



SD BIOSUPPLY WASTEWATER TREATMENT AND BIOGAS UTILIZATION PROJECT



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Project Title	SD Biosupply Wastewater Treatment and Biogas Utilization Project
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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The proposed project has been implemented at Somdej Flour Mill Co. Ltd since 18th August 2005. The project activity is located in Karasin province, northeast of Thailand. The starch plant has a total production capacity of 300 tonnes of native starch per day. 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 plant, replacing the open anaerobic lagoon-based system. The UASB system generates and recovers biogas for energy generation purposes, avoiding methane emissions to the atmosphere. The methane captured by biogas system is consumed partially in the hot oil boilers for thermal utilization in starch drying process. This activity leads reduction of CO₂ emission by replacing fossil fuel consumption in the starch manufacturing process. Any surplus of biogas consumption is flared in the open flare system.

Prior to implementation of the project activity, the wastewater of the starch plant the plant was treated in 8 cascading open anaerobic lagoons. These conditions result in anaerobic environment within the ponds, resulting in methane generation from the organic content of the wastewater. Meanwhile, the energy supplied in the starch drying process was produced by heavy fuel oil (HFO) consuming in two hot oil boilers of starch factory. The consumption of HFO as fossil fuel is considered as a baseline thermal component of the project.

The project was registered as a VCS project since 06/05/2010. The first crediting period was considered from 28/03/2006 to 27/03/2016, while the second crediting period considers from 28/03/2016 to 27/03/2026. This is the first monitoring period under second crediting period which starts from 28/03/2016 to 31/12/2016. The total emission reductions archived in this monitoring period is 37,447 tCO₂.

1.2 Sectoral Scope and Project Type

The sectoral scope and type of the project is as follows:

Methane destruction component

Category III.H Version: 18.0:	Methane Recovery in Wastewater Treatment
Type of GHG emission mitigation action:	Destruction of methane emission
Sectoral Scope:	13 Waste Handling and Disposal

Thermal energy production component

Category I.C Version: 20.0:	Thermal energy production with or without electricity
Type of GHG emission mitigation action:	Displacement of more-GHG-intensive thermal energy production
Sectoral Scope:	1 Energy Industries

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

1.3 Project Proponent

Organization name	SD Biosupply Co., Ltd (Project owner: Responsible for implementation and operation of the project activity)
Contact person	Mr. Sivaroj Suralaertrungsri
Title	Managing Director
Address	113 Soi Chokchaijonjamrern, Rama III Road, Bangpongpan, Yannawa, Bangkok 10120, Thailand
Telephone	+66 2 683 1900-7
Email	mdroj_2work@somdej.co.th

1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon Asset Management Ltd. (Project developer: Responsible for development of emission reduction through the Voluntary Carbon Standard)
Contact person	Mr. Heuberger Renat
Title	CEO
Address	Technoparkstrasse 1, Zurich 8005 Switzerland
Telephone	+41 43 501 35 50
Email	registration@southpole.com

1.5 Project Start Date

The project start date was defined on 16/09/2005 based on the date when emission reductions began. As per VCS standard, the start date of crediting period is defined as 28/03/2006.

1.6 Project Crediting Period

This is the second crediting period of ten years. The crediting period starts from 28/03/2016 to 27/03/2026.

1.7 Project Location

The project site is located on the site of the SD Starch factory, 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 1.

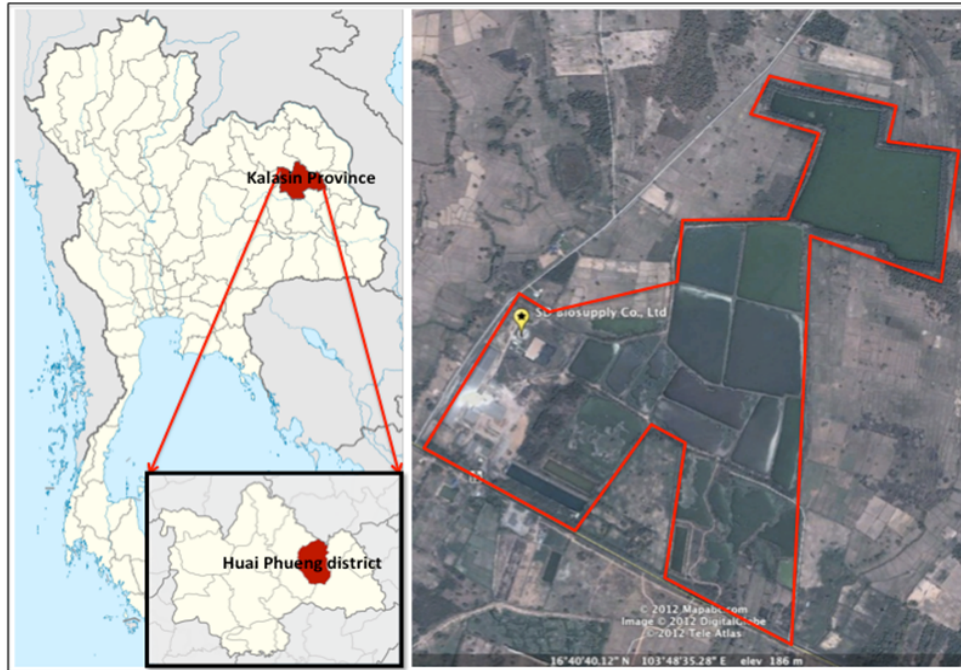


Figure 1: Project location and boundaries

1.8 Title and Reference of Methodology

Baseline and Monitoring Methodology for the project activity is defined:

- AMS III.H: Methane Recovery in Wastewater Treatment, version 18
- AMS I.C: Thermal energy for user with or without electricity, version 20

Tool referenced in the applied methodologies:

AMS-III.H

- “Project emissions from flaring”, version 3.0 (Tool06)

AMS-I.C

- “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”, version 3.0 (Tool03)
- “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” version 3.0 (Tool05)

1.9 Participation under other GHG Programs

The project is not registered under any GHG Program.

1.10 Other Forms of Credit

The project does not seek any GHG-related environmental credits.

1.11 Sustainable Development

The proposed project activity has been assessed in line with the sustainable development as per

1. National Resource and Environmental Dimension

- The project activity reduces GHG emission through the avoidance of methane emission from the existing open lagoon.
- The project activity captures biogas from the anaerobic wastewater treatment of starch factory. The biogas recovered is used for energy generation purpose; thereby the bad odor is reduced. The ambient air quality is improved accordingly.
- The project activity reduces GHG emission, other air pollutant emissions such as oxides of nitrogen, oxides of sulphur, carbon monoxide and particulates through reducing the combustion of fossil fuels.
- The project activity reduces the carbon intensity of the Thai national grid by reducing the emission of GHGs.
- The treated wastewater is recycled for internal consumption in the starch factory.

2. Social Dimension

The training program is provided to local employees of the project annually in order to enhance work skills.

3. Development/ Transfer of Technology

The project involves the use of some imported components and hence the transfer of technology from outside the country which provides an opportunity to promote and disseminate the successful application and integration of technologies for replication across Thailand.

4. Economic Dimension

- The project activity leads to the utilization of renewable energy and contributes thereby to energy security and savings in expenditure on imported fuel.
- The project activity increases the employment opportunities for the local people by setting up an industrial unit in the area.
- The project activity contributed to the employment of local people both in the skilled and semi-skilled category during the construction phase.

2 SAFEGUARDS

2.1 No Net Harm

There is no negative environmental and socio-economic impact. The project is a renewable energy biogas based thermal generation activity. In line with the operation license issued by the department of industrial work, the project follows the local regulation in order to maintain and prevent the environmental impact.

2.2 Local Stakeholder Consultation

Invitation procedure

The Stakeholder Consultation has been conducted by the project owner SD Biosupply Co., Ltd. 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 verbal means about the meetings, and place and date of the meetings. The stakeholder consultation was held at communities around the starch plant on 22/07/2008. Thus, all participants were able to examine the location where the proposed project takes place.

Meeting Participants

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

1. Local residents
2. Local government representatives
3. Delegates from political parties
4. Local entrepreneurs
5. Employees

There were 18 participants attended this meeting.

Language

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

Meeting agenda

- Project description of the project 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 documentation in following subjects 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 other emissions from the lagoons and creating new jobs.

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

The ongoing communication during the project implementation

The project activity has the grievance mechanism in place. The local stakeholder can either report at the security guard when they have any issue which want to raise to the plant or report the issue to the head of their village, then the head of the village would gather all the information and raise to the plant. During this monitoring period, no complain has been raised against the project activity. This could be confirmed during the remote audit.

2.3 AFOLU-Specific Safeguards

It is a non-AFOLU projects, perhaps, this section is not required.

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

The project was registered on 06/05/2010. The current monitoring period is from 28/03/2016 to 31/12/2016. The emission reductions for this period are 37,447 tCO₂e (VCUs). The implementation status of the project activity during this monitoring period was in-lined with the registered PD. There is no natural disaster or any accident that leads to the significantly changes in the amount of emission reductions in this period.

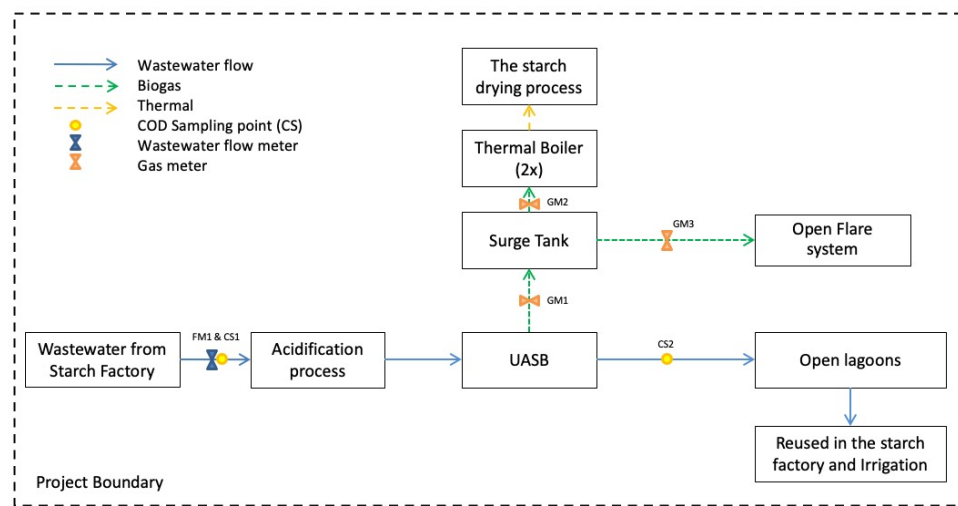


Figure 1 Flow Diagram of the project activity

3.2 Deviations

2.3.1 Methodology Deviations

Determination of EG_{thermal}

Formula that is deviated from the applied methodology is described below;

As per paragraph 33, AMS I.C version 20, for steam/heat produced using fossil fuels, the baseline emissions are calculated as;

$$BE_{\text{thermal, CO}_2, y} = (EG_{\text{thermal, y}} / \eta_{\text{BL, thermal}}) \times EF_{\text{FF, CO}_2}$$

As per the measurement requirement of monitoring parameter $EG_{\text{thermal, y}}$, heat generation is determined as the difference of the enthalpy of the hot fluid or thermal fluid generated by the heat generation equipment and the sum of the enthalpies of the feed-fluid. The respective enthalpies should be determined based on the mass (or volume) flows and the temperatures.

Deviated approach or formula / Deviated approach in this monitoring period:

The project proponent is not able to conduct the measurement of temperature (in and out) and the flow of the thermal fluid as per the applied methodology. Therefore, the deviated approach is introduced as following. The monitoring parameter of $EG_{\text{thermal, y}}$ could be estimated based production historical data and actual fuel energy input. By considering historical data, the estimation is considered from heat requirements per tonne of starch prior the implementation of project activity. 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 conservative 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.

The calculation formula is determined as following:

$$EG_{\text{thermal, y}} = \min (EG_{\text{thermal, historical}}, EG_{\text{thermal, energy input}})$$

Historical production approach:

$$EG_{\text{thermal, historical}} = Q_{\text{starch}} \times q_{\text{HFO, starch}} \times D_{\text{HFO}} \times NCV_{\text{HFO}}$$

Where:

Parameter	Details
$EG_{\text{thermal, historical}}$	Net quantity of thermal energy supplied by the project during year y (TJ)
Q_{starch}	Quantity of starch production in year y (tonne)
$Q_{\text{HFO, starch}}$	Specific energy consumption (HFO/tonne)
D_{HFO}	Density of HFO (tonne/litter)
NCV_{HFO}	NCV of fossil fuel (HFO) used in the process (0.0404 TJ/tonne)

Fuel energy input approach:

$$EG_{\text{thermal, energy input}} = BG_{\text{combusted, y}} \times W_{\text{CH}_4} \times D_{\text{CH}_4} \times NCV_{\text{CH}_4}$$

Where:

Parameter	Details
$EG_{\text{thermal, energy input}}$	Net quantity of thermal energy supplied by the project during year y (TJ)
$BG_{\text{combusted, y}}$	Amount of biogas sent to boiler in year y (Nm ³)
W_{CH_4}	Methane content in the biogas in the year y (%)
D_{CH_4}	Density of methane at normal condition (tonne/Nm ³)
NCV_{CH_4}	NCV of methane (TJ/tonne)

Where:

Justification for deviation:

When compared to the industrial research as per published data at Thai Tapioca Starch Association website¹, 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.

2.3.2 Project Description Deviations

The project activity was operated as written in the registered PD. This section is not applicable.

3.3 Grouped Projects

This project is not a grouped project. This section is not applicable.

¹ Source <http://www.thailandtapiocastarch.net/technology-detail/1/3/>:

4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

Data / Parameter	GWP _{CH4}
Data unit	tCO ₂ e/tCH ₄
Description	Global Warming Potential for Methane
Source of data	Default value as per IPCC
Value applied	25
Justification of choice of data or description of measurement methods and procedures applied	Default value as per IPCC
Purpose of Data	Calculation of baseline emission and project emissions
Comments	Global Warming Potential value of methane valid for the commitment period (Fourth Assessment Report: AR4)

Data / Parameter	B _{0,ww}
Data unit	kg _{CH4} /kg COD
Description	Methane producing capacity of the wastewater
Source of data	AMS III.H V18
Value applied	0.25
Justification of choice of data or description of measurement methods and procedures applied	IPCC defaults value
Purpose of Data	Calculation of baseline emission and project emissions
Comments	-

Data / Parameter	UF _{BL}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS III.H V18
Value applied	0.89
Justification of choice of data or description of	Default value

measurement methods and procedures applied	
Purpose of Data	Calculation of baseline emission
Comments	-

Data / Parameter	UF _{PJ}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS III.H V18
Value applied	1.12
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	MCF _{ww,treatment,BL,i}
Data unit	Fraction
Description	Methane correction factor for baseline wastewater treatment systems i
Source of data	AMS III.H V18, Table 2
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of baseline emission
Comments	-

Data / Parameter	MCF _{ww,treatment,PJ,k}
Data unit	Fraction
Description	Methane correction factor for project wastewater treatment systems k
Source of data	AMS III.H V18, Table III.H 2

Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emission
Comments	-

Data / 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%
Justification of choice of data or description of measurement methods and procedures applied	The removal efficiency is based on a measurement campaign. The efficiency was 98.45% that 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%.
Purpose of Data	Calculation of baseline emission
Comments	-

Data / Parameter	CFE _{ww}
Data unit	-
Description	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems.
Source of data	AMS-III.H version 18
Value applied	0.9
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emission
Comments	-

Data / Parameter	EF _y
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Data unit	tCO ₂ /MWh
Description	CO ₂ emission factor for grid power
Source of data	Thai DNA ²
Value applied	0.5637
Justification of choice of data or description of measurement methods and procedures applied	The value is based on the official public data.
Purpose of Data	Calculation of baseline emission and project emission
Comments	-

Data / Parameter	D _{CH4}
Data unit	kg/m ³
Description	Density of methane at normal condition (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.
Value applied	0.716
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emission
Comments	-

Data / Parameter	$\eta_{BL,thermal}$
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.20
Value applied	100
Justification of choice of data or description of measurement methods and procedures applied	Default values, 100% is the most conservative choice as per AMS I.C.

² <http://ghgreduction.tgo.or.th/download-tver/68-2017-11-28-06-43-22/353-2559.html>

Purpose of Data	Calculation of baseline emission
Comments	-

4.2 Data and Parameters Monitored

Data / Parameter	Q _{ww,y}																		
Data unit	m ³																		
Description	Volume of wastewater treated in year y																		
Source of data	Plant data																		
Description of measurement methods and procedures to be applied	Measurement was undertaken using flow meter																		
Frequency of monitoring/recording	Monitored continuously																		
Value monitored	<table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value monitored (m³)</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>28/03/2016 to 31/12/2016</td><td>399,772</td><td>400,798</td></tr></table>			Monitoring period	Value monitored (m ³)		Lower	Higher	28/03/2016 to 31/12/2016	399,772	400,798								
Monitoring period	Value monitored (m ³)																		
	Lower	Higher																	
28/03/2016 to 31/12/2016	399,772	400,798																	
Monitoring equipment	<table><tr><td>Serial Number</td><td>EB011320000</td></tr><tr><td>Manufacturer</td><td>Endress+Hauser</td></tr><tr><td>Model</td><td>Promag 10W</td></tr><tr><td>Accuracy</td><td>0.50%</td></tr><tr><td>Calibration frequency</td><td>annually</td></tr><tr><td>Calibration date</td><td>30/06/2015, 26/09/2016</td></tr><tr><td>Validity</td><td>25/09/2017</td></tr><tr><td>Installation</td><td>Commissioning to 20/04/2017</td></tr></table>			Serial Number	EB011320000	Manufacturer	Endress+Hauser	Model	Promag 10W	Accuracy	0.50%	Calibration frequency	annually	Calibration date	30/06/2015, 26/09/2016	Validity	25/09/2017	Installation	Commissioning to 20/04/2017
Serial Number	EB011320000																		
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Model	Promag 10W																		
Accuracy	0.50%																		
Calibration frequency	annually																		
Calibration date	30/06/2015, 26/09/2016																		
Validity	25/09/2017																		
Installation	Commissioning to 20/04/2017																		
QA/QC procedures to be applied	The meter has been calibrated annually 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. If the monitoring data has been monitored less than hourly measurements, confidence/precision level of 90/10 should be attained. Though during this monitoring period, the continuous flow meter has been used, the adjustment of the value was not necessary.																		
Purpose of the data	Calculation of baseline and project emissions																		
Calculation method	Not applicable																		

Comments	The error was applied to the monitoring data during 29/06/2016 to 26/09/2016, by comparing an error identified in a calibration report and permissible error recommended by the manufacturer, the maximum error of 0.50 % was applied to the monitored data during the gap. As a result of adjusting the monitoring data, the conservative value is applied for calculating emission reduction.
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Data / Parameter	COD _{ww,untreated,y}																
Data unit	tCOD/m ³																
Description	The chemical oxygen demand of the wastewater before and after the treatment system affected by the project activity																
Source of data	Plant data																
Description of measurement methods and procedures to be applied	The COD content was analyzed using a colorimetric method in the on-site laboratory of project. The results were logged in the plant operation report on a daily basis. The COD analysis was conducted according to national or international standards. COD was measured through representative sampling.																
Frequency of monitoring/recording	The monitoring was conducted on daily basis. Samples and measurement were ensured a 90/10 confidence/precision level.																
Value monitored	<table><tr><td rowspan="2">Monitoring period</td><td colspan="2">Value monitored (tCOD/m³)</td></tr><tr><td>Lower</td><td>Higher</td></tr><tr><td>28/03/2016 to 31/12/2016</td><td>0.026</td><td>0.028</td></tr></table>			Monitoring period	Value monitored (tCOD/m ³)		Lower	Higher	28/03/2016 to 31/12/2016	0.026	0.028						
Monitoring period	Value monitored (tCOD/m ³)																
	Lower	Higher															
28/03/2016 to 31/12/2016	0.026	0.028															
Monitoring equipment	The equipment of COD analysis was in line with the requirement of national or international standards. The results were logged in the plant operation report on a daily basis. <table><tr><td>Serial Number</td><td>041090C53333</td></tr><tr><td>Manufacturer</td><td>HACH</td></tr><tr><td>Model</td><td>DR890</td></tr><tr><td>Accuracy</td><td>0.24%</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Calibration date</td><td>18/09/2015, 01/11/2017</td></tr><tr><td>Validity</td><td>17/09/2016, 31/10/2017</td></tr></table>			Serial Number	041090C53333	Manufacturer	HACH	Model	DR890	Accuracy	0.24%	Calibration frequency	Annually	Calibration date	18/09/2015, 01/11/2017	Validity	17/09/2016, 31/10/2017
Serial Number	041090C53333																
Manufacturer	HACH																
Model	DR890																
Accuracy	0.24%																
Calibration frequency	Annually																
Calibration date	18/09/2015, 01/11/2017																
Validity	17/09/2016, 31/10/2017																
QA/QC procedures to be applied	The analysis method has been well documented and well accepted either by national or international standards. The relevant equipment has been calibrated annually 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 standard deviation method was used for ensuring the confidence/ precision level of 90/10. The adjustment has been applied to the average COD value.																

Purpose of the data	Calculation of baseline emission
Calculation method	Not applicable
Comments	There was calibration gap found during this monitoring period; 17/09/2016 to 31/12/2016. The error was applied to the monitoring data, by comparing an error identified in calibration report and permissible error recommended manufacturer, the maximum error of 5.457 % was applied to the monitored data during gap. As a result of adjusting monitoring data, the conservative value is applied for calculating emission reduction.

Data / Parameter	COD _{ww,treated,y}		
Data unit	tCOD/m ³		
Description	The chemical oxygen demand of the wastewater after the treatment system affected by the project activity		
Source of data	Plant data		
Description of measurement methods and procedures to be applied	This could be referred to description of parameter COD _{ww,untreated,y} .		
Frequency of monitoring/recording	Same as parameter COD _{ww,untreated,y}		
Value monitored	Monitoring period	Value monitored (tCOD/m ³)	
		Lower	Higher
	28/03/2016 to 31/12/2016	0.0007	0.0007
Monitoring equipment	Same as parameter COD _{ww,untreated,y}		
QA/QC procedures to be applied	Same as parameter COD _{ww,untreated,y}		
Purpose of the data	Calculation of project emissions		
Calculation method	Same as parameter COD _{ww,untreated,y}		
Comments	Same as parameter COD _{ww,untreated,y}		

Data / Parameter	S _{final,PJ,y}
Data unit	ton
Description	Amount of dry matter in the sludge
Source of data	Plant data

Description of measurement methods and procedures to be applied	The project proponent did not envisage the generation of any sludge during the monitoring period. Whenever sludge was removed from the reactor the practice of final disposal should be monitored by keeping written evidence of the amount of sludge removes and its application. Measurement of the total quantity of sludge on a wet basis should be conducted. The volume (m³) and density or direct weighting might be used to determine the sludge amount (wet basis). Representative samples (ensuring 90/10 confidence level) would be taken to determine moisture content to calculate the total sludge amount on dry basis.																																		
Frequency of monitoring/recording	Whenever the sludge was removed, the quantity should be recorded and documented.																																		
Value monitored	<table><tr><td>Monitoring period</td><td>Value monitored (ton)</td></tr><tr><td>28/03/2016 to 31/12/2016</td><td>0</td></tr></table>			Monitoring period	Value monitored (ton)	28/03/2016 to 31/12/2016	0																												
Monitoring period	Value monitored (ton)																																		
28/03/2016 to 31/12/2016	0																																		
Monitoring equipment	At the project activity, there are two weighs points. The sludge would be sent to weight on the weighbridge before end use. <table><tr><td>Serial Number</td><td>2006068</td></tr><tr><td>Manufacturer</td><td>Liner Instrument</td></tr><tr><td>Model</td><td>PM7</td></tr><tr><td>Accuracy</td><td>0.01%</td></tr><tr><td>Calibration frequency</td><td>Once in three years</td></tr><tr><td>Calibration date</td><td>17/03/2015</td></tr><tr><td>Validity</td><td>16/03/2018</td></tr><tr><td>Installation</td><td>Commissioning to 28/02/2017</td></tr></table> The following weighbridge is another one <table><tr><td>Serial Number</td><td>2015003</td></tr><tr><td>Manufacturer</td><td>Liner Instrument</td></tr><tr><td>Model</td><td>PM7</td></tr><tr><td>Accuracy</td><td>0.01%</td></tr><tr><td>Calibration frequency</td><td>Once in three years</td></tr><tr><td>Calibration date</td><td>06/08/2015, 25/12/2015, 03/04/2017, 05/12/2019</td></tr><tr><td>Validity</td><td>04/12/2022</td></tr><tr><td>Installation</td><td>Commissioning to now</td></tr></table>			Serial Number	2006068	Manufacturer	Liner Instrument	Model	PM7	Accuracy	0.01%	Calibration frequency	Once in three years	Calibration date	17/03/2015	Validity	16/03/2018	Installation	Commissioning to 28/02/2017	Serial Number	2015003	Manufacturer	Liner Instrument	Model	PM7	Accuracy	0.01%	Calibration frequency	Once in three years	Calibration date	06/08/2015, 25/12/2015, 03/04/2017, 05/12/2019	Validity	04/12/2022	Installation	Commissioning to now
Serial Number	2006068																																		
Manufacturer	Liner Instrument																																		
Model	PM7																																		
Accuracy	0.01%																																		
Calibration frequency	Once in three years																																		
Calibration date	17/03/2015																																		
Validity	16/03/2018																																		
Installation	Commissioning to 28/02/2017																																		
Serial Number	2015003																																		
Manufacturer	Liner Instrument																																		
Model	PM7																																		
Accuracy	0.01%																																		
Calibration frequency	Once in three years																																		
Calibration date	06/08/2015, 25/12/2015, 03/04/2017, 05/12/2019																																		
Validity	04/12/2022																																		
Installation	Commissioning to now																																		
QA/QC procedures to be applied	The measurement equipment has been calibrated at least once every three years based on relevant national requirement.																																		
Purpose of the data	Calculation of project emissions																																		
Calculation method	Not applicable																																		

Comments	There were two calibration gaps during this monitoring period. Eventhough there was no sludge being removed from the project activity. Thus, an error from the calibration gap would not affect the emission reduction calculation.
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Data / Parameter	BG _{burnt,y}														
Data unit	Nm ³														
Description	Biogas volume in year y														
Source of data	Plant data														
Description of measurement methods and procedures to be applied	In all cases, the amount of biogas recovered, fueled, flared or otherwise utilized was monitored ex post, using continuous flow meters. If the biogas stream flared and fueled (or utilized) were monitored separately, the two fractions could be added together to determine the total biogas recovered, without the need to monitor the recovered biogas before the separation.														
Frequency of monitoring/recording	The measurement monitoring was conducted continuously. At least hourly measurements were undertaken. The monitored data was recorded into the log sheet on daily basis.														
Value monitored	<table> <tr> <th>Monitoring period</th><th>Value monitored (Nm³)</th></tr> <tr> <td>28/03/2016 to 31/12/2016</td><td>3,272,418</td></tr> </table>	Monitoring period	Value monitored (Nm ³)	28/03/2016 to 31/12/2016	3,272,418										
Monitoring period	Value monitored (Nm ³)														
28/03/2016 to 31/12/2016	3,272,418														
Monitoring equipment	The biogas was monitored using a continuous flow meter. The volumetric flow meters have been automatically measured for temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm³). <table> <tr> <td>Serial Number</td><td>9A070602000</td></tr> <tr> <td>Manufacturer</td><td>Endress+Hauser</td></tr> <tr> <td>Model</td><td>T-mass 65</td></tr> <tr> <td>Accuracy</td><td>1.50%</td></tr> <tr> <td>Calibration frequency</td><td>Once in two years</td></tr> <tr> <td>Calibration date</td><td>03/12/2014, 18/07/2016, 17/05/2018, 07/06/2019</td></tr> <tr> <td>Validity</td><td>06/06/2021</td></tr> </table>	Serial Number	9A070602000	Manufacturer	Endress+Hauser	Model	T-mass 65	Accuracy	1.50%	Calibration frequency	Once in two years	Calibration date	03/12/2014, 18/07/2016, 17/05/2018, 07/06/2019	Validity	06/06/2021
Serial Number	9A070602000														
Manufacturer	Endress+Hauser														
Model	T-mass 65														
Accuracy	1.50%														
Calibration frequency	Once in two years														
Calibration date	03/12/2014, 18/07/2016, 17/05/2018, 07/06/2019														
Validity	06/06/2021														
QA/QC procedures to be applied	The flow meter was subject to periodic calibration according to the equipment's specifications (Operating Instructions document, page 68³) which is defined as once in two years. If the monitoring data has been monitored less than hourly measurements, confidence/precision level of 90/10 should be attained. During this monitoring period, the adjustment was not necessary as the flowmeter with continuous kind has been used.														

³ <https://www.instrumart.com/assets/Proline-T-Mass-65F-65I-manual.pdf>

Purpose of the data	Calculation of baseline and project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	W _{CH4}																
Data unit	%																
Description	Methane content in the biogas in the year y																
Source of data	Plant data																
Description of measurement methods and procedures to be applied	The fraction of methane in the biogas was measured with periodic measurement ensuring a 90/10 confidence/precision level. The methane content measurement was carried out close to a location in the system where a biogas flow measurement takes place.																
Frequency of monitoring/recording	Daily basis																
Value monitored	<table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value monitored</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>28/03/2016 to 31/12/2016</td><td>61.1%</td><td>61.9%</td></tr></table>			Monitoring period	Value monitored		Lower	Higher	28/03/2016 to 31/12/2016	61.1%	61.9%						
Monitoring period	Value monitored																
	Lower	Higher															
28/03/2016 to 31/12/2016	61.1%	61.9%															
Monitoring equipment	The methane fraction was measured using continuous gas analyzer. In case the continuous gas analyzer was not available (or not functioning), a portable gas analyzer was used to monitor the methane content. The measurement using portable gas analyzer was ensured with 90/10 confidence/precision level. <table><tr><td>Serial Number</td><td>ARAM-0090</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><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Calibration date</td><td>04/08/2015, 16/09/2016, 28/04/2017, 21/02/2018, 08/11/2018, 20/09/2018, 12/04/2019</td></tr><tr><td>Validity</td><td>11/04/2020</td></tr></table>			Serial Number	ARAM-0090	Manufacturer	Draeger	Model	X-am 7000	Accuracy	0.90%	Calibration frequency	Annually	Calibration date	04/08/2015, 16/09/2016, 28/04/2017, 21/02/2018, 08/11/2018, 20/09/2018, 12/04/2019	Validity	11/04/2020
Serial Number	ARAM-0090																
Manufacturer	Draeger																
Model	X-am 7000																
Accuracy	0.90%																
Calibration frequency	Annually																
Calibration date	04/08/2015, 16/09/2016, 28/04/2017, 21/02/2018, 08/11/2018, 20/09/2018, 12/04/2019																
Validity	11/04/2020																
QA/QC procedures to be applied	The monitoring equipment was calibrated 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 standard deviation method was used for ensuring the confidence/ precision level of 90/10. The adjustment has been applied to the average methane value.																

Purpose of the data	Calculation of baseline emissions
Calculation method	Not applicable
Comments	The calibration gap was found during the monitoring period; during 03/08/2016 to 16/09/2016. The error was applied to the monitoring data, by comparing an error identified in calibration report and permissible error recommended manufacturer, the maximum error of 0.90 % was applied to the monitored data during gap. As a result of adjusting monitoring data, the conservative value is applied for calculating emission reduction

Data / Parameter	BG _{combusted,y}	
Data unit	Nm ³	
Description	Amount of biogas sent to boiler in year y	
Source of data	Plant data	
Description of measurement methods and procedures to be applied	The biogas sent to boiler is monitored by using the continuous flow meter directly.	
Frequency of monitoring/recording	The measurement monitoring was conducted continuously. At least hourly measurements were undertaken. The monitored data was recorded into the log sheet on daily basis.	
Value monitored	Monitoring period	Value monitored (Nm ³)
	28/03/2016 to 31/12/2016	2,992,584
Monitoring equipment	The biogas was monitored using continuous flow meter. The volumetric flow meters have been automatically measured for temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm ³).	
	Serial Number	EA033D02000
	Manufacturer	Endress+Hauser
	Model	T-mass 65
	Accuracy	1.50%
	Calibration frequency	Once in two years
	Calibration date	03/12/2014, 18/07/2016,
	Validity	17/07/2018
QA/QC procedures to be applied	The flow meter was subject to periodic calibration according to the equipment's specifications (Operating Instructions document, page 68 ⁴) which is defined as once in two years.	

⁴ <https://www.instrumart.com/assets/Proline-T-Mass-65F-65I-manual.pdf>

	If the monitoring data has been monitored less than hourly measurements, confidence/precision level of 90/10 should be attained. During this monitoring period, the adjustment was not necessary as the flowmeter with continuous kind has been used.
Purpose of the data	Calculation of baseline emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	V _{RG,CH4}																	
Data unit	Nm ³																	
Description	Volumetric flow of the residual gas (methane) on dry basis at reference conditions in the minute m																	
Source of data	Plant records																	
Description of measurement methods and procedures to be applied	The biogas produced is monitored using the continuous flow meter directly.																	
Frequency of monitoring/recording	The measurement monitoring was conducted continuously. At least hourly measurements were undertaken. The monitored data was recorded into the log sheet on daily basis.																	
Value monitored	<table><tr><td>Monitoring period</td><td>Value monitored (Nm³)</td></tr><tr><td>28/03/2016 to 31/12/2016</td><td>5,218</td></tr></table>		Monitoring period	Value monitored (Nm ³)	28/03/2016 to 31/12/2016	5,218												
Monitoring period	Value monitored (Nm ³)																	
28/03/2016 to 31/12/2016	5,218																	
Monitoring equipment	The gas flow meters with an accepted level of accuracy (1.5%) has been installed and integrated with the SCADA system (Supervisory Control And Data Acquisition system) at the plant, providing continuous measurements of the total biogas volume produced by the UASB system. Volumetric flow meters have been automatically measured temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm³). <table><tr><td>Serial Number</td><td>EJ-10209</td></tr><tr><td>Manufacturer</td><td>Endress+Hauser</td></tr><tr><td>Model</td><td>T-mass AT70</td></tr><tr><td>Accuracy</td><td>1.50%</td></tr><tr><td>Calibration frequency</td><td>Once in two years</td></tr><tr><td>Calibration date</td><td>03/12/2014, 18/07/2016</td></tr><tr><td>Validity</td><td>17/07/2018</td></tr><tr><td>Installation</td><td>Commissioning to 12/07/2018</td></tr></table>		Serial Number	EJ-10209	Manufacturer	Endress+Hauser	Model	T-mass AT70	Accuracy	1.50%	Calibration frequency	Once in two years	Calibration date	03/12/2014, 18/07/2016	Validity	17/07/2018	Installation	Commissioning to 12/07/2018
Serial Number	EJ-10209																	
Manufacturer	Endress+Hauser																	
Model	T-mass AT70																	
Accuracy	1.50%																	
Calibration frequency	Once in two years																	
Calibration date	03/12/2014, 18/07/2016																	
Validity	17/07/2018																	
Installation	Commissioning to 12/07/2018																	

QA/QC procedures to be applied	The flow meter was subjected to periodic calibration (once in two years) according to the equipment's specifications. (Operating Instructions document, page 68⁵) which is defined as once in two years. If the monitoring data has been monitored less than hourly measurements, confidence/precision level of 90/10 should be attained. During this monitoring period, the adjustment was not necessary as the flowmeter with continuous kind has been used.
Purpose of the data	Calculation of baseline emissions
Calculation method	-
Comments	The meter was calibrated before installation; no error was used to adjust the value. The parameters could be seen as "BG _{Flare,y} " under the submitted ER calculation sheet.

Data / Parameter	FC _{HFO,y}											
Data unit	Liters/y											
Description	Quantity of fuel type i (HFO) combusted in process j during the year y											
Source of data	Plant data, onsite measurement											
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. The monitored data was recorded into the log sheet on daily basis.											
Value monitored	<table><tr><td>Monitoring period</td><td>Value monitored (Litres)</td></tr><tr><td>28/03/2016 to 31/12/2016</td><td>1,620</td></tr></table>		Monitoring period	Value monitored (Litres)	28/03/2016 to 31/12/2016	1,620						
Monitoring period	Value monitored (Litres)											
28/03/2016 to 31/12/2016	1,620											
Monitoring equipment	There are two boilers being used in this monitoring period, thus two gas meters were used during this monitoring period. A proper record of all the fossil fuel consumed was maintained at the project site. OM1 <table><tr><td>Serial Number</td><td>92093 ID: TMC-4-1-0068-44</td></tr><tr><td>Manufacturer</td><td>ABB</td></tr><tr><td>Model</td><td>ABB 25RC</td></tr><tr><td>Accuracy</td><td>1.0%</td></tr><tr><td>Calibration frequency</td><td>Once in two years</td></tr></table>		Serial Number	92093 ID: TMC-4-1-0068-44	Manufacturer	ABB	Model	ABB 25RC	Accuracy	1.0%	Calibration frequency	Once in two years
Serial Number	92093 ID: TMC-4-1-0068-44											
Manufacturer	ABB											
Model	ABB 25RC											
Accuracy	1.0%											
Calibration frequency	Once in two years											

⁵ <https://www.instrumart.com/assets/Proline-T-Mass-65F-65I-manual.pdf>

	Calibration date	02/12/2014, 19/07/2016, 22/05/2018, 10/06/2019
	Validity	09/06/2021
	OM2	
	Serial Number	4164890 ID: TMC-0157-43
	Manufacturer	ABB
	Model	ABB 25RC
	Accuracy	1.0%
	Calibration frequency	Once in two years
	Calibration date	02/12/2014, 19/07/2016, 22/05/2018, 10/06/2019
	Validity	09/06/2021
QA/QC procedures to be applied	The meter was calibrated at least once in two years or as per the manufacturer's recommendations to maintain the measuring accuracy. The metered fuel consumption quantity should also be cross-checked with available purchase invoices.	
Purpose of the data	Calculation of project emissions	
Calculation method	-	
Comments	-	

Data / Parameter	EG _{thermal,y}
Data unit	TJ/year
Description	Net quantity of thermal energy supplied by the project activity during the year y
Source of data	Plant records
Description of measurement methods and procedures to be applied	The thermal oil flow rate and the temperature difference of the thermal oil before and after the boiler should be monitored. In case the monitoring equipment is not available, the methodology deviation approach 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 conservative 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 and quantity of biogas utilized are the monitored parameters in order to determine the thermal energy required in the project activity.
Frequency of monitoring/recording	Continuous monitoring, aggregated annually During this monitoring period the deviation has been introduced, please refer to the frequency of BG _{combusted} , and Q _{starch} ..

Value monitored	Biogas Approach	
	Monitoring period	Value monitored (TJ)
	28/03/2016 to 31/12/2016	65.18
	Historical Approach	
Monitoring equipment	Monitoring period	Value monitored (TJ)
	28/03/2016 to 31/12/2016	65.78
	The monitoring equipment is referred to monitoring parameter BG _{combusted} , and Q _{starch} . The value applied is based on the calculation as per the deviation approach.	
	This section is referred to parameter BG _{combusted} , and Q _{starch} .	
QA/QC procedures to be applied	Calculation of baseline emissions.	
Purpose of the data	Calculation method is based on the measurement of historical production data and energy input. The deviation approach is provided in section 2.6.	
Calculation method		
Comments	-	

Data / Parameter	EC _y	
Data unit	MWh/year	
Description	Quantity of electricity consumed by the project electricity consumption source j in year y	
Source of data	Monthly joint meter readings	
Description of measurement methods and procedures to be applied	Electricity consumption was monitored continuously by an import electricity meter of the PEA. The reading was based on monthly meter reading reports.	
Frequency of monitoring/recording	Continuous monitoring by electricity meter of the PEA.	
Value monitored	Monitoring period	Value monitored (MWh)
	28/03/2016 to 31/12/2016	558.87
Monitoring equipment	The monitoring was done by the import power meter, which is under Provincial Electricity Authority of Thailand (PEA) asset.	
	PEA Number	6001693334
	Manufacturer	TTC
	Spec	110V
	Phase	3-WIRE
	Model	ST-33TL
	Accuracy	0.5%

QA/QC procedures to be applied	The electricity meter is under the ownership of the PEA.
Purpose of the data	Calculation of project emissions
Calculation method	Not applicable
Comments	The meter maintenance is not under the jurisdiction of project proponent.

Data / Parameter	TDL _{j,y}
Data unit	-
Description	Average technical transmission and distribution losses for providing electricity to source j in year y
Source of data	World bank database (Thailand 2014) This is annual average value based on the most recent data available within the host country
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	Annually. In the absence of data from the relevant year, most recent figures has been used, but not older than 5 years.
Value monitored	6.11 % ⁶
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	Flame _m
Data unit	Flame on or Flame off
Description	Flame detection of flare in the minute m
Source of data	Plant data
Description of measurement methods	Measure using a fixed installation optical flame detector: Ultraviolet detector or Infra-Red or both

⁶ <https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?end=2017&locations=TH&st=null>

and procedures to be applied	
Frequency of monitoring/recording	Once per minute. Detection of flare recorded as minute that the flare was on, otherwise recorded as a minute that the flame was off.
Value monitored	0 as the equipment implemented at the project could not specify flame detection in minute m
Monitoring equipment	Flame detector
QA/QC procedures to be applied	Equipment has been maintained and calibrated in accordance with manufacturer's recommendations
Purpose of the data	Calculation of project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	$\eta_{\text{Flare-h}}$
Data unit	%
Description	Flare efficiency in the minute m
Source of data	Default value for open flares as per tool "project emission from flaring"
Description of measurement methods and procedures to be applied	The flare efficiency of 50% in the minute m is applied when the flare is detected in the minute m (Flame_m). If these conditions are not met, 0% default value has been used for this period.
Frequency of monitoring/recording	Continuous measurement
Value monitored	0% default factor was used in the calculation
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	EF _{FF,HFO}
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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
Description of measurement methods and procedures to be applied	Not Applicable
Frequency of monitoring/recording	Default value as per IPCC
Value monitored	77.4
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of 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.
Calculation method	Not applicable
Comments	-

Data / Parameter	NCV _{HFO}
Data unit	TJ/tonne
Description	Weighted average net calorific value of fuel type i (HFO) in year y
Source of data	IPCC 2006, Volume 2: Energy, Table 1.2.
Description of measurement methods and procedures to be applied	Not Applicable
Frequency of monitoring/recording	Default value as per IPCC
Value monitored	0.0404
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of Data	Calculation of baseline emission
Calculation method	Not applicable
Comments	-

4.3 Monitoring Plan

1. Monitoring Management

The details on monitoring approaches used in qualifying and reporting GHG emissions and/or removals relevant for the project and baseline scenario were elaborated in section 3.1 and 3.2. Data acquisition for the gas and wastewater flow meters is executed through the process control unit of the biogas plant and the plant operations software. Lab data is fed into the operations software through a manual data entry user interface. The biogas plant is operated by four operators (working in 3 shifts a day) who also collect data under the supervision of the assistant plant manager who is in charge of filing and processing data and report directly to biogas plant manager. All biogas plant staffs are trained by the Papop Company prior to full commissioning of biogas plant. Figure 2 outlines the structure of operational and management of the project activity.

2. Quality Assurance and Quality Control

The biogas plant manager monitors overall performance of the plant, ensures proper and timely calibration, data acquisition and storage.

3. On-site Procedures

The operations software creates daily logs of plant performance which are printed out and recorded electronically for periodic download onsite or remote transfer for further processing. Procedures for Calibration of Equipment. The biogas plant operators carry out calibration according to international standards.

4. Data Storage and Filing – Electric Workbook

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

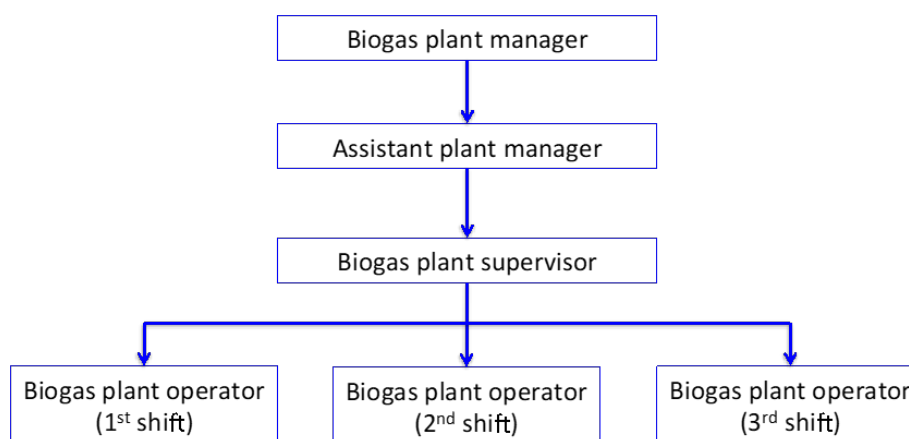


Figure 2: The structure of operational and management of the project activity

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

(a) Methane destruction component (AMS.III.H)

According to the paragraph 27 of AMS III.H, baseline emissions for the systems affected by the project activity may consist of:

- Emissions on account of electricity or fossil fuel used ($BE_{power,y}$);
- Methane emissions from baseline wastewater treatment systems ($BE_{ww,treatment,y}$);
- Methane emissions from baseline sludge treatment systems ($BE_{s,treatment,y}$);
- Methane emissions on account of inefficiencies in the baseline wastewater treatment systems and presence of degradable organic carbon in the treated wastewater discharged into river/lake/sea ($BE_{ww,discharge,y}$);
- Methane emissions from the decay of the final sludge generated by the baseline treatment systems ($BE_{s,final,y}$).

Baseline emissions (BE_y)

The baseline emissions are calculated as follows.

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

Where,

Parameter	Details	Quantification
BE_y	Baseline emissions in year y (tCO ₂ e)	40,660
$BE_{power,y}$	Baseline emissions from electricity or fuel consumption in year y (tCO ₂ e)	0
$BE_{ww,treatment,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO ₂ e)	40,660
$BE_{s,treatment,y}$	Baseline emissions of the sludge treatment systems affected by the project activity in year y (tCO ₂ e)	0
$BE_{ww,discharge,y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y (tCO ₂ e).	0
$BE_{s,final,y}$	Baseline methane emissions from anaerobic decay of the final sludge produced in year y (tCO ₂ e). If the sludge is controlled combusted, disposed in a landfill with biogas recovery, or used for soil application in the baseline scenario, this term would be neglected.	0

Baseline emissions of the wastewater treatment systems affected by the project activity ($BE_{ww,treatment,y}$):

Methane emissions from the baseline wastewater treatment systems affected by the project ($BE_{ww,treatment,y}$) are determined using the methane generation potential of the wastewater treatment systems as per the paragraph 29 of AMS III.H version 18. The following equation is used.

$$BE_{ww,treatment,y} = \sum Q_{ww,i,y} * COD_{inflow,i,y} * \eta_{COD,BL,i} * MCF_{ww,treatment,BL,i} * B_{o,ww} * U_{BL} * GWP_{CH_4} \quad (2)$$

Where,

Parameter	Details	Quantification
$BE_{ww,treatment,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO ₂ e)	28/03/2016 to 31/12/2016 = 40,660
$Q_{ww,i,y}$	Volume of wastewater treated in baseline wastewater treatment system i in year y (m ³)	Please see details under section 4.2 Data and Parameters Monitored
$COD_{inflow,i,y}$	Chemical oxygen demand of the wastewater inflow to the baseline treatment system i in year y. Average value may be used through sampling with the confidence/precision level 90/10 (t/m ³).	
$\eta_{COD,BL,i}$	COD removal efficiency of the baseline treatment system i	87.62%
$MCF_{ww,treatment,BL,i}$	Methane correction factor for the baseline anaerobic wastewater treatment i (MCF values as per table III.H.2)	0.8
i	Index for baseline wastewater treatment system	-
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC lower value for domestic wastewater of 0.25 kg CH ₄ /kg COD) ⁷	0.25
U_{BL}	Model correction factor to account for model uncertainties (0.89) ⁸	0.89
GWP_{CH_4}	Global Warming Potential for methane (value of 25)	25

The parameter $\eta_{COD,BL,i}$ is based on the historical COD measurement of the baseline system prior implementation of project activity. The measurement campaign of 11 days was conducted in order to determine the COD removal efficiency. This is in line with paragraph 39 (b) of AMS. III-H.

³ The IPCC default value of 0.25 kg CH₄/kg COD was corrected to take into account the uncertainties. Project activities may use the default value of 0.6 kg CH₄/kg BOD, in case the parameter BOD_{5,20} is used to determine the organic content of the wastewater. In this case, baseline and project emissions calculations shall use BOD instead of COD in the formulas, and the monitoring of the project activity shall be based in direct measurements of BOD_{5,20}, i.e., the estimation of BOD values based on COD measurements is not allowed.

⁴ Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

Baseline emission from electricity and fuel consumptions ($BE_{power, y}$)

The only electricity consumption devices used in the baseline wastewater treatment systems are pumps for pumping the wastewater from the starch factory into the open anaerobic lagoons. There is no consumption of fossil fuels for the operation of the baseline system. Please note that consumption of fossil fuels for heat generation at the starch plant are considered in the emission reduction component as per AMS.I.C.

For the sake of simplification and conservativeness, baseline emissions from electricity and fuel consumptions ($BE_{power, y}$) are assumed to be zero.

$$BE_{power, y} = 0$$

Baseline emission from wastewater discharge ($BE_{ww, discharge, y}$)

In the baseline scenario, treated wastewater is not discharged into sea/lake/river, therefore methane emissions from degradable organic carbon in treated wastewater discharged ($BE_{ww, discharge, y}$) in e.g. a river, sea or lake in the baseline situation is assumed to be zero.

$$BE_{ww, discharge, y} = 0$$

Baseline emissions of the sludge treatment systems affected by the project ($BE_{s, treatment, y}$)

There is no sludge treatment system in the baseline scenario, only a wastewater treatment system based on open anaerobic lagoons, hence baseline emissions from sludge treatment are not taken into consideration.

Baseline emissions from final sludge disposal ($BE_{s, final, y}$)

For the sake of conservativeness, it is assumed that the sludge is used for soil application in the baseline scenario. Therefore, baseline methane emissions from anaerobic decay of the final sludge ($BE_{s, final, y}$) produced is also neglected.

$$BE_{s, final, y} = 0$$

(b) Thermal energy production component AMS.I.C:

As per paragraph 33 of AMS I.C, for steam/heat produced using fossil fuels the baseline emissions are calculated as follows:

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

Where:

Parameters	Details	Quantification
$BE_{thermal, CO_2, y}$	the baseline emissions from steam/heat displaced by the project activity during the year y in tCO ₂ e	28/03/2016 to 31/12/2016 = 5,065

$EG_{thermal,y}$	the net quantity of steam/heat supplied by the project activity during the year y in TJ.	Please see details under section 4.2 Data and Parameters Monitored
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.	77.40
$\eta_{BL,thermal}$	the efficiency of the plant using fossil fuel that would have been used in the absence of the project activity	100%

In the ex-post calculations, the amount of energy delivered by the dual fuel fired boiler is used to estimate the baseline emissions. This is based on the methodology deviation provided in section 2.2. In order to estimate the replacement of fossil fuel. The project proponent uses a conservative approach based on amount of heat required for starch drying, which in turn is estimated on historic heat requirements per tonne of starch and compensating heat energy supplied by HFO and the amount of biogas delivered to the starch factory. The details as following;

1. $EG_{thermal}$: Determination based on historical data of starch production:

$$EG_{thermal,y} - \text{historical data} = (Q_{starch} * Q_{FO,starch}) * D_{FO} * NCV_{FO}$$

2. $EG_{thermal}$: Determination based on monitored value of biogas delivered to starch factory:

$$EG_{thermal,y} - \text{biogas delivered} = BG_{combusted,y} * D_{CH_4} * NCV_{CH_4} * \eta_{PJ,thermal}$$

$$EG_{thermal,y} = \min(EG_{thermal,y} - \text{historical data}, EG_{thermal,y} - \text{biogas delivered})$$

Where:

Parameter	Details	Quantification
$EG_{thermal,y} - \text{historical data}$	The net quantity of steam/heat supplied by the project activity during the year y (TJ) – based on historical data of starch production	Please see details under section 4.2 Data and Parameters Monitored
$EG_{thermal,y} - \text{historical data}$	The net quantity of steam/heat supplied by the project activity during the year y (TJ) – based on monitored value of biogas delivered to starch factory	
$Q_{starch,y}$	Quantity of dry starch produced in year y (tonnes)	28/03/2016 to 31/12/2016 = 51,875
$Q_{HFO,starch}$	Quantity of fossil fuel per unit of dry starch (liter/tonne)	33.75
NCV_{FO}	Net calorific value of the fuel oil (TJ/tonne)	0.04
D_{FO}	Density of fuel oil in the year y (tonnes/m ³)	0.93
NCV_{CH_4}	Net calorific value of methane	0.05

	(TJ/tonne)	
D _{CH4}	Density of methane at the temperature and pressure of the biogas in the year y (kg/m ³)	0.72

5.2 Project Emissions

(a) Methane destruction component: (AMS III.H)

As per the paragraph 41 of AMS III.H, Project activity emissions from the systems affected by the project activity are:

- CO₂ emissions from electricity and fuel used by the project facilities ($PE_{power, y}$);
- Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{ww, treatment, y}$);
- Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{s, treatment, y}$);
- Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater ($PE_{ww discharge, y}$);
- Methane emissions from the decay of the final sludge generated by the project activity treatment systems ($PE_{s, final, y}$);
- Methane fugitive emissions on account of inefficiencies in capture systems ($PE_{fugitive, y}$);
- Methane emissions due to incomplete flaring ($PE_{flaring, y}$);
- Methane emissions from biomass stored under anaerobic conditions which does not take place in the baseline situation ($PE_{biomass, y}$).

$$PE_y = \{PE_{power, y} + PE_{ww, treatment} + PE_{s, treatment} + PE_{ww discharge, y} + PE_{s, final, y} + PE_{fugitive, y} + PE_{biomass, y} + PE_{flaring, y}\} \quad (4)$$

Where,

Parameter	Details	Quantification
PE _y	Project emissions in year y (tCO ₂ e)	8,224
PE _{power, y}	Emissions from electricity or fuel consumption in the year y (tCO ₂ e)	335
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)	1,683

$PE_{s, \text{treatment}, y}$	Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation (tCO _{2e})	0
$PE_{ww, \text{discharge}, y}$	Methane emissions from degradable organic carbon in treated wastewater in year y (tCO _{2e})	0
$PE_{s, \text{final}, y}$	Methane emissions from anaerobic decay of the final sludge produced in year y (tCO _{2e})	0
$PE_{\text{fugitive}, y}$	Methane emissions from biogas release in capture systems in year y (tCO _{2e})	6,148
$PE_{\text{biomass}, y}$	Methane emissions from biomass stored under anaerobic conditions (tCO _{2e})	0
$PE_{\text{flaring}, y}$	Methane emissions due to incomplete flaring in year y (tCO _{2e})	58

Emissions from electricity consumption ($PE_{y, \text{power}} = PE_{EC,y}$)

As per paragraph 41, these emissions was calculated using “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”. The energy consumption data of all equipment/devices is required in the project activity wastewater and sludge treatment systems and systems for biogas recovery and flaring/gainful use.

$$PE_{\text{Power}, y} = EC_{PJ, j, y} * EF_{EF, j, y} * (1 + TDL_{j, y}) \quad (5)$$

Where,

Parameters	Details	Quantification
$PE_{y, \text{power}}$	Emissions from electricity consumption in the year y (tCO _{2e})	28/03/2016 to 31/12/2016 = 335
EC_y	Electricity from the grid consumed by the project activity (wastewater treatment, biogas recovery and biogas utilisation/flaring systems) (MWh)	Please see details under section 4.2 Data and Parameters Monitored
$TDL_{j, y}$	Average technical transmission and distribution losses for providing electricity to source j in year y	6.11%
EF_y	Thailand National Grid emission factor (tCO _{2e} /MWh)	0.5637

The project activity consumes power from the national grid system. In this monitoring period under the second crediting period, the emission factor of the project is referred to the published value announced by Thai DNA. This is in line with paragraph 17 of Tool 7 version 05, EB87 Annex 9.

Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{ww,treatment,y}$)

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 of paragraph 29 in AMS.III.H using an uncertainty factor of 1.06. The following equation is used.

$$PE_{ww,treatment,y} = \sum (Q_{ww,y} * \eta_{PJ,k,y} * MCF_{ww,treatment,PJ,k} * B_{o,ww} * UF_{PJ} * GWP_{CH4}) \quad (6)$$

Where,

Parameter	Details	Quantification
$PE_{ww,treatment,y}$	Emissions from degradable organic carbon in treated wastewater in year y (tCO ₂ e)	28/03/2016 to 31/12/2016 = 1,683
$Q_{ww,k,y}$	Volume of wastewater treated in project activity (m ³)	Please see details under section 4.2 Data and Parameters Monitored
$\eta_{COD,PJ,k,y}$	COD removal efficiency of the project wastewater treatment system k in year y (t/m ³) measured based on inflow COD and outflow COD in system k	100%
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for the project wastewater treatment system k (MCF values as per table 2 in AMS III.H. version 18)	0.8
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC lower value for domestic wastewater of 0.25 kg CH ₄ /kg COD) ⁵	0.25
UF_{PJ}	Model correction factor to account for model uncertainties (1.12)	1.12
GWP_{CH4}	Global warming potential for methane (value of 25)	25

Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery ($PE_{s,treatment,y}$)

The project activity does not include sludge treatment system, therefore the emission from sludge treatment system are not taken into consideration.

Methane emissions from degradable organic carbon in treated wastewater ($PE_{ww,discharge,y}$)

⁵ The IPCC default value of 0.25 kg CH₄/kg COD was corrected to take into account the uncertainties. Project activities may use the default value of 0.6 kg CH₄/kg BOD, in case the parameter BOD_{5,20} is used to determine the organic content of the wastewater. In this case, baseline and project emissions calculations shall use BOD instead of COD in the formulas, and the monitoring of the project activity shall be based in direct measurements of BOD_{5,20}, i.e., the estimation of BOD values based on COD measurements is not allowed.

In the project activity the treated wastewater has been discharged in existing open lagoons and there was no discharge to river, sea or lake. Hence, emissions from this component have not been included in the assessment.

Methane emissions from the decay of the final sludge produced ($PE_{s, final, y}$)

No final sludge has been removed from the digester. If there were, the project proponent would apply final sludge for field application as fertilizer and the final disposal of the sludge should be monitored. Therefore, as suggested by the AMS III.H, the emission from anaerobic decay from the final sludge produced could be omitted.

Methane emissions from biogas release in capture systems ($PE_{fugitive, y}$)

Project activity emissions from methane release in capture systems are determined as per paragraph 42 of AMS III.H as given below.

$$PE_{fugitive, y} = PE_{fugitive, ww, y} + PE_{fugitive, s, y} \quad (7)$$

Where,

Parameter	Details	Quantification
$PE_{fugitive, y}$	Methane emissions from methane release in capture and utilization/combustion/flare \systems in year y (tCO ₂ e)	6,148
$PE_{fugitive, ww, y}$	Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year y (tCO ₂ e)	6,148
$PE_{y, fugitive, s}$	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y (tCO ₂ e)	0

(a) Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment ($PE_{fugitive, ww, y}$)

These emissions are calculated as follows:

$$PE_{fugitive, ww, y} = (1 - CEF_{ww}) * MEP_{ww, treatment, y} * GWP_{CH_4} \quad (8)$$

Where,

Parameter	Details	Quantification
CEF_{ww}	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems (a default value of 0.9 was used)	0.9
$MEP_{ww, treatment, y}$	Methane emission potential of wastewater treatment systems equipped with biogas recovery system in year y (tonne)	28/03/2016 to 31/12/2016 = 2,459

$$MEP_{ww,treatment,y} = Q_{ww,y} * B_{o,ww} * UF_{PJ} * \sum_k COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k} \quad (9)$$

Where,

Parameter	Details	Quantification
$Q_{ww,y}$	Volume of wastewater treated in project wastewater treatment system k in year y (m3/year)	Please see details under section 4.2 Data and Parameters Monitored
$B_{o,ww}$	Methane producing capacity of the wastewater	0.25
UF_{PJ}	Model correction factor to account for model uncertainties (1.12)	1.12
$COD_{removed,PJ,k,y}$	The chemical oxygen demand removed by the treatment system k of the project activity equipped with biogas recovery in the year y (tonnes/m3)	28/03/2016 to 31/12/2016 = 0.0007
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for the project wastewater treatment system k equipped with biogas recovery equipment (MCF values as per table III.H.2)	0.8

(b) Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y ($PE_{y,fugitive,s}$):

Sludge would be used only for land application, therefore no sludge treatment envisaged in the project activity. Therefore, emission from sludge treatment is not taken into consideration.

Methane emissions due to incomplete flaring ($PE_{flaring,y}$)

Methane emissions due to incomplete flaring in year y were calculated as per methodological tool “Project emissions from flaring”.

$$PE_{flare,y} = GWP_{CH4} * \sum F_{CH4,RG,m} * (1 - \eta_{flare}) * 10^{-3} \quad (10)$$

Where:

Parameter	Details	Quantification
$PE_{flare,y}$	Project emissions from flaring of the residual gas in year y (tCO ₂ e)	28/03/2016 to 31/12/2016 = 58
GWP_{CH4}	Global warming potential of methane valid for the commitment period (tCO ₂ e/tCH ₄)	25
$F_{CH4,RG,m}$	Mass flow of methane in the residue gas in the minute m (kg)	Please see details under section 4.2 Data and Parameters Monitored
$\eta_{flare,m}$	Flare efficiency in minute m	0%

Methane emissions from biomass stored under anaerobic conditions which does not take place in the baseline situation (PE biomass, y).

Biomass storage is not envisaged in the project activity. Therefore, methane emissions from biomass stored under anaerobic conditions are not taken into consideration.

(b) Thermal energy production (AMS.I.C):

According to paragraph 66 of AMS-I.C, CO₂ emissions from on-site consumption of fossil fuels due to the project activity was calculated using the latest version of “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”. As per paragraph 6 of the tool, the formula is determined as below.

$$PE_{FC,j,y} = \sum FC_{HFO,y} * COEF_{i,y} \quad (11)$$

Parameter	Details	Quantification
PE _{FC, y}	Project emissions due to combustion of fossil fuel in year y (tCO ₂ e)	28/03/2016 to 31/12/2016 = 5.0
FC _{HFO, y}	Amount of fossil used in the boiler in ton/yr	Please see details under section 4.2 Data and Parameters Monitored
COEF _{i,y}	CO ₂ emission coefficient of fuel type i in year y (tCO ₂ /mass or volume unit)	Please see details under following table

In comply with paragraph 7, the option B is selected for determination of COEF_{i,y}. The calculation is based following fomula;

$$COEF_{i,y} = NCV_{HFO} * EF_{HFO,CO2} \quad (12)$$

Parameter	Details	Quantification
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

By considering equation (13) and (14), parameter PE_{FC,j,y} could be determined as following:

$$PE_{FC,j,y} = \sum FC_{HFO,y} * NCV_{HFO} * EF_{HFO,CO2} \quad (13)$$

5.3 Leakage

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

5.4 Net GHG Emission Reductions and Removals

As per the paragraph 29 of AMS III.H and paragraph 28 of AMS I.C, emission reduction is estimated ex ante in the VCS PD using formulas mentioned in baseline, project and leakage emissions sections above. Emission reductions are estimated as follows;

$$ER_{y, \text{ex-post}} = BE_{y, \text{ex-post}} - (PE_{y, \text{ex-post}} + LE_{y, \text{ex-post}}) \quad (14)$$

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;

$$ER_{y, \text{ex-post}} = \min (BE_{y, \text{ex-post}} - PE_{y, \text{ex-post}} - LE_{y, \text{ex-post}}), (MD_y - PE_{\text{power}, y} - LE_{y, \text{ex-post}}) \quad (15)$$

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

$$MD_y = BG_{\text{burnt}, y} * W_{CH_4, y} * D_{CH_4} * FE * GWP_{CH_4} \quad (16)$$

Where:

Parameter	Details	Quantification
MD_y	Methane captured and destroyed/gainfully used by the project activity in the year y	28/03/2016 to 31/12/2016 = 32,722
$BG_{\text{burnt}, y}$	Biogas flared/combusted in year y (m^3)	Please see details under section 4.2 Data and Parameters Monitored
W_{CH_4}	Methane content in the biogas in the year y (mass fraction)	
D_{CH_4}	Density of methane at the temperature and pressure of the biogas in the year y (tonnes/ m^3)	0.0007
FE	Flare efficiency in year y (fraction) If the biogas is combusted for gainful purposes, e.g. fed to an engine, an efficiency of 100 per cent may be applied.	0

According to the equation 16, the emission reduction as per the paragraph 29 of AMS III.H and paragraph 28 of AMS I.C achieved on any year are as following;

Parameter	Details	Quantification
$ER_{y, \text{ex-post}}$	Emission reductions achieved by the project activity based on monitored values for year y (tCO_2e) The emission reduction is based on MD_y approach under AMS-III.H + BE_y from AMS-I.C.	28/03/2016 to 31/12/2016 = 37,447

BE _{y, ex-post}	Baseline emissions calculated as per paragraph ex post monitored values (BE_AMS-III.H COD approach + BE_AMS-I.C)	28/03/2016 to 31/12/2016 = 45,725
PE _{y, ex-post}	Project emissions calculated as per paragraph ex post monitored values	For AMS-III.H COD approach & AMS-I.C 28/03/2016 to 31/12/2016 = 8,229 For AMS-III.H MD_y approach & AMS-I.C 28/03/2016 to 31/12/2016 = 340
BE - MD _y approach	Methane captured and destroyed/gainfully used by the project activity in the year y (BE_AMS-III.H MD approach + BE_AMS-I.C)	28/03/2016 to 31/12/2016 = 37,787

The ex-post emission reductions during this monitoring period, from 28/03/2016 to 31/12/2016 was based on the lower value between COD approach and MD approach. The emission reductions for this monitoring period as calculated, are equal to 37,447 tCO₂e.

During this monitoring period, the ex-ante calculation is equal to 39,057 tCO₂e, which is higher than the ex-post emission reduction. The reason of the lower emission reduction came from the lower quantity of biogas being generated. Referring to technical proposal in registered PD, the ex-ante biogas generation is equal to 4,860,000 Nm³, while the approximate ex-post value was 33 % of adjustment from the ex-ante value. The biogas generation could not be envisaged at the time of validation. It may also happen that in the future verification, the quantity of biogas may go up. Therefore; it could be concluded that the decrease in emission reductions is not permanent but dependent on various factors, which could neither be controlled nor predicted in advance.

Where,

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)
2016	37,787	340	0	37,447
Total	37,787	340	0	37,447