data:	Measured – Historical data based on colorimetric analysis
Value applied:	87.5%
Purpose of the data:	Baseline 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:	Official data (from Ministry of Energy, Thailand)
Value applied:	0.5057
Purpose of the data:	Baseline emission calculation
Any comment:	Conservative choice and publically available data during validation.

Data Unit / Parameter:	UF_{BL}
Data unit:	Factor
Description:	Model correction factor to account for model uncertainties
Source of data:	AMS III.H. v.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. v.13
Value applied:	1.06
Purpose of the data:	Project 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:	Baseline emission calculation
Any comment:	

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:	Baseline 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:	Plant data
Value applied:	181.3
Purpose of the data:	Project emission calculation
Any comment:	

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 - Volumetric flow meters
Description of measurement methods and procedures to be applied:	The volumetric flow meters are installed at the inlet of CSTR1 and CSTR2.
Frequency of monitoring/recording:	Continuous monitoring with recording on daily basis.
Value monitored:	see table below
Monitoring equipment:	FM1 and FM2 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:	-

Period	Value
Jan'09 – Dec'09	150,513
Jan'10 - Dec'10	166,126
Jan'11 – Dec'11	153,364
Jan'12 – May'12	49,952

Data Unit / Parameter:	$COD_{ww, untreated, y}$
Data unit:	mg/l

Description:	COD of wastewater entering the wastewater treatment system
Source of data:	Measured – Colorimetric analysis
Description of measurement methods and procedures to be applied:	Colorimetric method in the on-site laboratory of the treatment plant. The COD sampling point is in the sump just before CSTR1 and CSTR2, because the CSTR operate in parallel.
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>Jan’09 – Dec’09</td><td>66,395</td></tr><tr><td>Jan’10 - Dec’10</td><td>68,721</td></tr><tr><td>Jan’11 – Dec’11</td><td>79,545</td></tr><tr><td>Jan’12 – May’12</td><td>80,411</td></tr></table>
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. In addition, to ensure accuracy in laboratory measurements , the wastewater sample istested by external laboratory at least once a year.
Calculation method:	-
Any comment:	• Calculations are based on weighted daily measurements of COD and wastewater for a transparent estimate of VERs. The COD sampling point is in the sump just before CSTR1 and CSTR2, because the CSTR operate in parallel. • In case of high VFA in the effluent of CSTR which is the signal of overloading or system failure , the raw wastewater will be mixed with soft water before entering CSTR. This operation will dilute the COD concentration in CSTR in order to recover the bacteria in CSTR. The $COD_{ww,untreated,y}$ will be lower than normal range on that day. • During peak season , huge amount of fresh pla fruits are supplied to the milling factory. Since the production capacity of the factory is limited , the storage time of fruit plam before milling is longer than normal. The free fatty acid content in fresh fruit palm will destroy the plam fruit , so called “rotten palm fruit”. When this rotten plam

	fruit entering the milling process , it will generate very high COD in wastewater discharged from factory.

Data Unit / Parameter:	$COD_{y,out,CSTR,y} = COD_{in,CL,y}$
Data unit:	mg/l
Description:	COD of wastewater exiting the CSTR system or COD entering the covered lagoon process
Source of data:	Measured – Colorimetric analysis
Description of measurement methods and procedures to be applied:	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:	see table below
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. In addition, to ensure accuracy in laboratory measurements , the wastewater sample istested by external laboratory at least once a year.
Calculation method:	-
Any comment:	Calculations are based on weighted daily measurements of COD and wastewater for a transparent estimate of VERs.

Period	Value
Jan'09 – Dec'09	7,755
Jan'10 - Dec'10	5,013
Jan'11 – Dec'11	5,326
Jan'12 – May'12	5,705

Data Unit / Parameter:	$COD_{y,out,CL}$
Data unit:	mg/l
Description:	COD of wastewater exiting the covered lagoon treatment process
Source of data:	Measured – Colorimetric analysis
Description of measurement methods and procedures to be applied:	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>Jan'09 – Dec'09</td><td>6,183</td></tr><tr><td>Jan'10 - Dec'10</td><td>3,552</td></tr><tr><td>Jan'11 – Dec'11</td><td>3,049</td></tr><tr><td>Jan'12 – May'12</td><td>3,289</td></tr></table>
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. In addition, to ensure accuracy in laboratory measurements , the wastewater sample istested by external laboratory at least once a year.
Calculation method:	-
Any comment:	Calculations are based on weighted daily measurements of COD and wastewater for a transparent estimate of VERs.

Data Unit / Parameter:	W_{CH4}
Data unit:	%
Description:	Methane content in biogas in the year y
Source of data:	Measured with application of 95% confidencial level as per deviation 1.
Description of measurement methods and procedures to be applied:	The fraction of methane in the biogas is measured by gas analyzer at the biogas supply line to generator.
Frequency of monitoring/recording:	As per explanation of deviation 1
Value monitored:	<table><tr><th>Period</th><th>Value</th></tr><tr><td>Jan'09 – Dec'09</td><td>Low - 48.04% , Up - 66.57%</td></tr><tr><td>Jan'10 - Dec'10</td><td>Low - 52.60% , Up – 53.59%</td></tr><tr><td>Jan'11 – Dec'11</td><td>Low - 53.37% , Up – 53.87%</td></tr><tr><td>Jan'12 – May'12</td><td>Low - 51.69% , Up – 52.41%</td></tr></table>
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:	More information is provided in deviation 1.

Data Unit / Parameter:	$BG_{combusted, y}$
Data unit:	Nm^3
Description:	Amount of biogas combusted for gainful use in the year y
Source of data:	Measured – continuously using gas flow meter
Description of measurement methods and procedures to be applied:	Gas flow meters are installed at boiler and generation sets.
Frequency of monitoring/recording:	Continuous monitoring with recording on daily basis.
Value monitored:	(see table below)
Monitoring equipment:	GM2 , GM3 and GM4 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:	The unit conversion is required for GM2 as per deviation 2.
Any comment:	

Period	Value
Jan'09 – Dec'09	3,825,976
Jan'10 - Dec'10	4,277,426
Jan'11 – Dec'11	4,093,383
Jan'12 – May'12	1,795,583

Data Unit / Parameter:	$BG_{TOFlare, y}$
Data unit:	Nm^3
Description:	Amount of biogas flared in the year y
Source of data:	Measured • Gas flow meter for flare, GM6 • Gas flow meters GM1 and GM5 for deviation 3
Description of measurement methods and procedures to be applied:	The gas flow meter is installed at the flare system.
Frequency of monitoring/recording:	Continuous monitoring with recording on weekly basis.

Value monitored:	The actual monitored value from GM6 is 0. As per deviation 3 , the unbalance volume is considered as flare amount. **Period** / **Value** Jan'09 – Dec'09: 280,029 Jan'10 - Dec'10: 0 Jan'11 – Dec'11: 251,296 Jan'12 – May'12: 60,650
Monitoring equipment:	GM1 , GM5 and GM6 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:	More information is provided in deviation 3.

Data Unit / Parameter:	EG_y
Data unit:	MWh
Description:	Net electricity generated by gas engines operated on biogas from wastewater treatment plant during the year y
Source of data:	Power sale invoices based on net electricity sold to PEA grid
Description of measurement methods and procedures to be applied:	Electricity transmission meter is installed for recording electricity sold to PEA grid.
Frequency of monitoring/recording:	Continuous measuring with recording on monthly basis.
Value monitored:	**Period** / **Value** Jan'09 – Dec'09: 6,391 Jan'10 - Dec'10: 6,058 Jan'11 – Dec'11: 3,845 Jan'12 – May'12: 2,194
Monitoring equipment:	PEA meter no. 20963231 (EM1)
QA/QC procedures to be applied:	The invoice is approved by PEA's authorized person.
Calculation method:	-
Any comment:	The electricity generated from two generators is supplied to factory and exported to grid.

	Whereas the active power demand (kWh) recorded by generator's control panel cannot be neither calibrated nor verified. Hence , the value from PEA invoice is used for emission calculation althought it is not the net power produced from generators. This is conservative approach since it results in decreasing of the emission reduction of electricity generation component.

Data Unit / Parameter:	EC_y
Data unit:	MWh/y
Description:	Electricity consumption by wastewater treatment system and biogas plant in a year "y"
Source of data:	The electricity meter is installed at biogas plant.
Description of measurement methods and procedures to be applied:	Electricity consumption is monitored continuously by an electricity meter.
Frequency of monitoring/recording:	Continuous measuring with recording on daily basis.
Value monitored:	**Period** / **Value**: Jan'09 – Dec'09: 483; Jan'10 - Dec'10: 433; Jan'11 – Dec'11: 525; Jan'12 – May'12: 288
Monitoring equipment:	EM2 as per information in **Table 5**
QA/QC procedures to be applied:	The power meter is calibrated at least once every 2 years.
Calculation method:	-
Any comment:	-

Value monitored (EC_y):

Period	Value
Jan'09 – Dec'09	483
Jan'10 - Dec'10	433
Jan'11 – Dec'11	525
Jan'12 – May'12	288

Data Unit / Parameter:	Sludge removed and its application
Data unit:	Tonnes
Description:	The quantity and type of application of organic material / sludge removed from CSTRs and covered lagoon system.

Source of data:	Weighing equipment available at site are is used before using the material for any other purpose. Plant record every time sludge is removed from the system
Description of measurement methods and procedures to be applied:	The data from weighing equipment and the final application is recorded.
Frequency of monitoring/recording:	Plant operators record every sludge removal trips.
Value monitored:	0 , no sludge was removed during this monitoring period
Monitoring equipment:	-
QA/QC procedures to be applied:	Plant manager's signature is required on the record.
Calculation method:	-
Any comment:	-

Data Unit / Parameter:	$Q_{biogas,flare,h}$
Data unit:	Nm^3/hr
Description:	Biogas sent to flare during a particular hour h
Source of data:	Log record shall be maintained on an hourly basis to ascertain net amount of biogas has gone to flare unit during a particular hour.
Description of measurement methods and procedures to be applied:	The biogas flow meter is installed at flare system for continuous measuring.
Frequency of monitoring/recording:	Continuous monitoring with recording on daily basis
Value monitored:	Please refer to $BG_{TOFlare,\ y}$
Monitoring equipment:	GM6 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:	

Data Unit / Parameter:	$\eta_{flare\text{-}h}$
Data unit:	%
Description:	Flare efficiency
Source of data:	"Tool to determine project emissions from flaring gases containing methane"
Description of measurement methods	The efficiency of the flaring process is defined as

and procedures to be applied:	50% based on the default factor for open flares.
Frequency of monitoring/recording:	Continuous monitoring
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 the flare efficiency is not monitored , the 0% is applied for conservativeness.

3.3 Description of the Monitoring Plan

The monitoring plan is described in section 3.4 of the registered PD. The documented procedures , work instructions and forms have been established and implemented in accordance with ISO 9001 standard.

The daily operation data recording is carried out by plant operators. The report will be checked and approved by biogas plant supervisor. The calibration of all monitoring equipment is planned and controlled by QC&QA Manager.

The wastewater samples are analyzed and recording the result by lab analyst. The result is approved by QC&QA Manager.

All logsheet is collected and summarized by Administrator. The daily report is prepared and submited to Factory Manager on daily basis. The mothly data file is sent to consultant for emission reduction 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

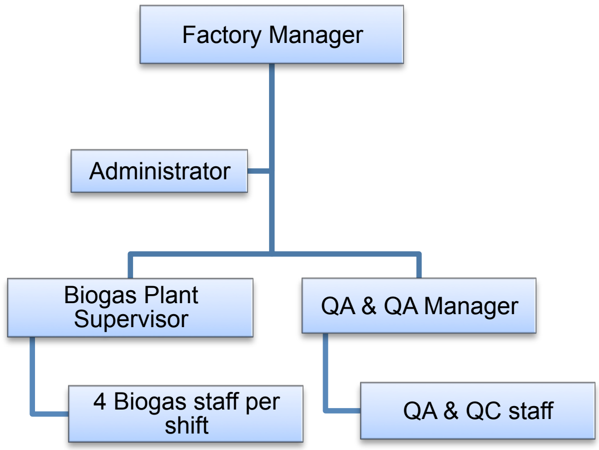
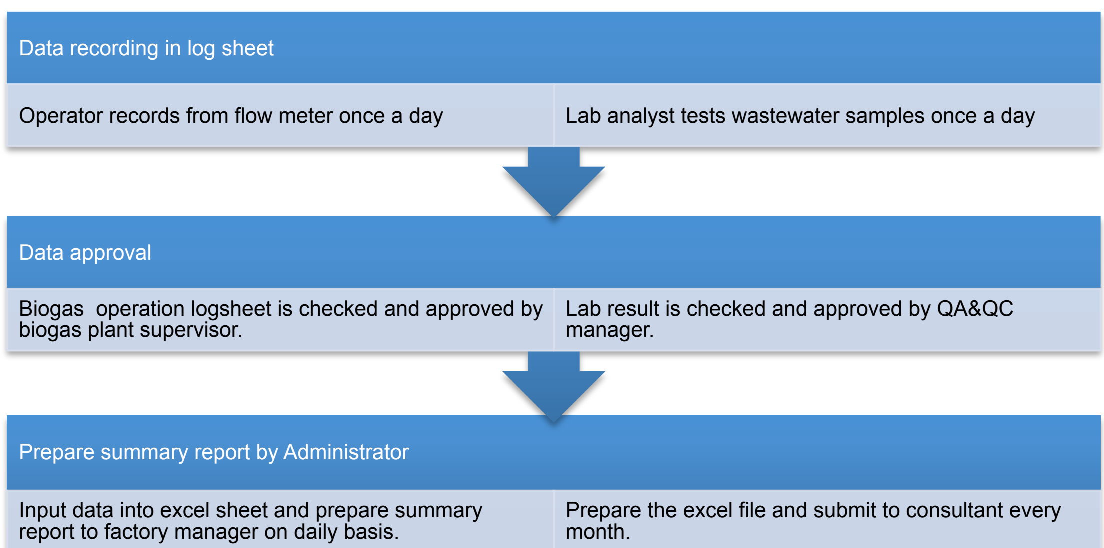


Figure 2 : The organization structure of Biogas Plant

Data Collection and management system



Data storage and backup

- The original log sheets are collected and stored at factory office by Administrator.
- The excel spreadsheets and reports are stored in administrator's computer and company's server. The backup of sever is responsed by IT staff.
- 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

$$BE_y = BE_{power,y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{s,final,y}$$

Where:

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

Baseline Emissions for AMS I.D

Emissions from electricity generation ($BE_{elec,y}$)

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:

$$BE_y = BE_{gen,y} = EF_y * EG_y \quad \textbf{Equation 3}$$

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 (tCO2e/MWh)

Table 1 : Summary of baseline emissions calculation

AMS III. H.				
Parameter	**2009**	**2010**	**2011**	**2012**
$BE_{ww, treatment, y}$	29,272	32,862	34,926	12,083
$BE_{power, y}$	0	0	0	0
$BE_{s, treatment, y}$	0	0	0	0
$BE_{ww, discharge, y}$	0	0	0	0
$BE_{s, final, y}$	0	0	0	0
$BE_{y, ex post}$	***29,272***	***32,862***	***34,926***	***12,083***

MD_y	***28,650***	***33,828***	***33,854***	***14,191***

AMS I. D.				
Parameter	**2009**	**2010**	**2011**	**2012**
$BE_{gen, y} = ER_{power, y}$	***3,231***	***3,063***	***1,944***	***1,109***

4.2 Project Emissions

$$PE_y = PE_{power,y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y}$$

Where: **Equation 4**

Parameter	Details
PE_y	Project activity emissions in the year *y* (tCO_2e)
$PE_{power,y}$	Emissions from electricity or fuel consumption in the year *y* (tCO_2e).
$PE_{ww,treatment,y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year *y* (tCO_2e).
$PE_{s,treatment,y}$	Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year *y* (tCO_2e).
$PE_{y,ww,discharge}$	Methane emissions from degradable organic carbon in treated wastewater in year *y* (tCO_2e).

$PE_{s,final,y}$	Methane emissions from anaerobic decay of the final sludge produced in year *y* (tCO_2e).
$PE_{fugitive,y}$	Methane emissions from biogas release in capture systems in year *y*
$PE_{flaring,y}$	Methane emissions due to incomplete flaring in year *y*
$PE_{biomass,y}$	Methane emissions from biomass stored under anaerobic conditions.

Table 2 : Summary of project emissions calculation

Parameter	2009	2010	2011	2012
$PE_{power, y}$	244	219	265	146
$PE_{ww, treatment, y}$	3,421	2,169	1,719	604
$PE_{s, treatment, y}$	0	0	0	0
$PE_{ww, discharge, y}$	0	0	0	0
$PE_{s, final, y}$	0	0	0	0
$PE_{fugitive, y}$	**3,425**	**4,014**	**4,326**	**1,496**
$PE_{fugitive, s, y}$	*0*	*0*	*0*	*0*
$PE_{fugitive, ww, y}$	*3,425*	*4,014*	*4,326*	*1,496*
$PE_{flaring, y}$	**2,803**	**-**	**2,036**	**478**
$PE_{biomass, y}$	0	0	0	0
$PE_{y, ex post}$	***9,893***	***6,403***	***8,346***	***2,723***

4.3 Leakage

The used technology is not equipment transferred from another activity, therefore according to AMS.III.H and AMS.I.D , there is no leakage to be considered.

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 1**

Where:

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

Table 3 : Emission reduction calculation

	Parameter	2009	2010	2011	2012
AMS III. H.	ER - approach 1 (COD)	19,378	26,458	26,579	9,359
	ER - approach 1 (MD_y)	28,405	33,608	33,589	14,045
	$ER_{ww, y}$	19,378	26,458	26,579	9,359
AMS I. D.	$ER_{power, y}$	3,231	3,063	1,944	1,109
Total ER for the project activity		**22,609**	**29,521**	**28,523**	**10,468**
					91,121

5 ADDITIONAL INFORMATION

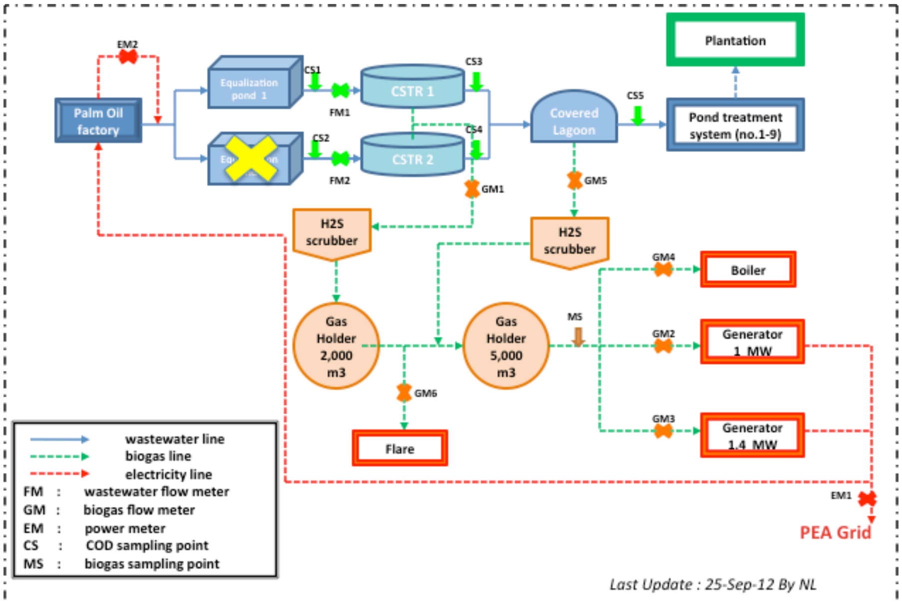


Figure 3 : Monitoring diagram

Table 4 : Monitored Data

Parameter	Unit	2009	2010	2011	2012
$Q_{ww,y}$	m^3	150,513	166,126	153,364	49,952
$COD_{ww, untreated, y,}$	mg/l	66,558	68,721	79,545	80,411
$COD_{out, CSTR,y} = COD_{in,CL,y}$	mg/l	7,755	5,013	5,326	5,705
$COD_{y,out, CL}$	mg/l	6,183	3,552	3,049	3,289
$COD_{load, untreated, y}$	Tonnes	10,088	11,325	12,036	4,164
$COD_{load, out, CL, y}$	tonnes	931	590	468	164
$COD_{load, out, lagoon, y}$	tonnes	15.82	10.03	7.95	2.79
$COD_{load, removed,i, y}$	tonnes	8,827	9,909	10,532	3,644
$COD_{removed, PJ, CL, y}$	$tonne/m^3$	0.06084	0.06462	0.07543	0.08008
$COD_{load,removed, PJ, lagoon, y}$	$tonne/m^3$	0.00608	0.00349	0.00300	0.00323
$MEP_{ww, treatment, y}$		1,631	1,912	2,060	712
$BG_{combusted, y}$	Nm^3	3,825,976	4,277,426	4,093,383	1,795,583
$BG_{TOFlare, y}$	Nm^3	280,029	0	251,296	60,650
W_{CH4} - Lower	%	48.04%	52.60%	53.37%	51.69%
W_{CH4} - Upper	%	66.57%	53.59%	53.87%	52.41%
EG_y	MWh	6,391	6,058	3,845	2,194
EC_y	MWh	483	433	525	288
Sludge removed	*Tonnes*	*0*	*0*	*0*	*0*
$Q_{biogas,flare,h}$	Nm^3/hr	*0*	*0*	*0*	*0*
$\eta_{flare-h}$	*%*	*0%*	*0%*	*0%*	*0%*
$BG_{produced,y,CSTR}$	Nm^3	*4,458,823*	*854,048*	*3,388,386*	*1,930,865*
$BG_{produced,y, CL}$	Nm^3	*317,439*	*-*	*723,096*	*205,955*

Table 5 : Information of monitoring equipment

Meter	Location	Tag	Brand	Model	Accuracy	S/N	Calibration Date				
							Bef. 2008	2009	2010	2011	2012
FM1	CSTR1	FT/007	E+H	PROMAG 50 DN50	0.5% OR	79006020000	3-Jul-07	29-Aug-09		4-Mar-11	
FM2	CSTR2	FT/008	E+H	PROMAG 50 DN50	0.5% OR	A2019020000	3-Jul-07	29-Aug-09		24-Sep-11	
GM1	CSTR	FT/013	E+H	t-mass 65 I	1%OR+0.5%FS	A30CEA02000	3-Apr-08		24-Sep-10		
GM2	Gen 1 MW	FT/004	Actaris	TZ 100	1.00%	8759701001	12-Jul-07	24-Aug-09			
GM3	Gen 1.4 MW	FT/012	E+H	t-mass 65 I	1%OR+0.5%FS	A20B2B02000	29-Feb-08		24-Sep-10		
GM4	Boiler	FT/015	E+H	t-mass 65 I	1%OR+0.5%FS	9908A202000	23-Sep-07		28-Sep-10		
GM5	Covered Lagoon	FT/014		t-mass 65 I	1%OR+0.5%FS	AC0A3602000	21-Oct-08		25-Aug-10		
GM6	Flare		E+H	t-mass 65 I	1%OR+0.5%FS	E1059F02000				17-Feb-11	
EM1	To grid		PEA meter		-	20963231					
EM2	Biogas plant		Merlin Gerin	PM700	1%		18-Oct-08		26-Sep-10		
CH4-new	Gas analyzer	BC/011	Geotech	Biogas Check	3.0%	BM 12438			8-Apr-10	7-Apr-11	6-Mar-12
CH4-old	Gas detector		RAE	LP-1200	Not identified		No calibration required				
CODmeter	Lab - COD		Hanna	C99	10 mg/l	H105199	10-Oct-08		2-Dec-10		