

SD BIOSUPPLY WASTEWATER TREATMENT AND BIOGAS UTILIZATION PROJECT



Document Prepared By:

South Pole Carbon Asset Management Ltd.

Technoparkstrasse 1, 8005 Zurich Switzerland

Phone +41 44 633 78 70

Fax +41 63 14 23

info@southpolecarbon.com

www.southpolecarbon.com

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Prepared By	South Pole Carbon Asset Management Ltd.
Contact	Technoparkstrasse 1, 8005 Zurich Switzerland Phone +41 44 633 78 70 Fax +41 63 14 23 info@southpolecarbon.com www.southpolecarbon.com

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1 PROJECT DETAILS

1.1 Summary Description of Project

The project was implemented at Somdej Flour Mill Co. Ltd. on August 18th, 2005. Prior to implementation of the project activity, the wastewater of the starch plant was treated in 8 cascading open anaerobic lagoons.

The project activity entails the installation of an anaerobic wastewater treatment facility, based on Upflow Anaerobic Sludge Blanket (UASB) biogas reactor technology, at the existing starch manufacturing plant, replacing the open anaerobic lagoon based system. The biogas reactor system generates and recovers biogas for energy generation purposes, avoiding methane emissions to the atmosphere. The captured methane is used as fuel in existing heat generating devices in the starch plant replacing heavy fuel oil partially, which leads to further green house gas emission reductions (CO₂) by replacing fossil fuel. Any surplus methane is flared in an open flare.

The starch factory was using two boilers based on fossil fuels before the implementation of the project activity. During the current monitoring period, the two boilers were replaced by two new boilers in 2010 and 2012. The total capacity of the new boilers is 7.268MWth. The replacement of boilers has no impact on the project activity. The boilers were replaced to avoid stoppages to the production of starch. The project boundary is shown in the **Figure 1** below.

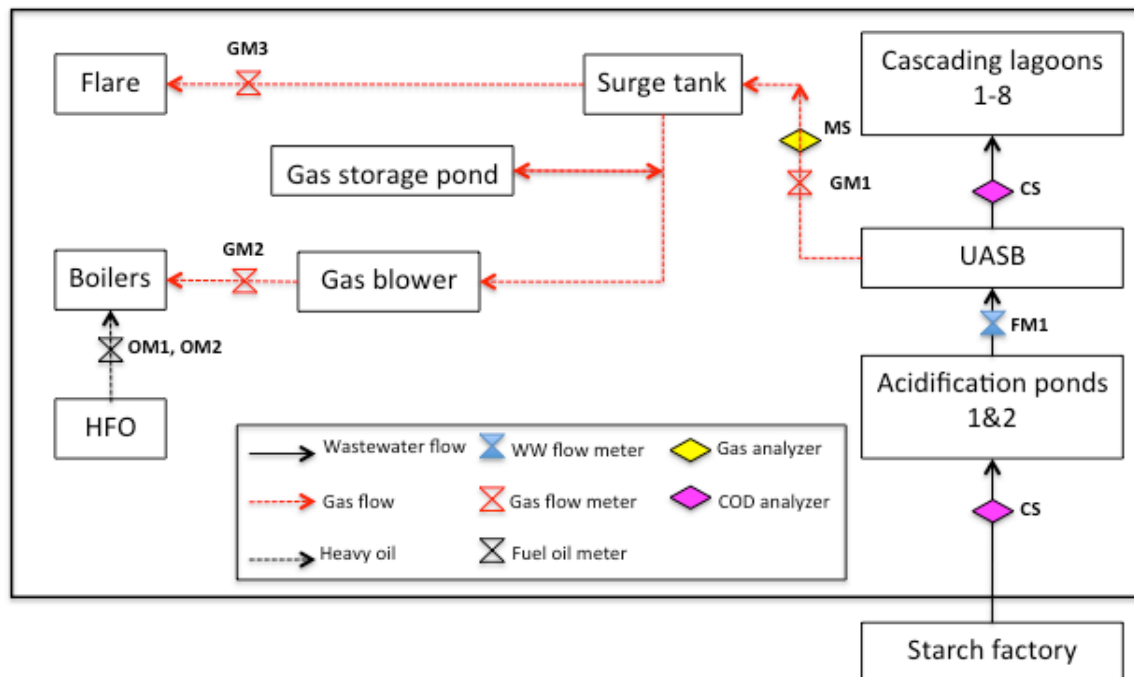


Figure 1: The project system boundary (after UASB digester implementation)

By means of this monitoring report, the greenhouse gas emission reductions achieved by the project activity “**SD Biosupply Wastewater Treatment and Biogas Utilization Project**” at SD Biosupply Co., Ltd during the period of 01/01/2009-31/05/2012 are being verified and certified as per requirements of the Voluntary Carbon Standard, Version 3.

Further background information on the project activity can be found in the Project Design Document (PD). The project was registered on 06/05/2010. The 1st verification and certification for the period of 28/03/2006-31/12/2008. The PD and associated documents are available on the VCS project database at the following link:

<https://vcsprojectdatabase2.apx.com/myModule/Interactive.asp?Tab=Projects&a=2&i=416&lat=16.677833&lon=103.805464&bp=1>

1.2 Sectoral Scope and Project Type

The type/category of the project is according to Appendix B, "Simplified Modalities and Procedures for Small-Scale CDM Project Activities", as follows:

Methane avoidance component:

Type III: Other Project Activities

Category III.H: Methane Recovery in Wastewater Treatment

Sectoral Scope: 13 Waste Handling and Disposal

Thermal energy generation component:

Type I: Renewable energy projects

Category I.C: Thermal energy for the user with or without electricity

Sectoral Scope: 1 Energy Industries

The project is not a grouped project, not an AFOLU project.

1.3 Project Proponent

The project proponents contributed to the current report by assigning the following roles and responsibilities to:

PP1: SD Biosupply Co., Ltd

Representative: Mr. Sutee Suralertrungsri, Managing Director

Roles: Project owner (responsible for implementation and operation of the project activity)

Contact: SD Biosupply Co., Ltd. 113 Soi Chokchaijonjamrern, Rama III Road, Bangpongpan, Yannawa, Bangkok 10120 Thailand Tel: +66 2 683 1900-7 Fax: +66 2 683 0892

PP2: South Pole Carbon Asset Management Ltd.

Representative: Mr. Ingo Puhl, Managing Partner

Roles: Project developer, (responsible for development of emission reductions through the voluntary carbon standard)

Contact: South Pole Carbon Asset Management Ltd. Technoparkstrasse 1, Zurich 8005, Switzerland Tel: +66 2 678 8979 Fax: +66 2 678 8978
info@southpolecarbon.com www.southpolecarbon.com

1.4 Other Entities Involved in the Project

No other entity was involved in the project.

1.5 Project Start Date

According to version 6.4 of the VCS PD, the project start date was defined on 16/09/2005 based on the date when emission reductions began (section 1.6 in the registered PD). As per VCS 2007 guidelines, the start date of crediting period is defined as 28th March 2006.

1.6 Project Crediting Period

The duration of the project activity is estimated to 15 years as per UASB lifetime. After the initial crediting period of ten years, from 28/03/2006-27/03/2016, subsequent renewals of the crediting time might be considered according to the status of the project activity and baseline revision at that time.

The 1st monitoring report issued certified credit for 28/03/2006-31/12/2008. This is the 2nd monitoring report, which is conducted for the period of 01/01/2009-31/05/2012.

1.7 Project Location

The project site is located on the site of Somdej Flour Mill Co., Ltd located at address: 99 Moo 10, Somdej-Khuchinarai Road, Kambong sub-district, Huai Phueng district, Kalasin, approx. 580 km from Bangkok. The project coordinates are 16° 40'40.20"N and 103° 48' 19.67'E as shown in **Figure 2**.

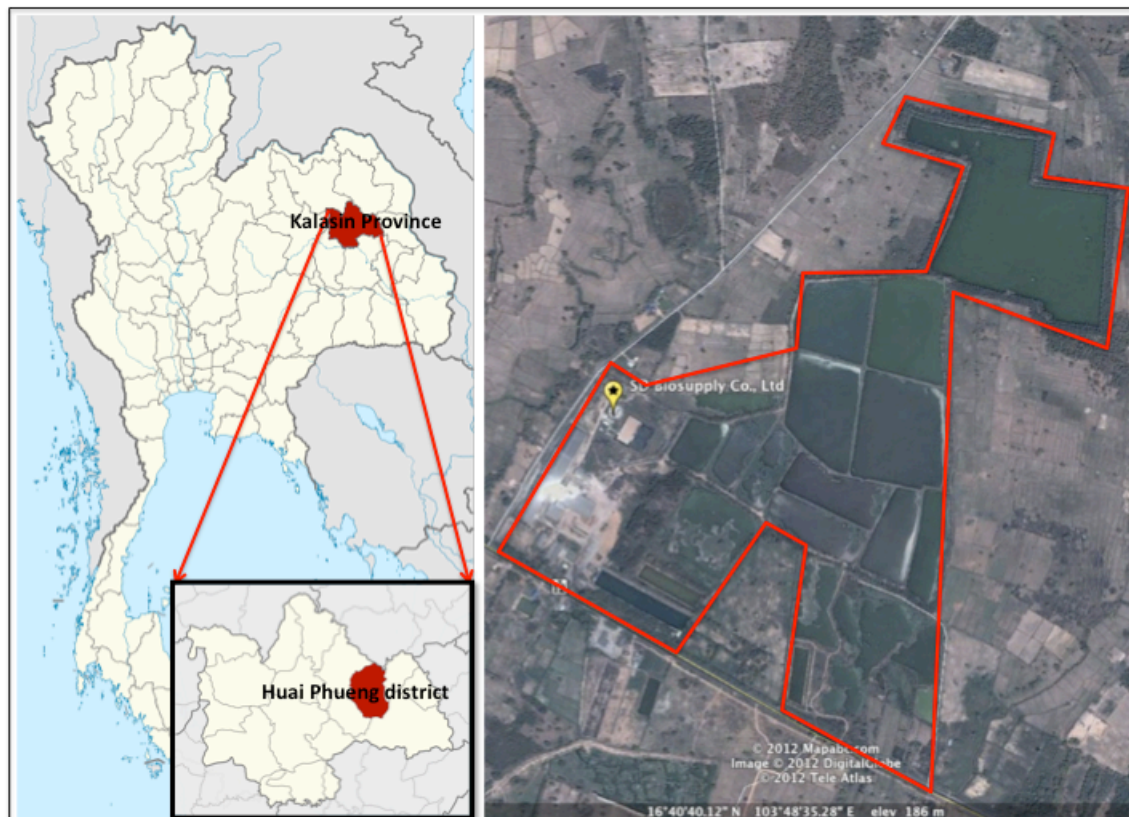


Figure 2: Project location and boundar

1.8 Title and Reference of Methodology

Baseline & Monitoring Methodology for the project activity is defined:

- AMS III.H: Methane Recovery in Wastewater Treatment, version 12, EB 47.
- AMS I.C: Thermal energy for user with or without electricity, version 14, EB 46.

AMS. III.H. refers to: Tool to determine project emissions from flaring gases containing methane", Annex 13, EB 28

AMS.I.C. refers to: Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion" version 1.2 and,

Tool to calculate baseline, project and/or leakage emissions from electricity consumption" version 1.0

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The project was registered on 06/05/2010 and first verification covered the period 28/03/2006-31/12/2008. The current monitoring period is from 01/01/2009 to 31/05/2012. The emission reductions for this period are 98,903 tCO₂e VERs. The implementation status of the project activity during this monitoring period shows in **Table 1**. There is no natural disaster or any accident that leads to the significantly changes in the amount of emission reductions in this period.

Table 1: The implementation status of the project activity

Date	Event
01/01/2009	Project started recording the amount of fuel oil consumption in the boilers.
15/06/2009	Project installed gas flow meter (GM3) to measure the amount of biogas sent to flare
20/01/2010	The portable gas analyzer was used to measure the methane content of the biogas
25/06/2010	Boiler no.2 is replaced with new boiler
April/2012	Boiler no.1 is replaced with new boiler
18-19/07/2012	The verification was conducted for the 2 nd monitoring period of 01/01/2009-31/05/2012.

2.2 Deviations from the Monitoring Plan

During the project implementation, there are some deviations from the monitoring plan established in the registered VCS PD version 6.4. In the 1st monitoring period, some deviations were applied due to incompleteness of monitoring equipment.. In this 2nd monitoring period, some monitoring equipments have been installed i.e. gas flow meter to measure gas to be flared, gas analyzer, fuel oil meters including the implementation of the standard methods for data monitoring and record as established in the registered PD. Therefore, in this 2nd monitoring period, some deviations are only applied for some periods when the equipments were not installed. The 1st monitoring period applied 6 deviations while there are 4 deviations applied in the 2nd monitoring period. The deviations are as follows:

Deviation 1 (Related to the use of equation to calculate MDy)

In the registered VCS PD, the equation for the calculation of MDy was given as:

$$MD_y = BG_{burn,y} * w_{CH_4,y} * D_{CH_4} * FE * GWP_{CH_4}$$

This equation is not very transparent in accounting for biogas flared and biogas combusted in the boilers. Therefore, the detailed equation can be written as:

$$MD_y = W_{CH_4} * D_{CH_4} * GWP_{CH_4} * [(BG_{toflare,y} * FE) + (BG_{combusted,y} * DE)]$$

Where:

Parameter	Details
BG _{toflare,y}	Biogas sent to flare in year y (Nm3/year)
FE	Flare efficiency (fraction)
BG _{combusted,y}	Biogas combusted for gainful use in year y (Nm3/year)
DE	Destruction efficiency of biogas combusted for a gainful use (fraction)

Given that the parameter DE (destruction efficiency) was not explicitly explained in the VCS PD, it can be taken as 100% to be conservative. This is in line with the clarification provided by SSC WG¹.

Deviation 2:

Approach in the monitoring plan

As per paragraph 15, AMS I.C version 14, for steam/heat produced using fossil fuels, the baseline emissions are calculated as $BE_{thermal, CO_2,y} = (EG_{thermal, y} / \eta_{BL, thermal}) * EF_{FF, CO_2}$. Paragraph 29 (b) (i) mentions “(a) metering the thermal and/or electrical energy produced; (i) in the case of heat energy (e.g. hot air, hot water), direct measurement of flow and temperature is required”.

¹ cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZDKUHEF5LB07QICT1P

Deviated approach in this monitoring period

As the direct measurement of temperature (in and out) and the flow of the thermal fluid was not conducted, this is a deviation from the monitoring plan in the VCS PD. Therefore, $EG_{thermal,y}$ can be estimated based on amount of heat required for starch drying which in turn is estimated on heat requirements per tonne of starch based on historical data. The approach estimates the thermal energy delivered by the project activity based on historical fuel oil consumption and starch production for the given year. The conservativeness of approach is ensured by comparing the total energy delivered by the fuels burnt in the project activity and thermal energy estimate based on historical fuel oil consumption values.

The conservativeness of the historical data: the historical data of Somdej Flour Mill Co., Ltd is available for 3 years (2002-2004) on starch production and heavy oil consumption as follows:

Year	Dry starch (tonne)	Heavy oil (litre)	Litre of HFO/tonne of dry starch
2002	64,830	2,187,940	33.8
2003	66,347	2,303,060	34.7
2004	57,837	2,111,970	36.5
Average	-	-	35.0

Based on the historical data, the project has considered the most conservative average specific energy consumption during 2002-2004, which is 33.8 litre of HFO/tonne of dry starch in year 2002.

When compared to the industrial research as per published data at Thai Tapioca Starch Association website², the average of 33.6 litre of HFO/ tonne of dry starch (range: 25.9-39.4) is found. The lowest historical data of 33.8 l/t is considered, as it is the most conservative and precise value based on the applied technology and equipment at Somdej starch plant. By the way, the value assumed in project activity is still in the suggested range and close to the average value of 33.6 litre of HFO/ tonne of dry starch.

Deviation 3:

Approach in the monitoring plan

As per paragraph 36, AMS III.H version 12, "...the fraction of methane in the gas should be measured with a continuous analyzer or, alternatively, with periodical measurements at a 95% confidence level." Footnote 13 of the same methodology mentions "fraction of methane (CH₄) in biogas shall be measured using equipment that can directly measure methane content in the biogas, estimation methane content of biogas based on measurement of other constituents of biogas such as CO₂ is not permitted."

Deviated approach in this monitoring period

The methane analyzer was installed in January 2010. Before that time (in year 2009), the project applied the instrument measuring the fraction of CO₂ and estimated the fraction of CH₄ by subtract the fraction of CO₂ from 100% therefore; the available CH₄ fraction in year 2009 is not applicable and thus, it is deviated from the validated monitoring plan and the applied methodology.

² Source: <http://www.thaitapiocastarch.org/article05.asp>

In the absence of the CH₄ fraction data in year 2009, the average data available from January 2010-May 2012 is calculated with 95% confidence level, results in 57.9% and 74.1% methane content. To be conservative, the lower CH₄ content value is applied for the baseline emission calculation and the higher CH₄ content value is applied for the project emission calculation. The conservativeness of the approach for baseline and project emission described as follow:

For baseline emissions: The lower methane content of 57.9% is applied for baseline emission calculation. Comparing to the technical proposal from Papop (technology provider), which shows that 65% is a default value at the time of design phase, the applied value is much lower than the design. In addition, comparing to the average monitored values from years 2010-2012, which range between 61.4-69.2%, the applied value is also much lower. The lower value of methane content would be more conservative to determine the baseline emission. By the way, the CH₄ percentage has no affect on baseline emission estimation, as the COD approach is more conservative.

For project emissions: The higher methane content of 74.1% is applied for project emission calculation. Comparing to the technical proposal from Papop (technology provider), which shows that 65% is a default value at the time of design phase, the applied value is much higher than the design. In addition, comparing to the average monitored values from years 2010-2012, which range between 61.4-69.2%, the applied value is also much higher. The higher value of methane content would be more conservative to determine the project emission.

For CH₄ fractions applied to estimate emission reduction in years 2010, 2011 and 2012, the values obtained from the portable methane analyzer thus, the monitored values are adjusted with 95% confidence level. The lower values are applied for estimated baseline emissions and the higher values are applied to estimate project emissions as conservative.

Deviation 4:

Approach in the monitoring plan

As per paragraph 36, AMS III.H version 12, "In all cases, the amount of biogas recovered, fuelled, flared or utilized e.g., injected into a natural gas distribution via a dedicated piped network) shall be monitored *ex post*, using continuous flow meter."

Deviated approach in this monitoring period

As the gas flow meter to monitor the amount of biogas sent to flare (GM3) was not available before June 2009, thus it is deviated from the validated monitoring plan and the applied methodology. The 1st monitoring period in years 2006-2008 applied the different values between the meter readings from the biogas produced (GM1) and biogas combusted in boiler (GM2) as AMS III.H V14, paragraph 36, and the clarification from CDM small scale working group (SSC WG) No.376³ allows the determination of the biogas captured from the two separately monitored fractions (biogas utilized and flared).

For this 2nd monitoring period, the deviated approach from the 1st monitoring period is applied for the period of January-June 2009 when the GM3 was not installed. As the project has biogas storage tank, it happens some days that the amount of biogas combusted is higher than the biogas generated and creates the negative value for the gas flared. To be conservative, the negative values are excluded from the summation of biogas to flare. From June 2009-May2012, the data readings from the gas meter (GM3)

³ <http://cdm.unfccc.int/methodologies/SSCmethodologies/clarifications/86108>

are applied. The emission reductions are estimated based on COD approach as this approach is much more conservative than biogas approach.

2.3 Grouped Project

Not applicable. This is not a grouped project.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data Unit / Parameter:	GWP _{CH₄}
Data unit:	tCO ₂ e/tCH ₄
Description:	Global Warming Potential for Methane
Source of data:	AMS III.H V12
Value applied:	21
Purpose of the data:	This parameter was used to calculate the emission of CH ₄ in form of CO ₂ for both baseline and project emission.
Any comment:	-

Data Unit / Parameter:	B _{o,ww}
Data unit:	kg CH ₄ /kg COD
Description:	Methane producing capacity of the wastewater
Source of data:	AMS III.H V12
Value applied:	0.21
Purpose of the data:	This parameter was used to calculate the emission from wastewater treatment system for both baseline and project activity.
Any comment:	As per AMS III.H V12, the IPCC default value of 0.25 kg CH ₄ /kg COD was corrected to 0.21 kg CH ₄ /kg COD to take into account the uncertainties.

Data Unit / Parameter:	UF _{BL}
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data:	AMS III.H V.12
Value applied:	0.94

Purpose of the data:	This parameter was used to calculate the baseline activity emissions.
Any comment:	-

Data Unit / Parameter:	UF_{PJ}
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data:	AMS III.H V.12
Value applied:	1.06
Purpose of the data:	This parameter was used to calculate the project activity emissions.
Any comment:	-

Data Unit / Parameter:	$MCF_{ww,treatment,BL,i}$
Data unit:	-
Description:	Methane correction factor for baseline wastewater treatment systems <i>i</i>
Source of data:	AMS III.H V.12, Table III.H.1
Value applied:	0.8
Purpose of the data:	This parameter was used to calculate the baseline emissions from the wastewater treatment system.
Any comment:	-

Data Unit / Parameter:	$MCF_{ww,treatment,PJ,k}$
Data unit:	-
Description:	Methane correction factor for project wastewater treatment systems <i>k</i>
Source of data:	AMS III.H V.12, Table III.H.1
Value applied:	0.8
Purpose of the data:	This parameter was used to calculate the project emissions from the wastewater treatment system.
Any comment:	-

Data Unit / Parameter:	COD removal efficiency-baseline
Data unit:	%

Description:	Chemical oxygen demand removal efficiency of baseline treatment system
Source of data:	Historical data of baseline lagoons based on colorimetric analysis
Value applied:	87.62
Purpose of the data:	This parameter, the COD removal efficiency of the baseline lagoons system before the project implementation, is used to calculate the baseline emissions.
Any comment:	The removal efficiency based on a measurement campaign. The efficiency was 98.45% which must be multiplied with 0.89 for a conservative estimation as per AMS III.H. The resulting COD removal efficiency factor of the baseline system is thus 87.62%.

Data Unit / Parameter:	CFE _{ww}
Data unit:	-
Description:	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems.
Source of data:	AMS III.H V.12
Value applied:	0.9
Purpose of the data:	This parameter was used to calculate the project emissions from biogas capture system.
Any comment:	-

Data Unit / Parameter:	EF _{FF,CO2}
Data unit:	tCO ₂ /TJ
Description:	Emission factor of fossil fuel replaced-residual fuel oil
Source of data:	IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23
Value applied:	77.4
Purpose of the data:	This parameter was used to calculate the baseline emissions from the use of the fossil fuel that would be used in the baseline scenario.
Any comment:	IPCC default values used for unavailability of national data. In pre project scenario, the residual fuel oil has been the main source of thermal

	energy for the processes.
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Data Unit / Parameter:	EF _y
Data unit:	tCO ₂ /MWh
Description:	CO ₂ emission factor for grid power
Source of data:	Official published data from the Electricity Generating Authority of Thailand (EGAT) and Energy Policy and Planning Office (EPPO)
Value applied:	0.521
Purpose of the data:	This parameter was used to calculate the project emissions from the use of the grid electricity in the project activity.
Any comment:	-

Data Unit / Parameter:	D _{CH₄}
Data unit:	Kg/m ³
Description:	Density of methane at normal conditions (T=273.15 K, p=101.325 kPa) of the biogas in the year y
Source of data:	Tool to determine project emissions from flaring gases containing methane. http://cdm.unfccc.int/methodologies/Tools/eb28_rep_an13.pdf
Value applied:	0.716
Purpose of the data:	This parameter was used to calculate the project emissions from flaring process.
Any comment:	-

Data Unit / Parameter:	η _{BL,thermal}
Data unit:	%
Description:	Efficiency of the boiler using fossil fuel that would have been used in the absence of the project activity.
Source of data:	AMS I.C V.14
Value applied:	100
Purpose of the data:	This parameter was used to calculate the baseline emissions from the use of the fossil fuel that would be used in the baseline scenario.

Any comment:	Default values, 100% is the most conservative choice as per AMS I.C.
Data Unit / Parameter:	NCV _{HFO}
Data unit:	TJ/tonne
Description:	Net Calorific Value of fuel oil displaced by biogas
Source of data:	IPCC 2006, Volume 2: Energy, Table 1.2.
Value applied:	0.0404
Purpose of the data:	This parameter was used to calculate the baseline emissions from the use of the fossil fuel that would be used in the baseline scenario. It provides the energy generated by the amount of heavy oil that would be used in the absence of the project.
Any comment:	IPCC default values shall be used only when country or project specific data are not available or difficult to obtain.

3.2 Data and Parameters Monitored

Data Unit / Parameter:	Q _{ww,y}
Data unit:	m ³
Description:	Volume of wastewater treated in year y
Source of data:	Measured-Volumetric flow meter-FM1
Description of measurement methods and procedures to be applied:	A flow meter for wastewater measurement is provided.
Frequency of monitoring/recording:	Continuous monitoring, record on the daily basis
Value monitored:	01/01/2009-31/12/2009 = 545,232 m ³ 01/01/2010-31/12/2010 = 439,394 m ³ 01/01/2011-31/12/2011 = 476,242 m ³ 01/01/2012-31/05/2012 = 192,037 m ³
Monitoring equipment:	In this monitoring period, 2 meters were used and replaced as detailed in section 3.3 of this monitoring report. Both of them are electromagnetic flow meter brand 'Endress+Huaser' Model: Promag 10W as detailed below:

	S/N	S/N 6B00F220000 and S/N EB0011320000
	Equipment Type	Electromagnetic flow meter
	Manufacturer	Endress+Huaser
	Model	Promag 10W
	Accuracy	±0.5%
The technical information can be found on http://www.endress.com/corporate#product/10W .		
QA/QC procedures to be applied:	The meter is high accuracy magnetic kind. The meter shall be calibrated at least once in two years or as per the manufacturer's recommendations to maintain the measuring accuracy. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager. The excel file is prepared and submitted to the plant manager to approve monthly. After approved by plant manager, the data is sent to the technology provider to ensure the wastewater treatment and biogas generation system working properly.	
Calculation method:	Not applicable	
Any comment:	This is the amount of wastewater entering the UASB system.	

Data Unit / Parameter:	COD _{ww,untreated,y}
Data unit:	mg/l
Description:	COD of wastewater entering the treatment plant
Source of data:	Measured-Colorimeter analysis
Description of measurement methods and procedures to be applied:	The COD content is analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The results are logged in the plant operation report on a daily basis.
Frequency of monitoring/recording:	Daily basis
Value monitored:	01/01/2009-31/12/2009 = 23,313 mg/l 01/01/2010-31/12/2010 = 19,139 mg/l 01/01/2011-31/12/2011 = 20,917 mg/l 01/01/2012-31/05/2012 = 22,391 mg/l
Monitoring equipment:	The portable colorimeter brand 'Hach' Model:

	DR/890 is used. The calibration interval is annually. The details of the colorimeter shown below: <table border="1"> <tr> <td>S/N</td><td>HAC04109C53333</td></tr> <tr> <td>Equipment type</td><td>Portable colorimeter</td></tr> <tr> <td>Manufacturer</td><td>Hach</td></tr> <tr> <td>Model</td><td>DR/890</td></tr> <tr> <td>Accuracy</td><td>±0.24%</td></tr> </table> The technical information can be found on http://www.hach.com/dr-890-portable-colorimeter/product-downloads?id= 7640439041	S/N	HAC04109C53333	Equipment type	Portable colorimeter	Manufacturer	Hach	Model	DR/890	Accuracy	±0.24%
S/N	HAC04109C53333										
Equipment type	Portable colorimeter										
Manufacturer	Hach										
Model	DR/890										
Accuracy	±0.24%										
QA/QC procedures to be applied:	The colorimetric method is well documented and well accepted either by national or international standards. The colorimeter shall be calibrated annually or as per manufacturer's recommendations to maintain the measuring accuracy. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager. The excel file is prepared and submitted to the plant manager to approve monthly. After approved by plant manager, the data is sent to the technology provider to ensure the wastewater treatment and biogas generation system working properly. It is recommended by the colorimeter testing company to calibrate colorimeter annually. Therefore, there are calibration gaps during 05/05/2009 to 01/11/2009 and 26/04/2012 to 31/05/2012. The accuracy of ±4.55% and ±1.05% are applied for adjusting COD values of the mentioned periods in years 2009 and 2012, respectively (detail of the error applied is in the ER spread sheet).										
Calculation method:	The meter accuracy is taken into account with the COD data read by the colorimeter during the calibration gaps. The lower values are applied for baseline emission calculation and the higher values are applied for project emission calculation to be conservative.										
Any comment:	-										

Data Unit / Parameter:	COD _{y,out,UASB}
Data unit:	mg/l
Description:	COD of water exiting the UASB treatment process
Source of data:	Measured-Colorimeter analysis
Description of measurement methods and procedures to be applied:	The COD content is analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The results are logged in the plant operation report on a daily basis.
Frequency of monitoring/recording:	Daily basis
Value monitored:	01/01/2009-31/12/2009 = 889 mg/l 01/01/2010-31/12/2010 = 817 mg/l 01/01/2011-31/12/2011 = 574 mg/l 01/01/2012-31/05/2012 = 713 mg/l
Monitoring equipment:	Same as to monitor COD _{ww,untreated,y}
QA/QC procedures to be applied:	Same as COD _{ww,untreated,y}
Calculation method:	Same as COD _{ww,untreated,y}
Any comment:	-

Data Unit / Parameter:	BG _{prod,y}
Data unit:	Nm ³
Description:	Amount of biogas produced by the digester
Source of data:	Measured-Gas flow meter (GM1)
Description of measurement methods and procedures to be applied:	The biogas produced is monitored using the gas flow meter directly.
Frequency of monitoring/recording:	Continuous monitoring, record on the daily basis
Value monitored:	01/01/2009-31/12/2009 = 4,466,988 Nm ³ 01/01/2010-31/12/2010 = 3,309,180 Nm ³ 01/01/2011-31/12/2011 = 3,675,006 Nm ³ 01/01/2012-31/05/2012 = 1,855,073 Nm ³
Monitoring equipment:	In this monitoring period, 2 meters were used and replaced as detailed in section 3.3 of this monitoring report. Both of them are thermal gas mass flow meter which has details as follow: - Brand 'Fox', model: FT2-06SSSTE3DDBO.

	S/N	6571
	Equipment type	Thermal Mass flow meter
	Manufacturer	Fox
	Model	FT2-06ISSTE3DDBO
	Accuracy	±1% R + 0.2% FS flow accuracy
The technical information can be found on http://www.foxthermalinstruments.com/ft2.php - Brand 'Endress+Huaser', model: T-mass 65l.		
	S/N	EA033E02000
	Equipment type	Thermal mass flow meter
	Manufacturer	Endress+Huaser
	Model	T-mass 65l
	Accuracy	±1.5%
The technical information can be found on http://www.endress.com/corporate#product/65l		
QA/QC procedures to be applied:	The meter shall be calibrated at least once in two years or as per the manufacturer's recommendations to maintain the measuring accuracy. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager. The excel file is prepared and submitted to the plant manager to approve monthly. After approved by plant manager, the data is sent to the technology provider to ensure the wastewater treatment and biogas generation system working properly.	
Calculation method:	Not applicable	
Any comment:	-	

Data Unit / Parameter:	W_{CH_4}
Data unit:	%
Description:	Methane content in the biogas in the year y
Source of data:	- The CH_4 content in year 2009 is calculated from the average monitored values of years 2010-2012 due to incompleteness of the monitoring equipment.

	- Measured by gas analyzer for yrs 2010-2012										
Description of measurement methods and procedures to be applied:	The fraction of methane in the biogas shall be measured with a continuous analyzer, or alternatively, with periodic measurement ensuring a 95% confidence level. In this monitoring period, the portable gas analyzer has been used and 95% confidence level is accounted for the methane fraction.										
Frequency of monitoring/recording:	Daily basis										
Value monitored:	01/01/2009-31/12/2009 = - % (not available) 01/01/2010-31/12/2010 = 69.2% (monitored) 01/01/2011-31/12/2011 = 64.3% (monitored) 01/01/2012-31/05/2012 = 61.4% (monitored)										
Monitoring equipment:	The portable analyzer brand 'Draeger', model: X-am 7000 has been used. <table border="1"> <tr> <td>S/N</td><td>ARAM-0090</td></tr> <tr> <td>Equipment type</td><td>Portable analyzer</td></tr> <tr> <td>Manufacturer</td><td>Draeger</td></tr> <tr> <td>Model</td><td>X-am 7000</td></tr> <tr> <td>Accuracy</td><td>±0.90%</td></tr> </table> The technical information can be found on http://www.draeger.com/TH/th/products/gas_detecti on/portable/multi/cin_x-am_7000.jsp?showBackButton=true	S/N	ARAM-0090	Equipment type	Portable analyzer	Manufacturer	Draeger	Model	X-am 7000	Accuracy	±0.90%
S/N	ARAM-0090										
Equipment type	Portable analyzer										
Manufacturer	Draeger										
Model	X-am 7000										
Accuracy	±0.90%										
QA/QC procedures to be applied:	The portable gas analyzer shall be calibrated every 6 months as recommended by the manufacturer. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager. The excel file is prepared and submitted to the plant manager to approve monthly. After approved by plant manager, the data is sent to the technology provider to ensure the wastewater treatment and biogas generation system working properly. There are calibration gaps during 20/12/2010 to 11/01/2011 and 05/12/2011 to 17/01/2012. The accuracy of ±4.0% and ±0.9% are applied for adjusting fraction of methane of the mentioned periods in years 2010/2011 and 2011/2012, respectively (detail of the error applied is in the ER										

	spread sheet).
Calculation method:	The deviation is explained in Deviation 3, section 2.2.
Any comment:	Refer to deviation 3.

Data Unit / Parameter:	$BG_{\text{to flare,y}}/FV_{\text{RG,h}}$										
Data unit:	Nm ³										
Description:	Amount of biogas (volumetric flow) sent to flare system										
Source of data:	From Jan–Jun 2009, calculated from the total biogas produced and biogas utilized in boiler. From July 2009, measured using gas flow meter (GM3).										
Description of measurement methods and procedures to be applied:	For the period of Jan-Jun 2009 when the gas flow meter GM3 was not installed, the biogas sent to flare system is calculated using measured values of total biogas generated and biogas utilized in boiler system. Total biogas generated is measured using gas meter-GM1; and biogas utilized in boiler using gas meter-GM2. From July 2009, the biogas sent to flare is monitored directly by gas flow meter GM3.										
Frequency of monitoring/recording:	Continuous monitoring, record on the daily basis										
Value monitored:	01/01/2009-31/12/2009 = 143,830 01/01/2010-31/12/2010 = 23,749 01/01/2011-31/12/2011 = 59,723 01/01/2012-31/05/2012 = 0										
Monitoring equipment:	In this monitoring period, 2 meters were used and replaced as detailed in section 3.3 of this monitoring report. Both of them are thermal gas mass flow meter which has details as follow: - Brand 'Fox', model: FT2-06SSSTE3DDBO. <table border="1"> <tr> <td>S/N</td><td>7544</td></tr> <tr> <td>Equipment type</td><td>Thermal mass flow meter</td></tr> <tr> <td>Manufacturer</td><td>Fox</td></tr> <tr> <td>Model</td><td>FT2-06SSSTE3DDBO</td></tr> <tr> <td>Accuracy</td><td>±1% R + 0.2% FS flow accuracy</td></tr> </table>	S/N	7544	Equipment type	Thermal mass flow meter	Manufacturer	Fox	Model	FT2-06SSSTE3DDBO	Accuracy	±1% R + 0.2% FS flow accuracy
S/N	7544										
Equipment type	Thermal mass flow meter										
Manufacturer	Fox										
Model	FT2-06SSSTE3DDBO										
Accuracy	±1% R + 0.2% FS flow accuracy										

	The technical information can be found on http://www.foxthermalinstruments.com/ft2.php - Brand 'Endress+Huaser', model: T-mass AT70. <table border="1"> <tr> <td>S/N</td><td>EJ-10209</td></tr> <tr> <td>Equipment type</td><td>Thermal mass flow meter</td></tr> <tr> <td>Manufacturer</td><td>Endress+Huaser</td></tr> <tr> <td>Model</td><td>T-mass AT70</td></tr> <tr> <td>Accuracy</td><td>±1.5%</td></tr> </table> The technical information can be found on http://www.endress.com/corporate#product/651	S/N	EJ-10209	Equipment type	Thermal mass flow meter	Manufacturer	Endress+Huaser	Model	T-mass AT70	Accuracy	±1.5%
S/N	EJ-10209										
Equipment type	Thermal mass flow meter										
Manufacturer	Endress+Huaser										
Model	T-mass AT70										
Accuracy	±1.5%										
QA/QC procedures to be applied:	The meter shall be calibrated at least once in two years or as per the manufacturer's recommendations to maintain the measuring accuracy. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager. The excel file is prepared and submitted to the plant manager to approve monthly. After approved by plant manager, the data is sent to the technology provider to ensure the wastewater treatment and biogas generation system working properly.										
Calculation method:	For the period of Jan-Jun 2009, the difference amount of biogas readings from GM1 and GM2 is applied as the flared gas and the exclusion of some negative data is done as the conservativeness approach for emission reduction estimation same as applied in the 1st monitoring period.										
Any comment:	Refer to deviation 4.										

Data Unit / Parameter:	$\eta_{\text{Flare-h}}$
Data unit:	%
Description:	Flare efficiency
Source of data:	Default value for open flares as per "Tool to determine project emissions from flaring gases containing methane" and flame detection records
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.

	The default factor of 50% might be only applied if a flame is detected at the flare for more than 20minutes in hour h, whenever biogas is sent to the flare system. If the biogas is sent to the flare for a period shorter than one hour, the flare detection signal shall be available for at least 1/3 of this period, following the same logic of the flaring tool (20 minutes out of 1 hour). If these conditions are not met, 0% default value should be used for this period. The flame detection signal shall be recorded electronically on a continuous basis. A comparison of the time stamp of the flame detection signal to the time stamp of biogas flow meter records as per SCADA records, measuring the biogas flow into the flare system, shall be used as basis for calculation of the flame detection time period. Other flare specific parameters, which might be required to monitor whether the flare operates within the specified range of operating conditions shall be monitored according to the manufacturer's specification.
Frequency of monitoring/recording:	The equipment to monitor the operational status of the flaring process should be continuous. As there is no monitoring equipment to measure the flare efficiency in this monitoring period therefore, there is no record of the data and the default value 0% is applied for the whole period.
Value monitored:	Apply 0% efficiency as per tool
Monitoring equipment:	There is incompleteness of monitoring equipment, therefore 0% efficiency is applied as per tool.
QA/QC procedures to be applied:	Flare maintenance is ensured on regular basis.
Calculation method:	Not applicable
Any comment:	-

Data Unit / Parameter:	$BG_{\text{combusted},y}$
Data unit:	Nm^3
Description:	Amount of biogas sent to boiler in year y
Source of data:	Measured-Gas flow meter (GM2)
Description of measurement methods and	The biogas produced is monitored using the gas

procedures to be applied:	flow meter directly.																												
Frequency of monitoring/recording:	Continuous monitoring, record on the daily basis																												
Value monitored:	01/01/2009-31/12/2009 = 4,315,527 Nm ³ 01/01/2010-31/12/2010 = 3,220,096 Nm ³ 01/01/2011-31/12/2011 = 3,504,633 Nm ³ 01/01/2012-31/05/2012 = 1,343,115 Nm ³																												
Monitoring equipment:	In this monitoring period, 3 meters were used and replaced as detailed in section 3.3 of this monitoring report. All of them are thermal gas mass flow meter which has details as follow: - Brand 'Endress+Huaser', model: T-mass AT70. <table border="1"> <tr><td>S/N</td><td>EJ-10209</td></tr> <tr><td>Equipment type</td><td>Thermal mass flow meter</td></tr> <tr><td>Manufacturer</td><td>Endress+Huaser</td></tr> <tr><td>Model</td><td>T-mass AT70</td></tr> <tr><td>Accuracy</td><td>±1.5%</td></tr> </table> The technical information can be found on http://www.endress.com/corporate#product/651 - Brand 'Fox', model: FT2-06SSSTE3DDBO. <table border="1"> <tr><td>S/N</td><td>7328</td></tr> <tr><td>Equipment type</td><td>Thermal mass flow meter</td></tr> <tr><td>Manufacturer</td><td>Fox</td></tr> <tr><td>Model</td><td>FT2-06SSSTE3DDBO</td></tr> <tr><td>Accuracy</td><td>±1% R + 0.2% FS flow accuracy</td></tr> </table> The technical information can be found on http://www.foxthermalinstruments.com/ft2.php - Brand 'Endress+Huaser', model: T-mass 65l. <table border="1"> <tr><td>S/N</td><td>EA033D02000</td></tr> <tr><td>Equipment type</td><td>Thermal mass flow meter</td></tr> <tr><td>Manufacturer</td><td>Endress+Huaser</td></tr> <tr><td>Model</td><td>T-mass 65l</td></tr> </table>	S/N	EJ-10209	Equipment type	Thermal mass flow meter	Manufacturer	Endress+Huaser	Model	T-mass AT70	Accuracy	±1.5%	S/N	7328	Equipment type	Thermal mass flow meter	Manufacturer	Fox	Model	FT2-06SSSTE3DDBO	Accuracy	±1% R + 0.2% FS flow accuracy	S/N	EA033D02000	Equipment type	Thermal mass flow meter	Manufacturer	Endress+Huaser	Model	T-mass 65l
S/N	EJ-10209																												
Equipment type	Thermal mass flow meter																												
Manufacturer	Endress+Huaser																												
Model	T-mass AT70																												
Accuracy	±1.5%																												
S/N	7328																												
Equipment type	Thermal mass flow meter																												
Manufacturer	Fox																												
Model	FT2-06SSSTE3DDBO																												
Accuracy	±1% R + 0.2% FS flow accuracy																												
S/N	EA033D02000																												
Equipment type	Thermal mass flow meter																												
Manufacturer	Endress+Huaser																												
Model	T-mass 65l																												

	<table> <tr> <td>Accuracy</td><td>±1.5%</td></tr> </table> The technical information can be found on http://www.endress.com/corporate#product/65FI	Accuracy	±1.5%
Accuracy	±1.5%		
QA/QC procedures to be applied:	The meter shall be calibrated at least once in two years or as per the manufacturer's recommendations to maintain the measuring accuracy. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager. The excel file is prepared and submitted to the plant manager to approve monthly. After approved by plant manager, the data is sent to the technology provider to ensure the wastewater treatment and biogas generation system working properly. There is calibration gap during 26/02/2005 to 24/06/2009 (4 years and 4 months). According to the calibration recommendation of the manufacturer⁴, 5-10 years calibration intervals is acceptable.		
Calculation method:	Not applicable		
Any comment:	-		

Data Unit / Parameter:	EC _y
Data unit:	MWh
Description:	Electricity from the grid consumed by the project activity (wastewater treatment, biogas recovery and biogas utilization/flaring systems)
Source of data:	Electricity transmission meter provided at point of supply to entire wastewater treatment plant.
Description of measurement methods and procedures to be applied:	Electricity consumption shall be monitored continuously by an electricity meter of the PEA.
Frequency of monitoring/recording:	Continuous monitoring by electricity meter of the PEA, the total electricity consumptions of each month is sent to the PP as the electricity invoice.
Value monitored:	The electricity bills are used as the electricity consumption of the project. 01/01/2009-31/12/2009 = 585.59 01/01/2010-31/12/2010 = 500.21

⁴ Standard Operating Procedure for Calibration and Maintenance, Endress+Huaser

	01/01/2011-31/12/2011 = 492.89 01/01/2012-31/05/2012 = 261.50
Monitoring equipment:	The electricity meter is owned and maintained by the PEA. The serial number of the installed meter for SD Biosupply Co., Ltd is 25249127.
QA/QC procedures to be applied:	The invoice is approved by PEA's authorized person.
Calculation method:	Not applicable
Any comment:	-

Data Unit / Parameter:	$S_{final,PJ,y}$
Data unit:	Tonne/ and type of application
Description:	Amount of final sludge generated by the wastewater treatment in the year y and type of application/disposal.
Source of data:	Sludge profile in case of any produced sludge is being taken out of the plant. Weighing equipment available at site are used before using the material for any other purpose.
Description of measurement methods and procedures to be applied:	Whenever sludge is removed from the reactor the practice of final disposal shall be monitored by keeping written evidence of the amount of sludge removes and its application. Monitoring of the final application shall be used to determine whether the final sludge disposal is either aerobic or anaerobic.
Frequency of monitoring/recording:	Whenever the sludge is removed, the quantity shall be recorded and documented.
Value monitored:	There is no sludge removed during the 2 nd monitoring period.
Monitoring equipment:	Using weighbridge before end use.
QA/QC procedures to be applied:	The technology provider holds the rights to procure all sludge from the project proponent and makes sure that the sludge removed is either used for soil application or start up of other anaerobic reactors.
Calculation method:	Not applicable
Any comment:	The UASB reactor is not supposed to produce any sludge. Only if the suspended solid concentration in the wastewater is too high, sludge production might require periodic

	removals. In addition, the removed sludge will be taken out of the plant by the technology provider and a sludge profile is kept too keep tracks of such process.
Data Unit / Parameter:	EG _{thermal,y}
Data unit:	TJ/year
Description:	Net quantity of thermal energy supplied by the dual fuel operated boiler (using biogas and HFO) after implementation of the project activity. The value is calculated based on measurements of operational parameters of the boiler.
Source of data:	The thermal oil flow rate and the temperature difference of the thermal oil before and after the boiler shall be monitored. In this monitoring period, the direct measurement of temperature (in and out) and the flow of the thermal fluid was not conducted thus, deviation approach 2 is applied. The approach estimates the thermal energy delivered by the project activity based on historical fuel oil consumption and starch production for the given year. The conservativeness of approach is ensured by comparing the total energy delivered by the fuels burnt in the project activity and thermal energy estimate based on historical fuel oil consumption values. Therefore, the amount of dry starch is the monitored parameter in order to calculate the thermal energy required in the project activity.
Description of measurement methods and procedures to be applied:	As per tool, EG_{thermal,y} is calculated as follows: $EG_{thermal,y} = \sum (T_{out} - T_{in}) \times Q_{oil,h} \times C_{oil}$ where: T out = temperature of heating medium (thermal oil) coming out the boiler T in = temperature of heating medium (thermal oil) going into the boiler Q oil,h = flow rate of thermal oil (kg) C oil = specific heat of oil in KJ/kg. K as per technical specifications In this monitoring period, the records of starch

	production of Somdej Flour Mill Co., Ltd. are used.
Frequency of monitoring/recording:	Record on the daily and monthly basis
Value monitored:	Due to incompleteness of monitoring equipment, the project has applied deviated approach 2 by monitoring the starch production in order to calculated $EG_{thermal,y}$ as follows: 01/01/2009-31/12/2009 = 73,884.3 tonnes 01/01/2010-31/12/2010 = 44,377.9 tonnes 01/01/2011-31/12/2011 = 47,204.2 tonnes 01/01/2012-31/05/2012 = 23,795.2 tonnes
Monitoring equipment:	The temperature and flow rate meter is not available. As per deviated approach 2, the starch production records of the starch plant (Somdej flour mill Co., Ltd) are used.
QA/QC procedures to be applied:	The temperature and flow rate meter shall be calibrated at least once in two years or as per the manufacturer's recommendations to maintain the measuring accuracy. As per deviated approach 2. the starch production records are kept carefully and can be compared against transportation records as well.
Calculation method:	The total energy delivered by the fuels burnt in the project activity and thermal energy estimated based on historical fuel oil consumption values are compared to ensure the conservativeness of the approach. The minimum value shall be applied for baseline emission calculation. Details of calculation as follow: $EG_{thermal,y}$-fuel energy input= $(FC_{HFO,y} * \rho_{HFO}/1000 * NVC_{HFO}) + (BG_{combusted,y} * \rho_{CH4} * W_{CH4} * NCV_{CH4})$ $EG_{thermal,y}$-historical data basis=. $(Q_{starch,y} * q_{HFO,starch} * \rho_{HFO}/1000 * NCV_{HFO})$ Where; $FC_{HFO,y}$ = See details in monitored parameter FC_{HFO} ρ_{HFO} = Density of fuel oil (0.93 kg/l) NVC_{HFO} = 40.4 GJ/tonne $BG_{combusted,y}$ = See details in monitored parameter

	$BG_{\text{combusted},y}$ ρ_{CH_4} = Density of methane (0.716 kg/m ³) W_{CH_4} = See details in monitored parameter W_{CH_4} NCV_{CH_4} = 0.050 TJ/tonne $Q_{\text{starch},y}$ = Amount of dry starch production in year y (as detailed in value monitored above) $q_{\text{HFO},\text{starch}}$ = Fuel consumption rate (0.00337 l/kg of dry starch)
Any comment:	Due to incompleteness of the monitoring equipment, the deviation approach 2 is applied.

Data Unit / Parameter:	$FC_{\text{HFO},y}$										
Data unit:	Liters/y										
Description:	Quantity of fossil fuel co-fired or fired along with biogas during a year y										
Source of data:	Measured-Fuel oil meter (OM1 and OM2)										
Description of measurement methods and procedures to be applied:	The fuel oil consumption is monitored using the fuel oil meter directly.										
Frequency of monitoring/recording:	Continuous monitoring, record on the daily basis										
Value monitored:	01/01/2009-31/12/2009 = 321,370 01/01/2010-31/12/2010 = 166,860 01/01/2011-31/12/2011 = 45,900 01/01/2012-31/05/2012 = 0										
Monitoring equipment:	2 fuel oil meters (OM1 and OM2) have been used since the commissioning date for boiler 1 and boiler 2. Both of them are Brand 'ABB', model: 25RC detailed as follow. <table> <tr> <td>S/N</td><td>TMC0157-43 and TMC-4-1-0068-044</td></tr> <tr> <td>Equipment type</td><td>Oil meter</td></tr> <tr> <td>Manufacturer</td><td>ABB</td></tr> <tr> <td>Model</td><td>25RC</td></tr> <tr> <td>Accuracy</td><td>±1%</td></tr> </table> The technical information can be found on http://www.abb.com/product/us/9AAC100398.aspx?country=TH	S/N	TMC0157-43 and TMC-4-1-0068-044	Equipment type	Oil meter	Manufacturer	ABB	Model	25RC	Accuracy	±1%
S/N	TMC0157-43 and TMC-4-1-0068-044										
Equipment type	Oil meter										
Manufacturer	ABB										
Model	25RC										
Accuracy	±1%										

QA/QC procedures to be applied:	The fuel oil meter shall be calibrated at least once in two years or as per the manufacturer's recommendations to maintain the measuring accuracy. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager. The excel file is prepared and submitted to the plant manager to approve monthly. The fuel oil meter had never been calibrated before 17/05/2009. The accuracy of $\pm 1.0\%$ is applied from 01/01/2009 to 17/05/2009 for OM1 and OM2 (detail of the error applied is in the ER spread sheet).
Calculation method:	The amount of fuel oil consumption read by the meter OM1 and OM2 is recorded separately and combined as a total consumption daily. For the period of 01/01/2009 to 17/05/2009 the meter accuracy of $\pm 1\%$ is taken into account with the monitored values.
Any comment:	-

3.3 Description of the Monitoring Plan

The monitoring plan is described in section 3.4 of the registered PD. The document procedures, work instructions and forms have been established and implemented accordance with ISO 9001 standard. The required monitoring equipment is installed by the operator. Flow meters are regularly calibrated to recognize procedures by the manufacturer and/or the external certified organizations. The sampling of wastewater is carried out on the daily basis by the onsite biogas plant operator according to appropriate industrial standards.

The biogas plant is operated by the operators (working 8 hrs/shift, 3 shifts a day) who is also responsible for wastewater sampling and analysis, record the readings from the flow meters, and maintain the daily operation of the wastewater treatment and biogas utilization facilities under the supervision of the biogas plant supervisor who is in charge of filing and processing data and report to the assistant plant manager. The data will be crosschecked by the assistant plant manager and reported monthly to the biogas plant manager for approval. After the data is approved by the plant manager, it is sent to Papop Co., Ltd, the technology provider, to ensure the wastewater treatment and biogas generation unit including the monitoring equipment is working properly. Papop will provide the suggestions or system checks.

All biogas plant staffs were trained by the Papop Company prior to full commissioning of biogas plant and also regularly trained by the biogas plant supervisor and the assistant plant manager in relevant issues to operate and maintain the wastewater treatment and biogas generation/utilization facilities. In addition, the staffs are also trained by other departments of the factory i.e. quality control department, safety department or sometimes, staffs are sent for the external training. All the training documents are based on the ISO system of the company. **Figure 3** outlines the structure of operational and management of the project activity.

All relevant data is stored electronically in excel sheets. The monitoring records shall be archived for a period of crediting period + 2 years.

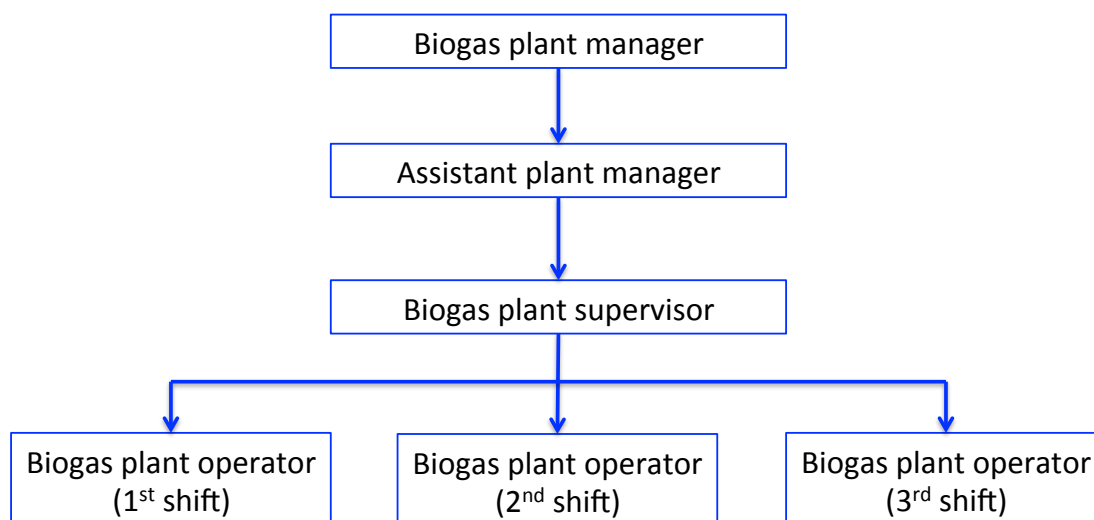


Figure 3: The structure of operational and management of the project activity

Calibration Records

The calibration record of wastewater flow meter is shown below;

Flow meter	Serial number	Position	Cal. date	Cal. by
FM1	S/N 6B00F220000 (Endress+Hauser)	Wastewater volume flow to UASB (Meter installed from the date of commissioning-	25/03/2008	Endress+Hauser (manufacturer)
			17/03/2009	MIT
			08/09/2010	MIT
	S/N EB0011320000 (Endress+Hauser)	Wastewater volume flow to UASB (Meter installed on January 14, 2012)	15/11/2011	Endress+Hauser (manufacturer)

The calibration record of gas meter is shown below;

Flow meter	Serial number	Position	Cal. date	Cal. by
GM1	6571 (Fox)	Biogas produced from UASB (Meter installed on September 9, 2008)	05/09/2008	FOX (manufacturer)
			24/06/2009	MIT
			27/05/2010	MIT
			09/05/2011	MIT

	EA033E02000 (Endress+Hauser)	Biogas produced from UASB (Meter installed on December 11, 2011)	10/10/2011	Endress+Hauser (manufacturer)
GM2	EJ-10209 (Endress+Hauser)	Biogas sent to Boiler (Meter installed on June 10, 2005)	26/02/2005	Endress+Hauser (manufacturer)
			24/06/2009	MIT
	7328 (FOX)	Biogas sent to Boiler (Meter installed on July 19, 2009)	27/03/2009	FOX (manufacturer)
			29/05/2010	MIT
			09/05/2011	MIT
	EA033D02000 (Endress+Hauser)	Biogas sent to Boiler (Meter installed on December 11, 2011)	07/10/2011	Endress+Hauser (manufacturer)
GM3	7544 (FOX)	Biogas sent to Flare (Meter installed on June 15,2009)	26/05/2009	MIT
			29/05/2010	MIT
			09/05/2011	MIT
	EJ-10209 (Endress+Hauser) (used to be GM2)	Biogas sent to Flare (Meter installed on December 9, 2011)	24/06/2009	Endress+Hauser (manufacturer)

The calibration record of COD measurement is shown below;

Flow meter	Serial number	Position	Calibration record	Cal.by
Colorimeter	HAC041090C533 33 (HACH)	Laboratory (Applied since June 10, 2005)	06/05/2008	Envi Science
			02/11/2009	Envi Science
			19/05/2010	Envi Science
			26/04/2011	Envi Science

The calibration of gas analyzer

Flow meter	Serial number	Position	Calibration record	Cal.by
Gas analyzer	ARAM-0090 (Drager)	Biogas produced from UASB (Applied since January 20, 2010)	12/01/2010	Drager (manufacturer)
			23/06/2010	Drager (manufacturer)
			12/01/2011	Drager (manufacturer)
			08/06/2011	Drager (manufacturer)

			18/01/2012	Drager (manufacturer)
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The calibration of fuel oil meter

Flow meter	Serial number	Position	Calibration record	Cal.by
OM1	TMC0157-43 (ABB)	Boiler 1 (Meter installed from the date of commissioning)	17/05/2009	MIT
			14/05/2010	MIT
			28/04/2011	MIT
OM2	TMC-4-1-0068-044 (ABB)	Boiler 2 (Meter installed from the date of commissioning)	17/05/2009	MIT
			14/05/2010	MIT
			28/04/2011	MIT

The calibration record of electricity consumption of SD Biosupply Co., Ltd.

Electricity consumption of SD Biosupply Co., Ltd. is imported from the Provincial Electricity Authority (PEA) who is the government organization of Thailand. Amount of electricity imported shows on the PEA meter, which will be maintained by the PEA.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

Emission reduction calculations are split in two parts, (A) methane avoidance component according to AMS III.H V.12, and (B) heat generation component according to AMS I.C V14.

4.1 Baseline Emissions

(A) Methane Avoidance Component as per AMS III.H V.12

According to the registered VCS PD, the baseline emissions are calculated as

$$BE_y = BE_{ww,treatment,y}$$

$$BE_{ww,treatment,y} = \sum_i Q_{ww,i,y} * COD_{removed,i,y} * MCF_{ww,treatment,BL,i} * B_{O,ww} * UF_{BL} * GWP_{CH_4} \quad (1)$$

Where,

Parameter	Details	Quantification (values after error or 95% confidence level applied)
BE _{ww, treatment, y}	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO ₂ e)	01/01/2009-31/12/2009 = 35,884 01/01/2010-31/12/2010 = 25,531

		01/01/2011-31/12/2011 = 28,780 01/01/2012-31/05/2012 = 12,237
$Q_{ww, i, y}$	Volume of wastewater treated in baseline wastewater treatment system i in year y (m^3)	01/01/2009-31/12/2009 = 545,251 01/01/2010-31/12/2010 = 439,394 01/01/2011-31/12/2011 = 476,242 01/01/2012-31/05/2012 = 192,037
$COD_{removed, i, y}$	Chemical oxygen demand removed by baseline treatment system i in year y (tonnes/ m^3) measured as the difference between inflow COD and the outflow COD in system i	See details in excel calculation
$MCF_{ww, treatment, BL, i}$	Methane correction factor for the baseline anaerobic wastewater treatment i	0.8
i	Index for baseline wastewater treatment system	1
$B_{o, ww}$	Methane producing capacity of the wastewater	0.21
UF_{BL}	Model correction factor to account for model uncertainties	0.94
GWP_{CH_4}	Global Warming Potential for methane	21

For this project which falls in the case 1(vi) as per AMS III.H V.12, paragraph 31, the emission reductions 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. The emission reductions achieved in any year are the lowest value of the following:

$$ER_{y, ex-post} = \min((BE_{y, ex-post} - PE_{y, ex-post} - LE_{y, ex-post}), (MD_y - PE_{power, y} - PE_{biomass, y} - LE_{y, ex-post})) \quad (2)$$

In case of flaring/combustion MD_y will be measured using the conditions of the flaring process:

$$MD_y = BG_{burnt, y} * W_{CH_4, y} * D_{CH_4} * FE * GWP_{CH_4} \quad (3)$$

As per the **Deviation 1**, the project activity aims to use methane destruction devices (boiler burners) other than flare for biogas combustion or in emergency case, the activity will use a combination of a flare and another methane destruction device. Therefore; the recommendation by SSC WG as per the following

link cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKUHEF5LB07QICT1P is applied to calculate MD_y of the project activity. Based on this, the alternative MD_y value is deviated from the approved methodology and can be calculated as follows:

$$MD_y = W_{CH_4,y} * D_{CH_4} * GWP_{CH_4} * [(BG_{toflare,y} * FE) + (BG_{combusted,y} * DE)] \quad (4)$$

Where,

Parameter	Details	Quantification (values after error or 95% confidence level applied)
MD _y	Methane captured and destroyed/gainfully used by the project activity in the year y (tCO ₂ e)	01/01/2009-31/12/2009 = 37,564 01/01/2010-31/12/2010 = 31,015 01/01/2011-31/12/2011 = 30,922 01/01/2012-31/05/2012 = 11,430
W _{CH₄, y}	Methane content in the biogas in the year y (mass fraction)	01/01/2009-31/12/2009 = 57.9% 01/01/2010-31/12/2010 = 64.1% 01/01/2011-31/12/2011 = 58.7% 01/01/2012-31/05/2012 = 56.6%
D _{CH₄}	Density of methane at the temperature and pressure of the biogas in the year y (tonnes/m ³)	0.000716
GWP _{CH₄}	Methane producing capacity of the wastewater	21
BG _{toflare,y}	Biogas sent to flared in year y (Nm ³)	01/01/2009-31/12/2009 = 143,830 01/01/2010-31/12/2010 = 23,749 01/01/2011-31/12/2011 = 59,723 01/01/2012-31/05/2012 = 0
BG _{combusted,y}	Biogas combusted for gainful use in year y (Nm ³)	01/01/2009-31/12/2009 = 4,315,527 01/01/2010-31/12/2010 = 3,220,096 01/01/2011-31/12/2011 = 3,504,633 01/01/2012-31/05/2012 = 1,343,115

FE	Flare efficiency in year y	0%
DE	Destruction efficiency of biogas combusted for a gainful use	100%

(B) Heat Generation Component as per AMS I.C V.14

According to the registered VCS PD, the baseline emissions are calculated as

$$BE_{thermal,CO_2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{FF,CO_2} \quad (5)$$

Where,

Parameter	Details	Quantification (values after error or 95% confidence level applied)
$BE_{thermal,CO_2,y}$	the baseline emissions from steam/heat displaced by the project activity during the year y in tCO ₂ e	01/01/2009-31/12/2009 = 7,251 01/01/2010-31/12/2010 = 4,355 01/01/2011-31/12/2011 = 4,633 01/01/2012-31/05/2012 = 2,107
$EG_{thermal,y}$	the net quantity of steam/heat supplied by the project activity during the year y in TJ.	01/01/2009-31/12/2009 = 93,686 01/01/2010-31/12/2010 = 56,271 01/01/2011-31/12/2011 = 59,855 01/01/2012-31/05/2012 = 30,172
EF_{FF,CO_2}	the CO ₂ emission factor per unit of energy of the fuel that would have been used in the baseline plant in (tCO ₂ / TJ), obtained from reliable local or national data if available, otherwise, IPCC default emission factors are used.	77.4
$\eta_{BL,thermal}$	the efficiency of the plant using fossil fuel that would have been used in the absence of the project activity	100%

As per registered VCS PD, the amount of energy delivered by the dual fuel fired boiler shall be used to estimate the baseline emissions. Due to incompleteness of the monitoring equipment, a deviation has been made, based on amount of heat required for starch drying, which in turn is estimated on heat

requirements per tonne of starch based on historical data. The approach estimates the thermal energy delivered by the project activity based on historical fuel oil consumption and starch production for the given year.

The deviated approach ensures that efficiency lost in system due to dual fired system is conservatively adjusted in baseline emissions. This means that if any efficiency loss happens due to dual fired system and the energy of same is supplied by fuel oil, using the given approach the loss is accounted in biogas usage, thereby estimating lower fuel oil replacement for baseline emission estimation. The conservativeness of approach is ensured comparing the total energy delivered by the fuels burnt in the project activity and thermal energy estimate based on historical fuel oil consumption values. Please refer to **Deviation 2**.

4.2 Project Emissions

(A) Methane Avoidance Component as per AMS III.H V.12

According to the registered VCS PD, the project emissions are calculated as

$$PE_y = PE_{power,y} + PE_{ww,treatment,y} + PE_{fugitive,y} + PE_{flaring,y} \quad (6)$$

Where,

Parameter	Details	Quantification (values after error or 95% confidence level applied)
PE_y	Project emissions in year y (tCO ₂ e)	01/01/2009-31/12/2009 = 7,887 01/01/2010-31/12/2010 = 4,926 01/01/2011-31/12/2011 = 5,379 01/01/2012-31/05/2012 = 2,107
$PE_{power,y}$	Emissions from electricity or fuel consumption in the year y (tCO ₂ e)	01/01/2009-31/12/2009 = 305 01/01/2010-31/12/2010 = 261 01/01/2011-31/12/2011 = 257 01/01/2012-31/05/2012 = 136
$PE_{ww, treatment, y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation (tCO ₂ e)	01/01/2009-31/12/2009 = 1,537 01/01/2010-31/12/2010 = 1,255 01/01/2011-31/12/2011 = 912 01/01/2012-31/05/2012 = 446

PE _{fugitive, y}	Methane emissions from biogas release in capture systems in year y (tCO ₂ e)	01/01/2009-31/12/2009 = 4,443 01/01/2010-31/12/2010 = 3,143 01/01/2011-31/12/2011 = 3,600 01/01/2012-31/05/2012 = 1,524
PE _{flaring, y}	Methane emissions due to incomplete flaring in year y (tCO ₂ e)	01/01/2009-31/12/2009 = 1,602 01/01/2010-31/12/2010 = 268 01/01/2011-31/12/2011 = 628 01/01/2012-31/05/2012 = 0

1. Emissions from electricity consumption (PE_{power,y})

Emissions from electricity consumption by the project activity facilities are calculated according to the paragraph 19 of AMS III.H. as given below.

$$PE_{power,y} = EC_y * EF_y \quad (7)$$

Where,

Parameter	Details	Quantification (values after error or 95% confidence level applied)
PE _{power,y}	Emissions from electricity or fuel consumption in the year y (tCO ₂ e)	01/01/2009-31/12/2009 = 305 01/01/2010-31/12/2010 = 261 01/01/2011-31/12/2011 = 257 01/01/2012-31/05/2012 = 136
EC _y	Electricity from grid consumed by the project activity (wastewater treatment, biogas recovery and biogas utilization/ flaring system (MWh)	01/01/2009-31/12/2009 = 586 01/01/2010-31/12/2010 = 500 01/01/2011-31/12/2011 = 493 01/01/2012-31/05/2012 = 262
EF _y	Thai national grid emission factor (tCO ₂ e/MWh)	0.521

2. Emissions from degradable organic carbon in treated wastewater ($PE_{ww, treatment, y}$)

Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation are calculated as per equation 2/paragraph 20 in AMS.III.H using an uncertainty factor 1.06. The following equation is used.

$$PE_{ww, treatment, y} = \sum Q_{ww, k, y} * COD_{removed, PJ, k, y} * MCF_{ww, treatment, PJ, k, y} * B_{o, ww} * UF_{PJ} * GWP_{CH_4}$$

(8)

Where,

Parameter	Details	Quantification (values after error or 95% confidence level applied)
$PE_{ww, treatment, y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation (tCO ₂ e)	01/01/2009-31/12/2009 = 1,537 01/01/2010-31/12/2010 = 1,255 01/01/2011-31/12/2011 = 912 01/01/2012-31/05/2012 = 447
$Q_{ww, k, y}$	Volume of wastewater treated in project wastewater treatment system k in year y (m ³)	01/01/2009-31/12/2009 = 545,251 01/01/2010-31/12/2010 = 439,394 01/01/2011-31/12/2011 = 476,242 01/01/2012-31/05/2012 = 192,037
$COD_{y, removed, PJ, k}$	Chemical oxygen demand removed by project wastewater treatment system k in year y (tonnes/m ³), measured as the difference between inflow COD and the outflow COD in system k	See details in excel calculation
$B_{o, ww}$	Methane producing capacity of the wastewater (IPCC default value of 0.21 kg CH ₄ /kg COD)	0.21
$MCF_{ww, treatment, PJ, k}$	Methane correction factor for the project wastewater treatment system k	0.8
UF_{PJ}	Model correction factor to account for model uncertainties	1.06

GWP _{CH4}	Global Warming Potential for methane	21
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3. Methane fugitive emissions on account of inefficiencies in capture systems (PE_{fugitive, y})

Project activity emissions from methane release in capture systems are determined as per paragraph 27 of AMS III.H as given below.

$$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y} \quad (9)$$

$$PE_{fugitive,ww,y} = (1 - CEF_{ww,y}) * MEP_{ww, treatment,y} * GWP_{CH4} \quad (10)$$

$$MEP_{ww,treatment,y} = Q_{ww,y} * B_{o,ww} * UF_{PJ} * \sum_k COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k} \quad (11)$$

Where,

Parameter	Details	Quantification (values after error or 95% confidence level applied)
PE _{fugitive,y}	Emissions from methane release in capture and utilization/combustion flare systems in year y (tCO ₂ e)	01/01/2009-31/12/2009 = 4,443 01/01/2010-31/12/2010 = 3,143 01/01/2011-31/12/2011 = 3,600 01/01/2012-31/05/2012 = 1,524
PE _{fugitive,ww,y}	Fugitive emission through capture inefficiencies in the anaerobic wastewater treatment in the year y (tCO ₂ e)	01/01/2009-31/12/2009 = 4,443 01/01/2010-31/12/2010 = 3,143 01/01/2011-31/12/2011 = 3,600 01/01/2012-31/05/2012 = 1,524
PE _{fugitive,s,y}	Fugitive emission through capture inefficiencies in the anaerobic sludge treatment in the year y (tCO ₂ e)	There is no sludge treatment in the project activity.
CEF _{ww}	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems	0.9
MEP _{ww, treatment,y}	Methane emission potential of wastewater treatment systems equipped with biogas recovery system in year y (tonnes)	01/01/2009-31/12/2009 = 2,116 01/01/2010-31/12/2010 = 1,497

		01/01/2011-31/12/2011 = 1,714 01/01/2012-31/05/2012 = 726
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4. Methane emissions due to incomplete flaring ($PE_{\text{flaring}, y}$)

Methane emissions due to incomplete flaring in year y are calculated as per the 'Tool to determine project emissions from flaring gases containing methane'. The project proponent has installed an open flaring system. For the determination of the flare efficiency, the default value of 0% is applied for the ex-post calculation as mentioned in **Deviation 1**. The amount of gas sent to flare is calculated by using the difference values of the meters from biogas produced and biogas combusted for the periods of Jan-June 2009 due to incomplete of monitoring equipment as mentioned in **Deviation 4**. As the portable gas analyzer was applied in 2010, the methane content of biogas is calculated by using the average monitored values from years 2010-2012 with 95% confidence level. The monitored values of years 2010-2012 are also adjusted with 95% confidence level and applied to the given years. The lower methane content is applied for baseline emission calculation and the higher methane content is applied for project emission calculation to be conservative as detailed in **Deviation 3**. The following equation is used to calculate the methane emission due to incomplete flaring.

$$PE_{\text{flaring}, y} = \sum_{h=1}^{8760} TM_{RG,h} * (1 - \eta_{\text{flaring}, h}) * \frac{GWP_{CH_4}}{1000} \quad (12)$$

$TM_{RG,h} = FV_{RG,h} * fv_{CH_4, RG,h} * \rho_{CH_4,n}$ which is rewritten in 1st monitoring report as

$$TM_{RG,h} = Q_{\text{biogas, flare}, y} * \%CH_4 * D_{CH_4} \quad (13)$$

Where,

Parameter	Details	Quantification (values after error or 95% confidence level applied)
$PE_{\text{flaring}, y}$	Methane emissions due to incomplete flaring in year y (tCO ₂ e)	01/01/2009-31/12/2009 = 1,602 01/01/2010-31/12/2010 = 268 01/01/2011-31/12/2011 = 628 01/01/2012-31/05/2012 = 0
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour h (kg/h)	01/01/2009-31/12/2009 = 76,298 01/01/2010-31/12/2010 = 12,762 01/01/2011-31/12/2011 = 29,927

		01/01/2012-31/05/2012 = -
$\eta_{\text{flare}, h}$	Flare efficiency in hour h	0
$Q_{\text{biogas, flare}, y}$ ($FV_{\text{RG}, h}$)	The biogas quantity flared by the project activity (Nm^3)	01/01/2009-31/12/2009 = 143,830 01/01/2010-31/12/2010 = 23,749 01/01/2011-31/12/2011 = 59,723 01/01/2012-31/05/2012 = - (see details in Deviation 4)
%CH ₄ ($f_{\text{VCH}_4, \text{RG}, h}$)	% of methane in biogas	01/01/2009-31/12/2009 = 74.1% 01/01/2010-31/12/2010 = 75.1% 01/01/2011-31/12/2011 = 70.0% 01/01/2012-31/05/2012 = 66.4% (see details in Deviation 3)
D_{CH_4} ($\rho_{\text{CH}_4, n}$)	Density of methane at normal condition (kg/m^3)	0.716

(B) Heat Generation Component as per AMS I.C V.14

According to the registered VCS PD, the project emissions are calculated as per 'tool to calculate project or leakage CO₂ emissions from fossil fuel combustion' as follow:

$$PE_{\text{FC}, y} = FC_{\text{HFO}, y} * NCV_{\text{HFO}} * EF_{\text{HFO}, \text{CO}_2} \quad (14)$$

Where,

Parameter	Details	Quantification
$PE_{\text{FC}, y}$	Project emissions due to combustion of fossil fuel in year y (tCO_2e)	01/01/2009-31/12/2009 = 937 01/01/2010-31/12/2010 = 485 01/01/2011-31/12/2011 = 133 01/01/2012-31/05/2012 = 0
$FC_{\text{HFO}, y}$	Amount of fossil fuel used in boiler in ton/yr	01/01/2009-31/12/2009 = 299.75

		01/01/2010-31/12/2010 = 155.18 01/01/2011-31/12/2011 = 42.69 01/01/2012-31/05/2012 = 0
NCV _{HFO}	NCV of fossil fuel used in the process (TJ/tonne)	0.0404
EF _{HFO,CO2}	Emission factor of heavy fuel oil as per IPCC (tCO ₂ /TJ)	77.4

4.3 Leakage

The leakage predicted in the methodology employed is not applicable for this project activity as there was no transference of equipment in spite of new equipment had to be acquired.

4.4 Summary of GHG Emission Reductions and Removals

Year	Baseline Emission (tCO ₂ e)			Project Emission (tCO ₂ e)			Total Emission Reduction (tCO ₂ e)
	AMS.III.H	AMS.I.C	Total	AMS.III.H	AMS.I.C	Total	
1 Jan-31 Dec, 2009	35,884	7,251	43,135	7,887	937	8,824	34,311
1 Jan-31 Dec, 2010	25,531	4,355	29,886	4,926	485	5,411	24,475
1 Jan-31 Dec, 2011	28,780	4,633	33,413	5,397	133	5,530	27,881
1 Jan-31 May, 2012	12,237	2,107	14,344	2,107	0	2,107	12,236
Total	102,432	18,346	120,778	20,317	1,555	21,872	98,903⁵

The increase in emission reductions can be attributed due to increase in days of operation and wastewater generation per unit ton of starch production during the current monitoring period. In the registered VCS PDD, the days of operation per year was assumed as 240 days/year and the wastewater generation rate was assumed at 4.7m³/ton of starch. These values were taken at the time of writing the VCS PD and validated by the DOE. During this monitoring period, the raw material was abundantly available to run the starch factory for longer duration than average. Furthermore, the factory also received special order from the government, which led to increase in the overall production; this is the result from the interference of tapioca price project of the government during years 2008/2009 and

⁵ Round down number as per excel sheet calculation to be conservative.

2011/2012. The wastewater generation rate during the current monitoring period ranges between 7.38-10.1 m³/t starch. It is dependent on the quality of raw material (starch content in the roots) due to variations in the weather conditions and crop production. The starch factory has also done some modification in their production processes to extract more starch from Tapioca, which also results in higher wastewater generation rate. The above-mentioned factors could not be envisaged at the time of validation. It may also happen that in the future verification, the production may go down due to the factors mentioned above. It should also be noted that during the first verification, the emission reductions were close to the PD estimates. Therefore; it can be concluded that the increase in emission reductions is not permanent but dependent on various factors, which can neither be controlled nor predicted in advance.

5 ADDITIONAL INFORMATION

Not applicable.