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

Document Prepared By South Pole Carbon Asset Management Ltd.

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Project Title	Wastewater Treatment with Biogas System in Palm Oil Mill at Sawi , Chumporn , Thailand
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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the 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.

This is the second and last verification for the first crediting period of this project activity. The first verification report for monitoring period of 01/01/2009 to 31/05/2012 , was issued on 19/10/2012. The project has achieved 104,426 tCO_2e in this monitoring period. Further background information on this project activity can be found in the VCS website[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 MW 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:

[1] http://vcsprojectdatabase.org/#/project_details/426.

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

Organization name	The Natural Palm Group Co.,Ltd.
Contact person	Kowit Khuansongtham
Title	Mr.
Address	250 M.12 Petchkasem Road , Khron , Sawi , Chumporn Thailand
Telephone	+66 77 557 170
Email	kowit@naturalpalm.com

1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon Asset Management Ltd.
Role in the project	Consultant
Contact person	Santosh Kumar Singh
Title	Mr.
Address	Technoparkstrasse 1 , Zurich 8005 , Switzerland
Telephone	+66 2 678 8977,9
Email	s.singh@southpole.com

1.5 Project Start Date

The project start date is 15/05/2006 which is the date of first usage of biogas at gas engine to generate power i.e. destructive of captured biogas starts.

1.6 Project Crediting Period

Crediting period of this project is ten years , starts from 01/06/2006 to 31/05/2016.

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°17’4”N and Long 99°5’7’’E.

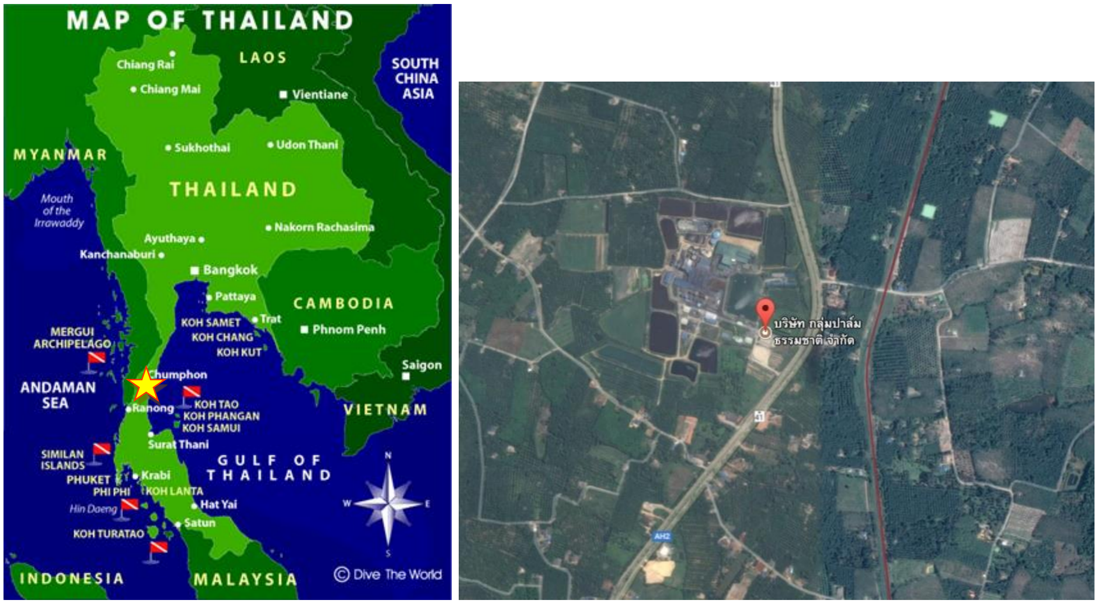


Figure 1 : Project Location

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.

1.9 Other Programs

Not Applicable.

1.10 Sustainable Development

1. Technical:
The advanced biogas reactor systems, CSTR and covered lagoon, are implemented for using biogas as fuel for electricity generators. As compared to the baseline scenario, the installed wastewater treatment system consists of an efficient process for wastewater treatment based on state of the art technology. The usage of reactor allows reducing the water losses due to evaporation and achieving the same efficiency of COD removal in a reduced period of time.

The anaerobic digester requires special training of skilled staff to operate and maintain the biogas plant, creating employment and leading to knowledge transfer to the host country and especially to rural region of the country. The use of this technology in wastewater treatment by the project owner will popularize the technological knowhow in the nearby areas and in plants looking for similar technologies in the country.

Also, the locally produced equipment may be put to use in other parts of Thailand for similar purposes. Geographically, transfer of technology and know-how has occurred mainly from urban to rural areas.

2. Economic:
New jobs will be created during the construction and operation phrases of biogas reactor systems. As well, regional economic development can foster through contracts to local firms. In addition, not only that partial reimbursement on the vast investment cost can be made through utilization of the captured biogas, the additional revenue from the sale of VERs will also make the project financially feasible.

3. Sectoral:
The project is a good example of an effective waste to energy project which in turn improve the long-term sustainability of the Thai Palm oil industry.

4. Social:
The project activity provides direct and indirect employment to the local community during construction of the project activity and as well as during operation. During construction, employment was offered for lot of local unskilled labors contributing to social well being and economic well being. The involvement of local employees in the project activity will help to enhance the skills of the labor in the region by training them in different technical areas. In addition, the close collaboration between external experts and local counterparts is expected to promote long-term sustainable partnerships, benefiting the local stakeholders.

The substitution of fuel oil with biogas from the project activity will result in energy security improvement of region. The noise, arising from pumps and blowers operating in the biogas plant, is insignificant. There are no other occupational health issues identified. The safety aspects of operating the biogas plant will be sufficiently addressed.

HDPE piping is used for transporting the generated gas, which avoids all possibilities of corrosion, leakage and fire hazard.

5. Environmental:

The proposed project activity captures the methane which otherwise would have been let into the atmosphere, and uses the biogas generated for energy purposes, thereby achieving better local air quality.

The project activity has zero discharge to the river or other natural sources such as soils and groundwater. The treated water which contains plant nutrients such as Nitrogen, Phosphorus and Potassium will be stored in the holding pond, the last pond in the wastewater treatment series. The project owner aims to use the final treated water for recycling water in the cleaning the raw material (tapioca root and for irrigation on the company's plantations. The benefits of this are water and fertilizer savings.

Since the project owner uses wastewater and stores water from precipitation for utilization in the manufacturing process should not be a problem for the local community. Thus, wastewater leakage is unlikely.

Further, the project avoids odour emissions as compared to an anaerobic lagoon, which contributes significantly to improved health and quality of life and around the project site.

Note that wastewater overflow might happen during the rainy season if the precipitation rate is higher than the outflow rate of the final pond for a sustained period of time. The palm oil mill and the pond systems are surrounded by agricultural land. Wastewater overflow can lead to a variety of problems that have significant environmental impacts. Excess nutrients in the wastewater will stimulate excessive plant growth which can disrupt normal functioning of the ecosystem, known as Eutrophication. Such problem could lead to social conflicts within the community. While wastewater can overflow from any ponds in the old anaerobic lagoon, the overflow can only happen from the post-treatment ponds in the closed anaerobic system.

Since the average water quality at the outlet of the project activity is better than that in the anaerobic lagoon ponds, the environmental impacts from overflow of wastewater is significantly reduced. Overall, the project has positive impacts on the local environment by improving air quality through reduction in odour and cleaner emissions. This can in turn improve the standard of living of the local population.

6. Geographic/site specific:

The project can be uniquely identified with no barriers regarding logistic. In addition, it is not located in sensitive area such as protected area or where there is any fragile or vulnerable habitats close by. Thus, there are no issues preventing the eligibility of the project in this regard.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

This is the second and last monitoring period of first crediting period of this project activity. The monitoring period is from 01/06/2009 to 31/05/2016 , both days are included.

The changes which may impact the project acivity in this monitoring period are listed as follows;

- The new CSTR no.3 which started to supply biogas on 10/04/2013 and CSTR no.4 which has been commisioned on 01/06/2016 , are not included in the project boundary and in the calculation of emission reductions.
- The third generator was installed on 31/10/2013 , to generate electricity from biogas supplied from CSTR no.3 and 4. The electricity delivered from this genarator is not counted in EG_y.
- The export of electricity generated from the project activity to the grid was stopped on 01/05/2012. The rest generated electricity from gas engines after consumed by project acivity , is delivered to biomass power plant.
- The gas flare station has been temporary disconnected from project activity , and fully closed during 23/02/2010 to 17/01/2013 for safety reason due to the construction of CSTR no.3. The biogas was not sent to flare during this period , as well as the monitoring from flow meter (GM4) was not done.

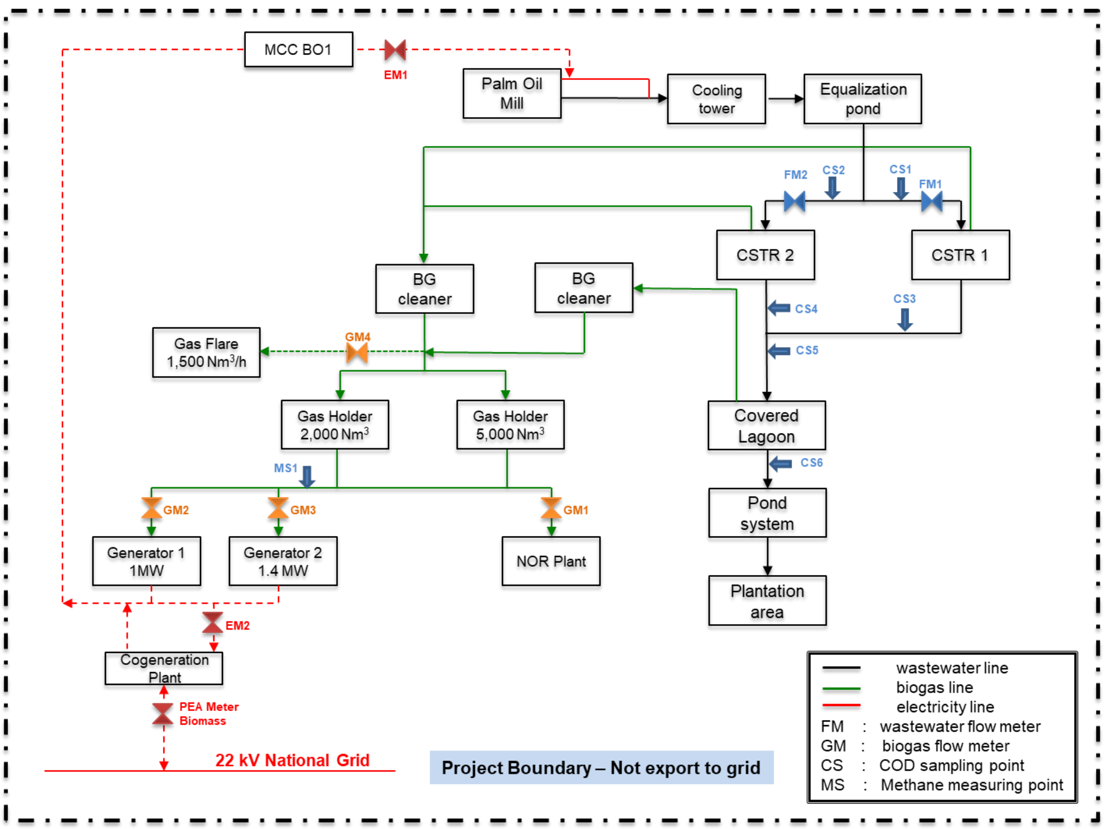


Figure 2 : Monitoring diagram of this monitoring period

2.2 Deviations

2.2.1 Methodology Deviations

Deviation 1

Description of deviation

The COD $_{ww.untreated,y}$, COD $_{out,CSTR,y}$ and $COD_{y,out,CL}$ was not measured on daily basis which required by the methodology. Especially from 2015 onwards , the composite samples of wastewater has been analyzed on weekly basis.

Period of deviation

This deviated approach is applied for the monitoring period.

Deviated approach

The wastewater analysis of the samples from the sump (before entering UASB and HCLU system) , and at the effluent from final open lagoon , were carried out , but not on every operational days. Refer to AMS III.H version16 , for COD parameters : Average value may be used through sampling with the confidence/precision level 90/10 . The example of calculating step from Annex 13 of EB 48 which is followed the standard statistical calculation is applied.

1) Calculate sample mean (μ).

$$\mu_{COD,y} = \sum_{m=1}^{n_m} COD_y / n_m$$

Where :

$\mu_{COD,y}$ = Mean of the COD $_{ww,untreated,y}$ and COD $_{y,out,PJ,lagoon}$ in year y ()

COD_y = Monitored COD $_{ww,untreated,y}$ and COD $_{y,out,PJ,lagoon}$ in measurement m in year y

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

2) Calculate the sample standard deviation (σ).

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

Where :

$\sigma_{COD,y}$ = Standard deviation of COD $_y$ the in year y ()

3) Calculate the 95% confidence interval.

$$\mu_{COD,y} - t * \sigma_{COD,y} / \sqrt{n_m} \leq COD_y \leq \mu_{COD,y} + t * \sigma_{COD,y} / \sqrt{n_m}$$

Where :

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

4) Use the lower bound of the 95% confidence interval obtained above for $COD_{ww,untreated,y}$ and the upper bound for $COD_{out,CSTR,y}$ and $COD_{y,out,CL}$ to ensure conservativeness.

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

Justification for deviated approach

This approach is inline with conservative principle , the upper bound value is used for project emission calculation while the lower bound value is used for baseline emission calculation , to achieve the lower emission reductions.

Deviation 2

Description of deviation

The %CH_4 , methane content in biogas was not measured by a continuous gas analyzer which required by the methodology. This deviation is also applied for the previous verification.

Period of deviation

This deviated approach is applied for the whole monitoring period.

Deviated approach

The data is periodically measured at least on daily basis before sending to biogas utilization components (boiler set , generator set and flare). The monitored data is adjusted for 95% confidence level according to the guideline described in Annex 13 of EB 48.

1) Calculate sample mean (μ).

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

Where :

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

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

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

2) Calculate the sample standard deviation (σ).

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

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

Where :

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

3) Calculate the 95% confidence interval.

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

Where :

t = Value from standard t distribution for a confidence level of 95% with degrees of freedom n_m-1[3]

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

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

Justification for deviated approach

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

2.2.2 Project Description Deviation

Deviation 1

Description of deviation

The monitoring of EG_y and EC_y is changed from the description provided in the registered PD due to the situation for electricity generation and consumption at the project activity has been changed.

- The PPA , Power Purchasing Agreement to sell the electricity from project activity to grid was cancelled on 01/05/2012. The electricity generated from project activity has been delivered to the new biomass power plant which started operation (SCOD) on 31/01/2012.
- The export and import electricity from grid directly to project activity is no more applicable.
- The electricity used by project activity has been served by the installed generator set as primary source , which is same as previous situation. The biomass power plant can deliver electricity to the project activity as secondary source instead of to import electricity from grid.

Period of deviation

This deviated approach is applied for the whole monitoring period.

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

<u>Deviated approach</u>

The baseline emissions for AMS I.D (EG_y) and the project emissions for AMS III.H (EC_y) are not considered for the emission reduction calculation.

- **EG_y**

  From registered VCS PD , EG_y is the net electricity generated by gas engines operated on biogas from wastewater treatment plant , can be monitored by electricity transition meter provided at point of power generation sets or power sales invoices based on net electricity sold to PEA grid.

  Since the PPA was cancelled then PEA meter has been removed. Therefore the EG_y is considered as zero for conservativeness.

- **EC_y**

  From registered VCS PD , EC_y is the electricity consumption by wastewater treatment system and biogas plant , which is calculated from the maximum rated consumption. For the project scenario , the project activity can import electricity from grid which the grid emission factor will be used for calculate the project emissions.

  In the existing situation , the installed generator set is the primary source of electricity supply for the project activity which can be monitored via power meter (EM1). In case the generators cannot operate , the electricity will be supplied from the biomass power plant as the secondary source. Then , there is no electricity imported from grid.

  In case the electricity is supplied from generators , the consumption will be included in EG_y. If the electricity consumption is supplied from biomass power plant which is not fossil fuel based power plant , then the emissions of biomass firing for electricity generation should be zero.

<u>Justification for deviation</u>

In the ER calculation sheet , the actual monitored data of EG_y (from the power monitoring units at generators) and EC_y is shown in table below.

Monitored data regarding AMS I.D							
		PD value	2012	2013	2014	2015	2016
EC_y	MWh	1747	368	636	516	350	284
EG_y	MWh	8103	3,001	8,733	5,050	3,403	4,384
$EG_{y,export}$	MWh						6,588

The EC_y which is monitored via EM1 is much more less than the amount of electricity generated from generator no.1 and no.2. Most of electricity generated is delivered to the biomass power plant which is monitored via EM2. If both monitored parameters are included in the emission reduction calculation. The project will achieve 12,423 tCO_2 as BE for AMS I.D while the PE of AMS III.H will be 1,090 tCO_2. The project activity should get 11,333 tCO_2e additional from the inclusion of electricity monitored data. Therefore , to neglect this amount of emission reductions should be considered as conservativeness.

<u>Impact on methodology applicability and baseline:</u>
All deviations above only relate to monitoring description. The baseline is still the same as described in the registered VCD PD and there is no impact on the applicability of the methodology.

<u>Impact on additionality:</u>
All applied deviations have no impact on additionality as it relates to only the changes in monitoring description.

2.3 Grouped Project

This project activity is not a grouped project.

2.4 Safeguards

2.4.1 No Net Harm

The project activity does not create any potential negative environmental and socio-economic impacts.

2.4.2 Local Stakeholder Consultation

A detailed Stakeholder consultation was conducted by the project proponent at the project site and is explained as follows:

Invitation procedure

The Stakeholder Consultation has been conducted by the project owner Natural Palm Oil Co., Ltd Chumporn with assistance from South Pole Carbon Asset Management Limited (Switzerland based company responsible for VER project development). Stakeholder groups have been identified and informed through oral means about the meetings.

Place and date of the meetings

The stakeholder consultation was held in the communities around the plant on 10 September 2008. Thus, all participants were able to examine the location where the proposed project will take place.

Meeting Participants

The meeting was attended by local residents and representatives from the following stakeholder categories:

1. Local residents
2. Local government representatives
3. Teachers from local school
4. Local entrepreneurs

30 participants accepted the invitation and attended the meeting.

Language

Documentation and meeting was held in Thai (local language).

Meetings procedure

- Project description of and environmental impacts (10 min)
- Questions and Answers session (5 min)
- General feedback (5 min)

Meeting documents and protocols

On completion of the various meetings, the following documentation was collected and attested by the signatures of the stakeholders that were present:

1. Non-technical description of the project
2. Environmental impacts of the project
3. Contribution to sustainable development

Compilation of comments received:

The overall response to the project, from all invited stakeholders, was encouraging and positive to local environment and social-economic conditions by cleaning the wastewater in a more efficient way, avoiding odour emissions from the lagoons and creating new jobs.

In all, no adverse reactions, comments, or clarifications were received during the Stakeholder Consultation process. The project participants did not recognize any need to make changes to the project design or monitoring plan.

Current Practice : The project proponent maintains a register at the plant, to make sure any current feedback is provided by local people in fair and transparent manner. The communication between the company and all stakeholders is also presented on company website (www.naturalpalm.com).

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	GWP_{CH4}
Data unit	-
Description	Global warming potential of methane gas
Source of data	Default value from AMS III.H
Value applied	• 21 for 2012 • 25 for 2013 onwards
Justification of choice of data or description of	• Intergovernmental Panel on Climate Change, Climate Change 1995: The Science of Climate Change (Cambridge, UK: Cambridge University Press, 1996).

measurement methods and procedures applied	• As per Annex 1 - clause 5 of VCS standard version 3.7, Project shall transition to the updated GWP at their project crediting period renewal.
Purpose of the data	Calculation of baseline and project emissions
Comments	-

Data / Parameter	$B_{o,ww}$
Data unit	kg CH_4/kg COD
Description	Methane producing capacity of the COD in wastewater
Source of data	IPCC default value, corrected as per methodology AMS III.H.
Value applied	0.21
Justification of choice of data or description of measurement methods and procedures applied	IPCC default value. Based on AMS III.H v.13
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / 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
Justification of choice of data or description of measurement methods and procedures applied	The baseline wastewater treatment system consists in a succession of deep lagoons (depth more than 2 metres) therefore MCF value is chosen as 0.8.
Purpose of the data	Calculation of baseline emissions
Comments	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 / Parameter	$MCF_{,ww,treatment,PJ,lagoon}$
Data unit	Fraction

Description	Methane correction factor for the 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
Justification of choice of data or description of measurement methods and procedures applied	The project wastewater treatment system without biogas recovery (secondary treatment) consists in a succession of deep lagoons, with depth more than 2 metres, so the value of 0.8 has been chosen.
Purpose of the data	Calculation of project emissions
Comments	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 / Parameter	$MCF_{,ww,treatment,PJ,CSTR}$
Data unit	Fraction
Description	Methane correction factor for the project wastewater treatment system k
Source of data	Table III.H.1. of AMS III.H. v.13
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	The project wastewater treatment system equipped with biogas recovery is a CSTR, therefore MCF value is chosen as 0.8.
Purpose of the data	Calculation of project emissions
Comments	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 / Parameter	D_{CH4}
Data unit	Kg/m^3
Description	Density of methane at normal conditions
Source of data	Tool to determine project emissions from flaring gases containing methane.
Value applied	0.716
Justification of choice of data or description of	CDM EB as per EB28 Meeting report (Annex 13)

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

Data / Parameter	CFE_{ww}
Data unit	Fraction
Description	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems.
Source of data	Equation 12 in AMS III.H v.13
Value applied	0.9
Justification of choice of data or description of measurement methods and procedures applied	Default value as per AMS III.H v.13
Purpose of the data	Calculation of project emissions
Comments	-

Data / 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%
Justification of choice of data or description of measurement methods and procedures applied	The COD removal efficiency is based, on COD values for baseline system before implementation of project activity. The COD reduction across the baseline treatment system is multiplied by a factor of 0.89 for conservative estimation of baseline emissions. Actual reduction across the system is approximately 98.3%

Date of examination	1st	last pond	efffidency
15-Jan-05	56,069	1,205	98.71%
10-Feb-05	53,282	1,545	98.26%
5-Mar-05	40,594	960	98.58%
9-Apr-05	52,634	1,185	98.65%
20-May-05	32,901	865	98.42%
15-Jun-05	53,930	1,970	97.81%
11-Jul-05	44,377	1,100	98.51%
4-Aug-05	41,820	1,510	97.83%
8-Nov-05	46,524	1,390	98.21%
15-Dec-05	55,459	1,835	98.01%
Average	47,759	1,357	98.30%

Purpose of the data	Calculation of baseline emissions
Comments	-

Data / 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
Justification of choice of data or description of measurement methods and procedures applied	Conservative choice and public available data during validation.
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	UF_{BL}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS III.H. v.13
Value applied	0.94
Justification of choice of data or description of measurement methods and procedures applied	According to the AMS III.H., version 13, correction factor will be used for estimation of baseline emissions
Purpose of the data	Calculation of baseline emissions

Comments	-

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

Data / Parameter	FE
Data unit	%
Description	Flare efficiency
Source of data	Tool to determine project emissions from flaring gases containing methane.
Value applied	50%
Justification of choice of data or description of measurement methods and procedures applied	Default value for open flare as per Tool to determine project emissions from flaring gases containing methane has been applied.
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	DE
Data unit	%
Description	Destruction efficiency of the electricity generator
Source of data	SSC WG
Value applied	100%

Justification of choice of data or description of measurement methods and procedures applied	According to clarification from SSC WG "in the case that the biogas is combusted for a gainful use of the released energy as in an engine or a power plant, a destruction efficiency of 100% can be used for the portion of biogas that is combusted when applying AMS III.H., i.e. use a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use"[4]
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	P_{el}
Data unit	kW
Description	Total eelectrical capacity of the equipment installed in the project activity
Source of data	Plant data
Value applied	181.3
Justification of choice of data or description of measurement methods and procedures applied	Extract from nameplate of the electrical equipment.

Auxiliary Equipment	power (kW)	Auxiliary Equipment	power (kW)
Cooling pump	7.5	circulation gas pump	4
Cooling pump	7.5	oxigen pump	0.55
EQ pump	5.5	gas pump	0.55
EQ pump	5.5	circulation gas pump	4
EQ pump	5.5	circulation gas pump	18.5
EQ pump	5.5	circulation pump	18.5
circulation pump	11	circulation pump	18.5
Circulation pump	11	circulation pump	18.5
oxigen pump	0.55	soft effuent pump	5.5
oxigen pump	0.55	soft effuent pump	5.5
circulation gas pump	4	gas blower	11
oxigen pump	0.55	gas blower	11
gas pump	0.55		
		Total	181.3

Purpose of the data	Calculation of project emissions
Comments	-

3.2 Data and Parameters Monitored

Data / Parameter	$Q_{ww,y}$
Data unit	m^3
Description	Volume of wastewater treated in the year y

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

Source of data	Measured - Volumetric flow meters (FM1 , FM2)
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	Presented in Table 3
Monitoring equipment	FM1 and FM2 as per information provide in Table 4
QA/QC procedures to be applied	The flow meters are calibrated at least once every 3 years.
Purpose of the data	Calculation of baseline and project emissions
Calculation method	-
Comments	-

Data / Parameter	$COD_{ww,untreated,y}$
Data unit	mg/l
Description	COD of wastewater entering the wastewater treatment system (CS1 , CS2)
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. • The methodology deviation 1 is applied for 95% of confidential level adjusting.
Frequency of monitoring/recording	The analysis of composite sample is carried out on weekly basis.
Value monitored	Presented in Table 3
Monitoring equipment	Spectrophotometer for COD test as per information provide in Table 4
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 is tested by external laboratory at least once a year.
Purpose of the data	Calculation of baseline and project emissions
Calculation method	-
Comments	-

Data / Parameter	$COD_{out,CSTR,y}$ = $COD_{in,CL,y}$
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 (CS3 , CS4)
Description of measurement methods and procedures to be applied	• Colorimetric method in the on-site laboratory of the treatment plant. • The COD sampling points are at the outlet from CSTR1 and CSTR2. • The methodology deviation 1 is applied for 95% of confidential level adjusting.
Frequency of monitoring/recording	The analysis of composite sample is carried out on weekly basis.
Value monitored	Presented in Table 3
Monitoring equipment	Spectrophotometer for COD test as per information provide in Table 4
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 is tested by external laboratory at least once a year.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / 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 (CS6)
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 at the outlet from covered lagoon. • The methodology deviation 1 is applied for 95% of confidential level adjusting.
Frequency of monitoring/recording	The analysis of composite sample is carried out on weekly basis.
Value monitored	Presented in Table 3

Monitoring equipment	Spectrophotometer for COD test as per information provide in Table 4
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 is tested by external laboratory at least once a year.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	W_{CH4}
Data unit	%
Description	Methane content in biogas in the year y
Source of data	Measured (MS1) , with application of 95% confidential level as per methodology deviation 2.
Description of measurement methods and procedures to be applied	The fraction of methane in the biogas is measured by gas analyser at the biogas supply line to generator.
Frequency of monitoring/recording	The methane content in biogas is measured during the operating of generators , at least once a day.
Value monitored	Presented in Table 3
Monitoring equipment	Gas analyzer as per information provide in Table 4
QA/QC procedures to be applied	The gas analyzer is calibrated at least once every 3 years.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / 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 (GM1 , GM2 , GM3)
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	Presented in Table 3
Monitoring equipment	Biogas flow meter (GM1,GM2 and GM3) as per information provide in Table 4
QA/QC procedures to be applied	The flow meters are calibrated at least once every 3 years.
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	The amount of biogas recorded by GM2 , biogas sent to generator no.1 , is adjusted for calibration delay in 2013 and 2014.

Data / Parameter	$BG_{TOFlare,y}$
Data unit	Nm^3
Description	Amount of biogas flared in the year y
Source of data	Measured by gas flow meter (GM4)
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 daily basis.
Value monitored	Presented in Table 3
Monitoring equipment	Biogas flow meter (GM4) as per information provide in Table 4
QA/QC procedures to be applied	The flow meter is calibrated at least once every 3 years.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / 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 (EM2)
Description of measurement methods and procedures to be applied	Refer to the project description deviation 1 in section 2.2.2

Frequency of monitoring/recording	Refer to the project description deviation 1 in section 2.2.2
Value monitored	Not Applicable
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	As per project description deviation 1, this monitoring parameter is not considered in this monitoring period.

Data / Parameter	EC_y
Data unit	MWh
Description	Electricity consumption by wastewater treatment system and biogas plant in a year "y"
Source of data	Power sale invoices based on net electricity sold to PEA grid (EM1)
Description of measurement methods and procedures to be applied	Refer to the project description deviation 1 in section 2.2.2
Frequency of monitoring/recording	Refer to the project description deviation 1 in section 2.2.2
Value monitored	Not Applicable
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	As per project description deviation 1, this monitoring parameter is not considered in this monitoring period.

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

Description of measurement methods and procedures to be applied	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
Frequency of monitoring/recording	The data from weighing equipment and the final application is recorded.
Value monitored	0 - no sludge removed from project activity in this monitoring period.
Monitoring equipment	-
QA/QC procedures to be applied	Plant manager's signature is required on the record.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$Q_{biogas,flare,h}$
Data unit	Nm^3/hr
Description	Biogas sent to flare during a particular hour h
Source of data	Log record shall be maintained on an hourly basis to ascertain net amount of biogas has gone to flare unit during a particular hour.
Description of measurement methods and procedures to be applied	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	Biogas flow meter (GM4) as per information provide in Table 4
QA/QC procedures to be applied	The flow meter is calibrated at least once every 3 years.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$\eta_{flare-h}$
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	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.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	Since the flare efficiency is not monitored , the 0% is applied for conservativeness.

3.3 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 logs heet is collected and summarized by Administrator. The daily report is prepared and submitted to Factory Manager on daily basis. The monthly 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

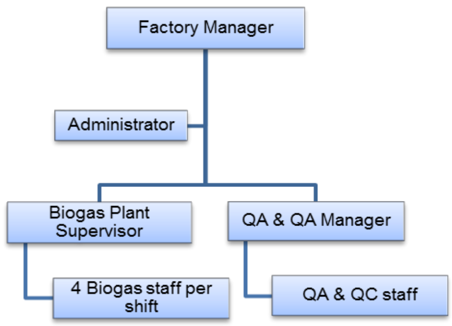
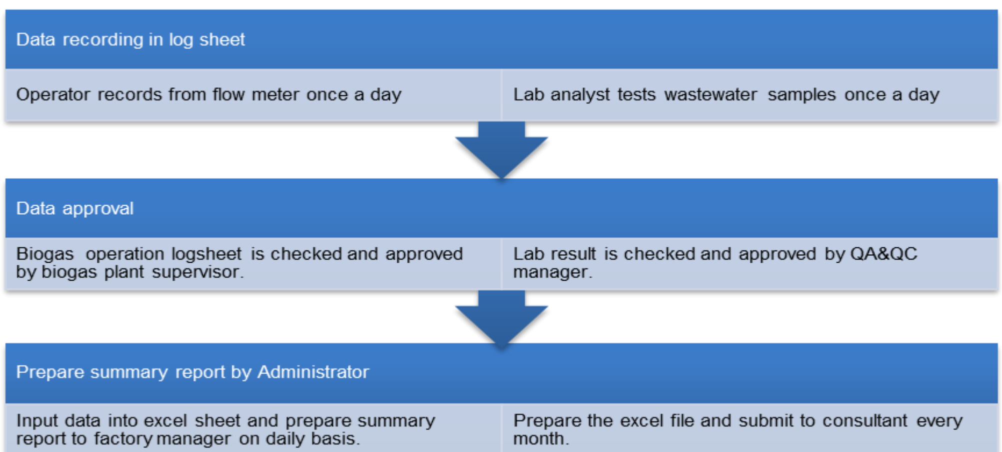


Figure 3 : The organization structure of Biogas Plant

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 responded 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

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

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:

$$BE_y = BE_{gen,y} = EF_y * EG_y$$ **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 (tCO_2e/MWh)

Table 1 : Calculation of Baseline Emissions (BE)

AMS III. H.					
Parameter	**2012 (Jun-Dec)**	**2013**	**2014**	**2015**	**2016**
$BE_{ww, treatment, y}$	17,019	36,027	33,866	19,586	23,877
$BE_{power, y}$	0	0	0	0	0
$BE_{s, treatment, y}$	0	0	0	0	0
$BE_{ww, discharge, y}$	0	0	0	0	0
$BE_{s, final, y}$	0	0	0	0	0
$BE_{y, ex post}$	***17,019***	***36,027***	***33,866***	***19,586***	***23,877***

MD_y	***11,831***	***39,629***	***36,478***	***20,368***	***27,045***

AMS I. D.					
Parameter	**2012 (Jun-Dec)**	**2013**	**2014**	**2015**	**2016**
$BE_{gen, y} = ER_{power}$	***0***	***0***	***0***	***0***	***0***

4.2 Project Emissions

Project activity emissions for AMS III.H

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

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 : Calculation of Project Emissions (PE)

Parameter	2012 (Jun-Dec)	2013	2014	2015	2016
$PE_{power, y}$	0	0	0	0	0
$PE_{ww, treatment,}$	862	2,193	1,771	1,240	1,738
$PE_{s, treatment, y}$	0	0	0	0	0
$PE_{ww, discharge, y}$	0	0	0	0	0
$PE_{s, final, y}$	0	0	0	0	0
$PE_{fugitive, y}$	2,095	4,393	4,162	2,383	2,879
$PE_{fugitive, s, y}$	*0*	*0*	*0*	*0*	*0*
$PE_{fugitive, ww, y}$	*2,095*	*4,393*	*4,162*	*2,383*	*2,879*
$PE_{flaring, y}$	0	0	0	0	0
$PE_{biomass, y}$	0	0	0	0	0
$PE_{y, ex post}$	***2,958***	***6,586***	***5,934***	***3,623***	***4,617***

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 Net GHG Emission Reductions and Removals

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

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

$$(MD_y - PE_{power,y} - PE_{biomass,y} - LE_{y,ex-post}$$ **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

Year	Baseline emissions or removals (tCO_2e)	Project emissions or removals (tCO_2e)	Leakage emissions (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
Year 2012	11,830	0	0	11,830
Year 2013	36,027	6,586	0	29,441
Year 2014	33,866	5,934	0	27,932
Year 2015	19,586	3,623	0	15,963
Year 2016	23,877	4,617	0	19,260
Total	**125,186**	**20,760**	**0**	**104,426**

APPENDIX 1: ADDITIONAL INFORMATION

Table 3 : Summary of monitored data

Parameter	Unit	PD value	2012	2013	2014	2015	2016
$Q_{ww,CSTR1,y}$	m^3		48,069	100,804	101,406	90,133	85,673
$Q_{ww,CSTR2,y}$	m^3		31,625	62,219	56,259	17,289	30,096
$Q_{ww,y}$	m^3	135,000	79,694	163,023	157,665	107,421	115,769
$COD_{ww, untreated, y}$	mg/l	80,000	73,597	63,974	62,181	52,782	59,704
$COD_{out, CSTR,y} = COD_{in,CL,y}$	mg/l	16,000	3,609	3,939	4,281	3,446	4,822
$COD_{y,out, CL}$	mg/l	6,400	3,306	3,453	2,884	2,963	3,854
$COD_{load, untreated, y}$	tonnes		5,865	10,429	9,804	5,670	6,912
$COD_{load, out, CL, y}$	tonnes		263	563	455	318	446
$COD_{load, out, lagoon, y}$	tonnes		32.94	70.37	56.83	39.79	55.77
$COD_{load, removed,i, y}$	tonnes		5,132	9,126	8,578	4,961	6,048
$COD_{removed, PJ, CL, y}$	$tonne/m^3$		0.07029	0.06052	0.05930	0.04982	0.05585
$COD_{load,removed, PJ, lagoon, y}$	$tonne/m^3$		0.00289	0.00302	0.00252	0.00259	0.00337
$MEP_{ww, treatment, y}$			998	1,757	1,665	953	1,151
$BG_{combusted, y}$	Nm^3	3,715,200	1,552,082	4,013,345	3,431,547	2,165,598	2,743,242
$BG_{TOFlare, y}$	Nm^3	0	0	0	0	0	0
W_{CH4}	%	60%	50.69%	55.16%	59.39%	52.54%	55.08%
EG_y	MWh	8,103	0	0	0	0	0
EC_y	MWh	1,747	0	0	0	0	0
Sludge removed	*Tonnes*	*0*	*0*	*0*	*0*	*0*	*0*
$Q_{biogas,flare,h}$	Nm^3/hr	*0*	*0*	*0*	*0*	*0*	*0*
$\eta_{flare-h}$	*%*	*50%*	*0%*	*0%*	*0%*	*0%*	*0%*

Table 4 : Information of monitoring equipments

Meter	Location	Tag	Brand	Model	Accuracy	S/N	Calibration Date						
							Before 2011	2012	2013	2014	2015	2016	2017
FM1	CSTR1	FT/007	E+H	PROMAG 50	0.5% OR	79006020000	4-Mar-11	15-Jun-12		30-Aug-14		4-Aug-16	
FM2	CSTR2	FT/008	E+H	PROMAG 50	0.5% OR	A2019020000	24-Sep-11	15-Jun-12		30-Aug-14			
			E+H	PROMAG 50	0.5% OR	K904AA20000						4-Aug-16	
GM4	Flare		E+H	t-mass 65 I	1%OR	E1059F02000	17-Feb-11	There was no flare operation (flare closed) from 23/02/10 to 17/01/13					
			Actaris	TZ 100	1%OR	8759701001	25-Aug-11						
GM1	Boiler		E+H	t-mass 65 I	1%OR	9908A202000	28-Sep-10	25-Aug-12					
			Binder	Combimass	1%OR	C130280					31-Mar-15		25-Feb-17
GM2	Gen 1 - 1.0 MW	FT/004	Actaris	TZ 100	1%OR	8759701001	25-Aug-11	25-Aug-12					
			E+H	Proline t-mass 65 I	1%OR	A30CEA02000	24-Sep-10			3-Sep-14		4-Aug-16	
			E+H	Proline t-mass 65 I	1%OR	A20B2B02000						4-Aug-16	19-Aug-17
GM3	Gen 2 - 1.4 MW	FT/012	E+H	t-mass 65 I	1%OR	A20B2B02000	24-Sep-10	25-Aug-12		3-Sep-14		4-Aug-16	19-Aug-17
MS	Gas analyzer	BC/011	Geotech	Biogas Check	0.03	BM 12438	7-Apr-11	6-Mar-12					
			Binder	Combimass	5.0%	11634			7-Jan-13		15-Jan-15	16-Dec-16	
			Geotech	Biogas5000	5.0%	G504389							6-Jan-17
CODmeter	Lab - COD		Hanna	C99	10 mg/l	H105199	2-Dec-10						
			Merck	Pharo		MTHA 0717-06		6-Jul-12			8-Jul-15		5-Jul-17