Monitoring report form for CDM project activity
(Version 07.0)

MONITORING REPORT		
Title of the project activity	CYY Biopower Wastewater treatment plant including biogas reuse for thermal oil replacement and electricity generation Project, Thailand	
UNFCCC reference number of the project activity	UNFCCC reference number: 2141 GS ID: GS560	
Version number of the PDD applicable to this monitoring report	4.1	
Version number of this monitoring report	3	
Completion date of this monitoring report	08/09/2020	
Monitoring period number	7^{th} monitoring period	
Duration of this monitoring period	01/05/2016 – 24/05/2018 (inclusive)	
Monitoring report number for this monitoring period	1	
Project participants	CYY Bio Power Co.,Ltd. South Pole Carbon Asset Management Ltd.	
Host Party	Thailand	
Applied methodologies and standardized baselines	AM0022 ver.4 - Avoided Wastewater and On-site Energy Use Emissions in the industrial Sector	
Sectoral scopes	Sectoral scope: 13 Waste handling and disposal Sectoral scope: 1 Energy industries (renewable - / non-renewable sources)[1]	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	0 tCO_2e	133,295 tCO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	212,362 tCO_2e	

[1] This sectoral scope is applicable in line with Appendix of the Standard: Applicability of sectoral scopes, version 01.

SECTION A. Description of project activity

A.1. General description of project activity

The project activity involves the installation of an upflow anaerobic sludge blanket technology (UASB) and two gas engines at an existing starch factory for:

a) the extraction of methane (biogas) from the wastewater stream through the biogas reactor;
b) the reuse of biogas as fuel in the existing thermal oil boiler within the starch plant for starch drying;
c) the reuse of biogas as fuel for power generation (using two gas engines each of 1.36 MW_{el} capacity)

The implementation of the project activity helps in the avoidance of methane emissions (a greenhouse gas, or GHG), which in the baseline scenario would have been released from the anaerobic decay of wastewater. Instead, biogas is used as a fuel in the thermal oil boiler and in the gas engine. The use of biogas reduces the GHG emissions related to fossil fuel use in the boiler and in the grid in the baseline scenario.

Brief description of the installed technology and equipment
The following equipment has been installed in the project activity:

Component	Manufacturer	Type/Model	Brief description
Biogas reactor / Wastewater treatment system	Global Water Engineering (GWE) Ltd.,Hongkong	UASB	UASB has a designed Chemical Oxygen Demand (COD) reduction efficiency of 90%. The UASB is designed with a total volumetric capacity of 6,000 m^3. The hydraulic retention time is approximately 2.5 days in its total capacity as per the design proposal provided by the technology supplier.
Gas engine	DEUTZ	Biogas engine TBG 620 V16K	There are two electricity generation sets with a total installed capacity of 2.72 $MW_{el.}$
Flare	DWS	Elevated biogas flare	An open flare has a maximum capacity of 1,600 Nm^3/hr as per the technology description provided by the supplier.

Relevant dates for the project activity

Event	Date	Reference
Construction of UASB	04/08/2006	Purchase order for civil works
Commissioning of UASB	03/11/2007	Certificate of Civil Mechanical and Electrical Completion
Commissioning of gas engines	02/12/2008 – 08/12/2008	Minutes of Commissioning by Pro2 (technology provider)
Registration under UNFCCC	25/03/2009	UNFCCC website
1st monitoring period	25/03/2009 – 02/08/2009	UNFCCC website
Approval of revision of monitoring plane	12/08/2010	UNFCCC website
Approval of notification for changes in the registered Project Design Document (PDD)	16/03/2012	UNFCCC website
2nd monitoring period	03/08/2009 – 31/12/2010	UNFCCC website
3rd monitoring period	01/01/2011 – 31/12/2012	UNFCCC website

4th monitoring period	01/01/2013 – 20/08/2013	UNFCCC website
5th monitoring period	21/08/2013 – 14/09/2014	UNFCCC website
6th monitoring period	15/09/2014 – 30/04/2016	UNFCCC website

Total GHG emission reductions achieved in this monitoring period are 133,295 tCO_2e.

Further background information on the project activity can be found in the revised PDD for Post-Registration Change (PRC) under the following link: http://cdm.unfccc.int/Projects/DB/RWTUV1218617500.62/view

A.2. Location of project activity

The project site is located in Tombol Pongdaeng, Amphur Khamtalesor, Nakorn Ratchasima Province, Thailand (Host country). The coordinates of the project are Latitude 14º59'55"N (14.9986 N) and Longitude 101º54'42"E (101.9117 E).

A map indicating the location of the project is provided in **Figure 1**.

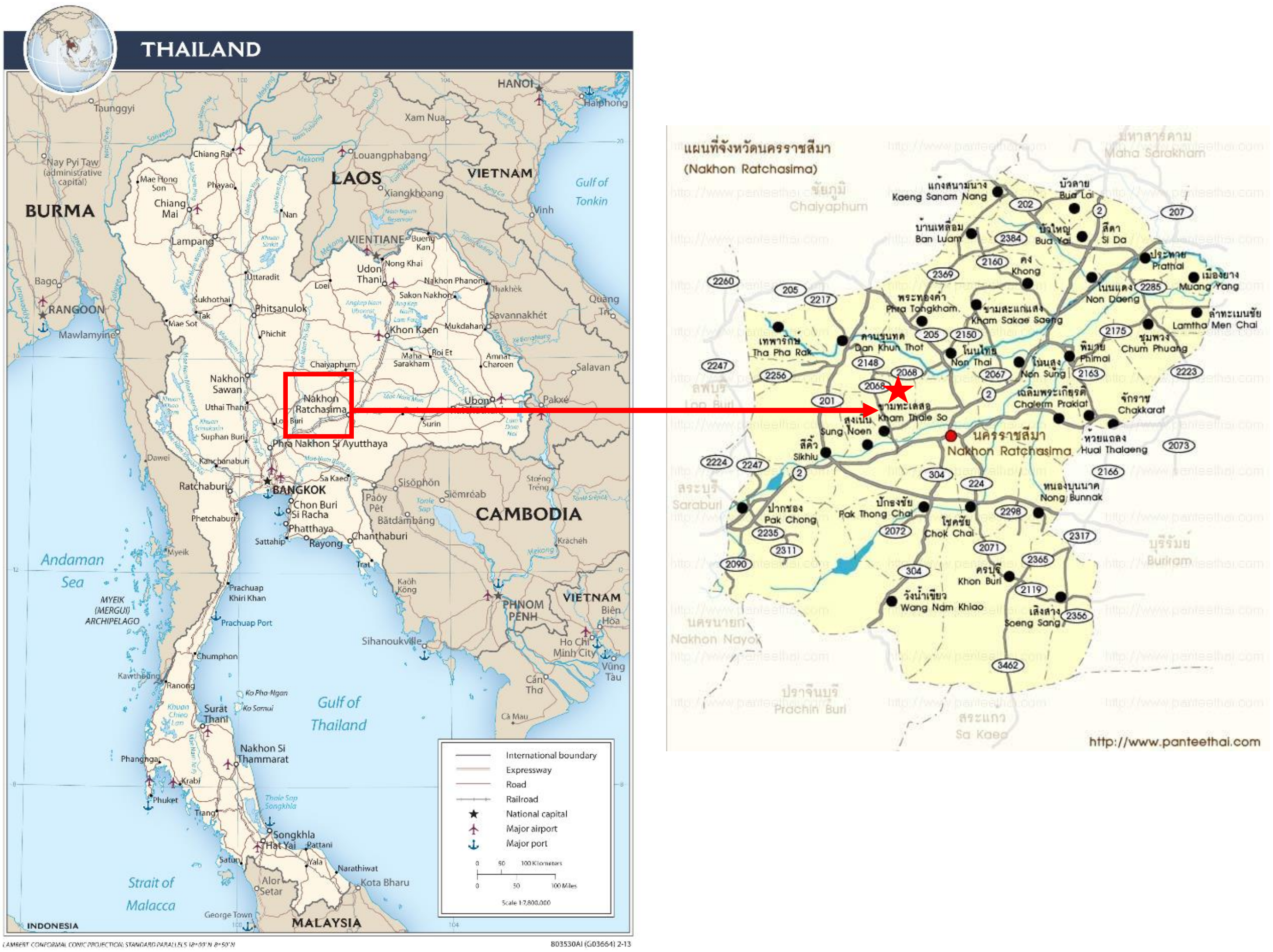

Figure 1: Location of the project activity

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Thailand (host)	CYY Bio Power Co.,Ltd. (Private entity)	No

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Switzerland	South Pole Carbon Asset Management Ltd. (Private entity)	No

A.4. References to applied methodologies and standardized baselines

a) The applied methodology
AM0022 version 04 – Avoided Wastewater and On-site Energy Use Emission in the Industrial Sector (https://cdm.unfccc.int/methodologies/DB/BM4NZO7YAH9373G9P0UZHN6G1XM3IW)

b) Within AM0022 following tools are used for this project activity:
- "Tool to determine project emissions from flaring gases containing methane" (EB 28 annex 13) was used to calculate the project emissions from the flaring of a residual gas stream containing methane (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf)
- "Tool to calculate the emission factor for an electricity system" (Version 01) was used to calculate the Carbon Emission Factor (CEF) of the electricity grid, required for the determination of baseline emissions caused by displacement of grid electricity. (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v1.pdf)

A.5. Crediting period type and duration

Crediting period type: Fixed
CDM crediting period: 25/03/2009 – 24/03/2019
Current monitoring period: 01/05/2016 – 24/03/2019
Length of the current monitoring period: 2 years 10 months and 24 days

GS crediting period: 25/05/2008 – 24/05/2018
Current monitoring period: 01/05/2016 – 24/05/2018
Length of the current monitoring period: 2 years and 24 days

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

The project activity involves the installation of UASB technology to generate biogas, which is used to replace fuel usage in an existing boiler within the starch plant and generate renewable electricity.

The wastewater flows from the factory into a storage lagoon. The influent first passes through a screen extractor in order to remove coarse particles. After the screening, the wastewater flows into an equalization pond.
The wastewater is then pumped into the reactors through an influent distribution system at the bottom of the reactor. The methane reactors are of the UASB type. In the UASB, the wastewater rises through an expanded bed of anaerobic active methanogenic sludge (the so called "sludge blanket") and an internal device at the top of the reactor, which results in a separation of the mixed liquor into clarified wastewater, biogas and sludge. The absence of any mechanical agitation allows a natural selection towards heavy flocs of active methanogenic sludge.

Excess sludge can eventually, from time to time, be withdrawn from the bottom of the reactor. This excess sludge is extremely thick (5–10% dissolved solids), stable, and can be dumped without problem, but it is widely sought-after to start up new reactors elsewhere. The effluent of the anaerobic treatment is further treated in some of the existing lagoons, receiving only 2% to maximum 10% of the original COD load.

A gas storage system was installed[2] at the project site in order to optimize the biogas utilization ratio by ensuring a better match between biogas generation and energy demand at the thermal oil boiler and gas engines, thus avoiding any unnecessary flaring of biogas. Part of the resulting biogas is used in the factory as fuel in an existing thermal oil boiler for starch drying. A dual fuel burner able to fire oil and gas is employed to burn only biogas or both fuels mixed together. The biogas meter is equipped to record the biogas consumption of the burner.

The rest of the biogas is used as fuel in two power generators (gensets) with a total installed capacity of 2.72 MW_{el}. Before use in the power generators, the biogas has to be treated to reduce the sulfur content of the biogas from tapioca starch factory effluent using a biogas “sweetening” plant, based on a proprietary sulfur removal system, which does not use chemicals (except for pH control in the oxidation phase). In practice a minimum of 90% removal is obtained. The scrubber is placed on top of the aeration basin, so as to allow for the gravitational flow of the washing water back into the inlet of the aeration basin. Water is then continuously pumped from the aeration basin into the scrubber tower.

The flare system is installed on the top of the reactors. The rest of the biogas apart from that utilized and collected in the gas storage system is destroyed in the flare system, which is also required as part of the at the wastewater treatment plant’s safety procedures.

The UASB system was commissioned in 2007 and the installation of two gas engines occurred later in 2008. The project activity was fully operational as of 29 November 2008, which is the commissioning date of the gas engines.

Implementation of the project during the monitoring period
During the monitoring period, no significant events occurred to affect the project activity as describe above. However, events that may have impacted the GHG emission reductions are detailed in Table 1. The calibration of the equipment was conducted as per the monitoring procedure of the project activity. However, there was a delay in calibration for the particular period. Thus, the procedure as per paragraph 366 of the VVS, Version 02.0 was applied for the measured values during the delay gap. All details for the delay gap and the errors applied are provided in section D.2, and the calculation of adjusted values can be found in the emission reduction calculation sheet.

Table 1: List of events that may have impacted the GHG emission reductions

Date	Events
21/09/2016 – 26/09/2016	Cable issue of the equipment for measuring ID1
01/01/2017 – 03/01/2017	No operation due to public holiday
12/04/2017 – 16/04/2017	No operation due to public holiday
24/11/2017 – 25/11/2017	Change in meter value of the equipment for measuring ID5 due to power drop at the starch factory
04/12/2017 – 22/01/2018	Malfunction of the equipment for measuring ID11
30/12/2017 – 31/12/2017	No operation due to public holiday
01/01/2018 – 03/01/2018	No operation due to public holiday
11/04/2018 – 19/04/2018	No operation due to public holiday

B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies, standardized baselines or other methodological regulatory documents

There were no temporary deviations from the registered monitoring plan or applied methodology during the monitoring period.

B.2.2. Corrections

There were no corrections applied during the monitoring period.

[2] The gas storage was constructed on 27/02/2010 during the second CDM monitoring period and was not part of the initial design of the project activity. The PDD was revised during the 2nd verification and was approved on 16/03/2012.

B.2.3. Changes to the start date of the crediting period

There were no changes to the start date of the crediting period.

B.2.4. Inclusion of monitoring plan

There was no inclusion of a monitoring plan applied to the registered project.

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents

The following changes from the registered monitoring plan were requested and approved during the third monitoring period.

AM0022 ID 16: volume of flow of wastewater directly to the current wastewater treatment system and bypassing the new wastewater treatment facility

This parameter was removed from the registered monitoring plan since it had no direct or indirect impact on the estimation of emission reductions.

The revision of the monitoring plan was approved on 12/08/2010.
(https://cdm.unfccc.int/Projects/DB/RWTUV1218617500.62/view)

There were no permanent changes to the registered monitoring plan during the current monitoring period.

B.2.6. Changes to project design

There was a change to the project design due to the installation of the gas storage in 2010, which was not part of the initial design for the project activity. The approval details on the change are provided as follows.

The approval date of the revised PDD: 16/03/2012
The version and completion date of the revised PDD: version 4.1 and dated 31/01/2012

There were no changes to the project design during the current monitoring period.

B.2.7. Changes specific to afforestation or reforestation project activity

The project activity is not afforestation or reforestation. Thus, this section is not applicable.

SECTION C. Description of monitoring system

Data management and emission reduction reporting:

The data management was done in the following manner.

- Data acquisition from the gas meters of flare and gas engines and the wastewater flow meter is executed on a daily basis through the process control unit, and the values are inputted manually into the CDM monitoring sheets by the plant staff and electronic format by the head of QC.
- Data acquisition from the gas meter at the boiler is recorded on a daily basis by the staff of the starch factory. The copied data is submitted to and kept by the head of QC. The values are transferred to an electronic log sheet by the head of QC.
- Electricity generation is recorded manually using operation sheets on a daily basis at the control unit of the gas engines and is then transferred to an electronic log sheet.

- Methane concentration is executed through the process control unit. The average values were calculated and inputted manually into the operation logbook and transferred to an electronic log sheet.
- For laboratory-monitored parameters, the records are written in log sheets on a daily basis and transferred to an electronic log sheet.
- The values from the electronic log sheet are used to estimate the emission reductions.
- The data is backed up in the form of Excel sheet on a different computer every four months by the head of QC, as well as on a portable storage system such as a compact disc.
- The data is archived for a period of two years after the crediting period.

The reporting of monitored parameters is done on a daily basis by the plant staff in the form of daily log reports. The data is compiled and inserted by the responsible staff into Excel report templates, which are used to calculate emission reductions and for monthly reporting respectively. The head of the QC team sends the printout of the summary monthly report to the plant manager and the managing director. The compiled Excel report is further sent to the project consultant for detailed emission reduction analysis. The managing director and project consultant meet at least once every three months to discuss emission reduction reporting. The details of the reporting procedure are explained in more detail in the table below, which summarizes the responsibilities of the staff at the project site.

QA/QC procedures:

- The calibrations for all the monitoring devices are available and are relevant to the monitoring period.
- The head of QC ensures the timely calibrations of the monitoring devices, data acquisition and storage of data.
- The roles and responsibilities of the project's staff are briefly tabulated below.

Roles	Responsibilities
Head of Quality Control	• Checks the completeness of the parameters monitored • Calculates and inserts the data on methane concentration into the logbook • Provides the monthly report • Sends the monthly report in print format to the plant manager and managing director • Sends aggregated reports via email to the project consultant on a monthly basis • Transfers all of the parameters monitored in logbooks into the electronic log file (Excel report) on a daily basis • Coordinates with the head of instrumentation to ensure the timely calibration of the monitoring equipment • Backs up the data from the excel reports every 4 months • Follows and collects the copied logbook for the monitored parameters at the boiler of the starch plant on a daily basis
Quality Control staff	• Takes samples and analyzes the characteristics of the wastewater • Fills in the logbook with the analysis result
Biogas system controller	• Fills in the data monitored for the biogas system from the process control unit to the logbook
Power system controller	• Fills in the data monitored for the power system from the process control unit to the logbook
Plant Manager	• Supervises and signs off the monthly report
Head of Instrumentation (Technician)	• Supports the operation of the biogas and power system • Maintains and repairs the equipment and machines • Coordinates with the Head of Quality Control to ensure the timely calibration of the monitoring equipment

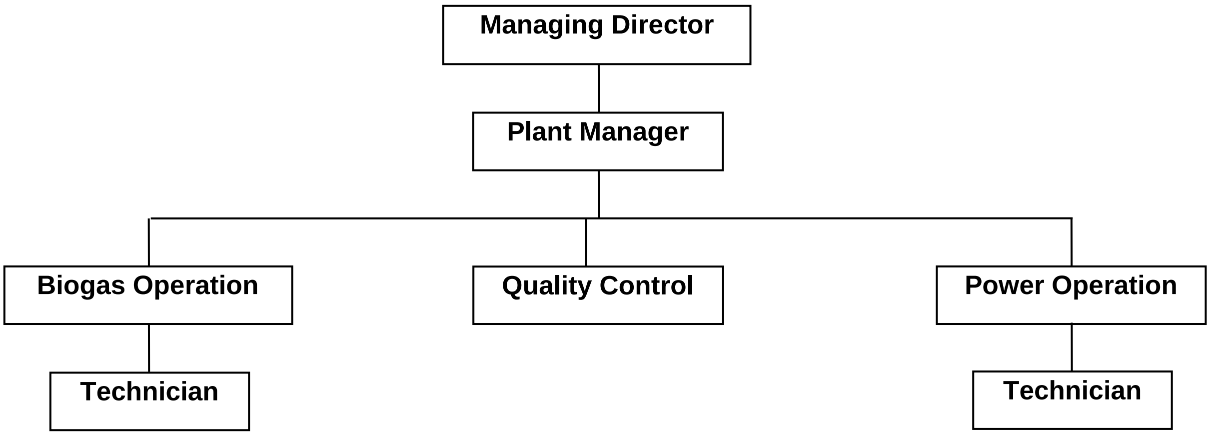

Figure 2: Organizational chart

Emergency procedures for the monitoring system

The daily operational checklist is conducted on a daily basis by the staff in charge of the overall checking of the operation. The staff on the next shift shall be made aware of any event from the previous day or previous shift and plan to promptly handle the situation. In the case of a problem with any of the equipment or a machine, the staff shall inform the project owner or the technical consultants on the project for the quick rectification of the problem.

Monitoring equipment of the project activity

Parameter Notation				**Monitoring equipment**	**Serial no.**	**Parameter description**
AM0022	**Registered PDD**	**SCADA representation**	**Tag no.**			
ID1	FM1	FT100	PD-MM-001	Wastewater flow meter	A0642633	Wastewater flows entering the project treatment facility
ID2[3]	n/a	n/a	n/a	n/a	n/a	Wastewater flow leaving the project treatment facility
ID3	n/a	n/a	PD-CL-001	Portable colorimeter	070890C64902	COD concentration of the wastewater entering the new anaerobic digestion system
ID4	n/a	n/a	PD-CL-001	Portable colorimeter	070890C64902	COD concentration of the wastewater leaving the new anaerobic digestion system
ID5	GM3	FT501	PD-DM-006	Gas Flow meter	C140397	Volume of biogas sent to facility heaters
ID7	n/a	n/a	n/a	Power meter	212606672 – export 206500531 – import	Electricity generated from collected biogas
ID8[4]	n/a	n/a	n/a	n/a	n/a	Fossil fuel volume equivalent to generating the same amount of heat generated from the biogas collected
ID9	GM2	FT105	PD-DM-002	Gas Flow meter	265DS6600065941	Biogas sent to flare
ID10	GM4	FT501A, FT501B	PD-DM-004	Gas Flow meter	FT501A: 265DS6600032493	Biogas sent to genset

[3] There is a revision to monitoring plan for this parameter, which was approved on 12/08/2010. This parameter referred to was established using ID1 and hydrological balance was assumed. Therefore, in the actual implementation it is not required to install a flow meter at the outlet of the project treatment facility.

[4] Calculated value

Parameter Notation				Monitoring equipment	Serial no.	Parameter description
AM0022	**Registered PDD**	**SCADA representation**	**Tag no.**			
			PD-DM-005		FT501B: 265DS6600028459	
ID11	n/a	AIT101	n/a	CH4 analyzer	ARBM-0023	Methane content in biogas
	n/a	n/a	PD-GA-001		11609[5]	
ID13	n/a	n/a	PD-CL-001	Portable colorimeter	070890C64902	Amount of chemical oxidizing agents entering system boundary
ID14[6]	n/a	n/a	n/a	n/a	n/a	Gen set combustion efficiency (combustion of methane)
ID15[4]	n/a	n/a	n/a	n/a	n/a	Heating system combustion efficiency (combustion of methane)
ID17	n/a	n/a	PD-GD-001	Gas detector	10110R4-006	Loss of biogas from pipeline
ID18	n/a	n/a	n/a	Weigh bridge	No.2: 0000237 No 3: 0001905	Organic material removed from wastewater facility
ID19[3]	n/a	n/a	n/a	n/a	n/a	Biogas calorific value

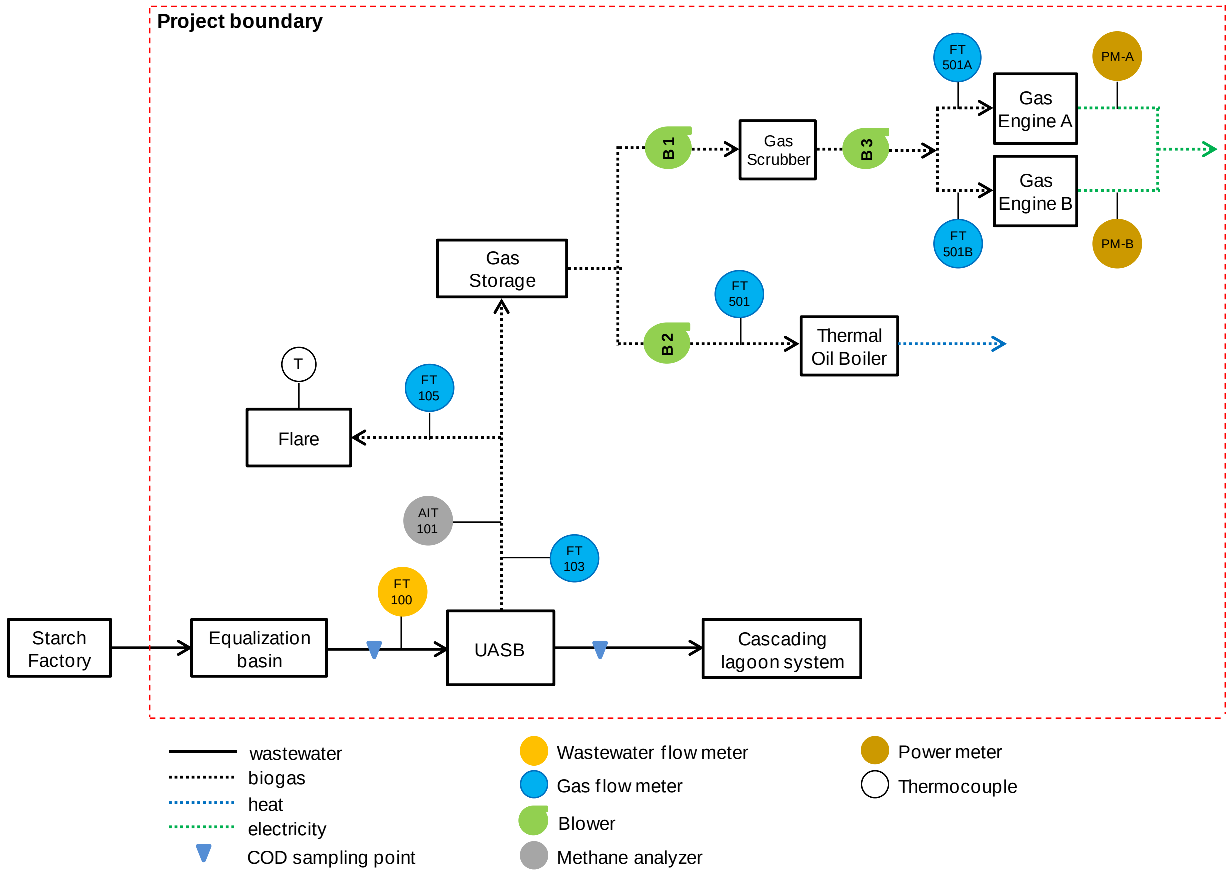

Figure 3: Flow diagram of the project activity representing the actual set-up of the monitoring system following approval of the monitoring plan revision

[5] Period of use has been provided in section D.2.
[6] Measurement of the parameter is done by third party.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	EF_{CH4}
Unit	kg CH_4/ kg COD
Description	Methane emission factor
Source of data	Estimated based on Intergovernmental Panel on Climate Change (IPCC) default value and available scientific literature
Value(s) applied	0.21
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	n/a

Data/Parameter	R_{lagoon}
Unit	%
Description	Organic material removal ratio
Source of data	Chemical analysis of effluent samples at inlet and outlet of lagoon system boundaries
Value(s) applied	98.90
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	

Data/Parameter	**Surface Aerobic Losses Factor**
Unit	kg COD/ha/day
Description	Surface aerobic losses factor per hectare of pond surface area per day
Source of data	Default value AM0022, Version 04
Value(s) applied	254
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	

Data/Parameter	**Chemical Oxidation Losses Factor**
Unit	kg COD/ m^3
Description	Chemical oxidation losses factor per cubic meter of effluent entering the lagoon-based treatment system
Source of data	Default value AM0022, Version 04
Value(s) applied	0.651 (used for conversion of the sulphate ion to COD)
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	n/a

Data/Parameter	$R_{deposition}$
Unit	%
Description	Organic material deposition ratio
Source of data	Project developer
Value(s) applied	7.05
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	-

Data/Parameter	E_{CH4_NAWTF}
Unit	%
Description	Proportion of methane emitted from UASB digesters
Source of data	Information provided by technology provider
Value(s) applied	1
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	n/a

Data/Parameter	R_{NAWTF}
Unit	%
Description	Total organic material removal efficiency of the new project wastewater facility
Source of data	Technical proposal prepared by technology provider
Value(s) applied	90
Choice of data or measurement methods and procedures	The technology provider guaranteed to reach 90% COD removal.
Purpose of data/parameter	Calculation of project emissions
Additional comments	n/a

Data/Parameter	f_{boiler}
Unit	%
Description	Proportion of biogas destroyed by combustion in the boilers used for heat generation.
Source of data	Technical literature
Value(s) applied	98.5
Choice of data or measurement methods and procedures	This value is based on technical literature and the manufacturer’s specifications of similar boilers. The factor is assumed to be conservative given the fact that the oxidation default value used for gaseous fuels in the 1996 IPCC Guidelines for National GHG Inventories was 100%.
Purpose of data/parameter	Calculation of project emissions
Additional comments	n/a

Data/Parameter	f_{engine}
Unit	%
Description	Proportion of biogas destroyed by combustion in the engines used for electricity generation.
Source of data	Technical literature

Value(s) applied	99
Choice of data or measurement methods and procedures	This value is based on technical literature and manufacturer's specifications of similar engines. The factor is assumed to conservative given the fact that the oxidation default value used for gaseous fuels in the 1996 IPCC Guidelines for National GHG Inventories was 100%.
Purpose of data/parameter	Calculation of project emissions
Additional comments	n/a

Data/Parameter	**CEF**
Unit	tCO_2/MWh
Description	Carbon emission factor for the electricity displaced by the electricity generated from the biogas
Source of data	Electricity Generation Authority of Thailand (EGAT), "Tool to calculate the emission factor for an electricity system"
Value(s) applied	0.52
Choice of data or measurement methods and procedures	CEF is calculated according to the "Tool to calculate the emission factor for an electricity system" as determined in the respective small-scale methodology for grid connected electricity generation (AMS-I.D v.13).
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	n/a

Data/Parameter	**EF**
Unit	tCO_2/TJ
Description	Carbon emission factor of heavy fuel oil
Source of data	2006 IPCC guidelines for National GHG Inventories
Value(s) applied	77.40
Choice of data or measurement methods and procedures	Default value
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	n/a

Data/Parameter	**NCV**
Unit	TJ/t
Description	Net calorific value (NCV) of heavy fuel oil
Source of data	2006 IPCC guidelines for National GHG Inventories
Value(s) applied	0.0404
Choice of data or measurement methods and procedures	Default value
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	n/a

Data/Parameter	**Density of CH_4**
Unit	$kgCH_4/Nm^3$ CH_4
Description	Density of methane at standard condition (0 degree Celsius, 1,013 bar)
Source of data	UNFCCC Methodological tool to determine project emissions from flaring gases containing methane, Table 1, page 12
Value(s) applied	0.716
Choice of data or measurement methods and procedures	Default value

Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	n/a

Data/Parameter	**Lagoon surface area**
Unit	Hectare
Description	Total lagoon area
Source of data	Project owner
Value(s) applied	25.18
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	n/a

Data/Parameter	**Flare efficiency**
Unit	%
Description	Flare efficiency for open flare
Source of data	Tool to determine project emissions from flaring gases containing methane
Value(s) applied	0% if the flame is not detected for more than 20 minutes during the hour, *h*. 50%, if the flame is detected for more than 20 minutes during the hour, *h*.
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	n/a

Data/Parameter	**Specific heavy fuel oil consumption**
Unit	t HFO/t starch
Description	Historic average heavy fuel oil consumption per ton of output (ton of dry starch)
Source of data	Historic fuel consumption of 2006/2007
Value(s) applied	0.033
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	n/a

Data/Parameter	**Specific electricity consumption**
Unit	MWh/t starch
Description	Historic average electricity consumption per ton of output (ton of dry starch)
Source of data	Historic electricity consumption of 2006/2007
Value(s) applied	0.222
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	n/a

D.2. Data and parameters monitored

<table>
<tr><td>Data/Parameter</td><td>AM0022 ID 1
Wastewater flows entering the project treatment facility</td></tr>
<tr><td>Unit</td><td>m^3</td></tr>
<tr><td>Description</td><td>Wastewater flow entering into the new anaerobic digestion system</td></tr>
<tr><td>Measured/calculated/ default</td><td>Measured continuously by the flow meter

In the CDM Monitoring Sheet, the data in m^3/day was calculated by the following
Data in day ‘x’ = (totalizer in day ‘x’) - (totalizer in day ‘x-1’)</td></tr>
<tr><td>Source of data</td><td>Log sheet</td></tr>
<tr><td>Value(s) of monitored parameter</td><td><table><tr><th>Monitoring period</th><th>Total value (m^3)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>505,538</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>975,503</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>276,514</td></tr></table></td></tr>
<tr><td>Monitoring equipment</td><td><table><tr><td>SCADA representation/tag no.</td><td>FT100/PD-MM-001</td></tr><tr><td>Equipment type</td><td>Electromagnetic flowmeter with flow converter</td></tr><tr><td>Manufacturer</td><td>Krohne</td></tr><tr><td>Model</td><td>IFC010D</td></tr><tr><td>Maximum permissible error</td><td>±0.3%</td></tr><tr><td>Serial no.</td><td>A0642633</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of previous calibration</td><td>25/08/2015
12/07/2016
25/05/2017</td></tr><tr><td>Date of latest calibration</td><td>30/08/2018</td></tr></table></td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>The meter continuously monitored the flow of wastewater. The accumulated reading was taken from the SCADA screen and logged into the electronic file by the operator on a daily basis.</td></tr>
<tr><td>Calculation method (if applicable)</td><td>n/a</td></tr>
<tr><td>QA/QC procedures</td><td>Flow meter underwent maintenance/calibration according to appropriate industry standards.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline and project emissions</td></tr>
<tr><td>Additional comments</td><td>The calibration was conducted in line with the calibration frequency.</td></tr>
</table>

<table>
<tr><td>Data/Parameter</td><td>AM0022 ID 2
Wastewater flows leaving the project treatment facility</td></tr>
<tr><td>Unit</td><td>m^3</td></tr>
<tr><td>Description</td><td>Wastewater flow leaving the new anaerobic digestion system</td></tr>
<tr><td>Measured/calculated/ default</td><td>Established using ID 1 and assuming hydrological balance</td></tr>
<tr><td>Source of data</td><td>Established using ID 1 and assuming hydrological balance</td></tr>
<tr><td>Value(s) of monitored parameter</td><td><table><tr><th>Monitoring period</th><th>Total value (m^3)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>505,538</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>975,503</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>276,514</td></tr></table></td></tr>
<tr><td>Monitoring equipment</td><td>Refer to the information provider for ID 1</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Refer to the information provider for ID 1</td></tr>
</table>

Calculation method (if applicable)	Refer to the information provider for ID 1
QA/QC procedures	Refer to the information provider for ID 1
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	The calibration was conducted in line with the calibration frequency.

Data/Parameter	**AM0022 ID 3** **Wastewater organic material concentration entering the project treatment facility**
Unit	kg COD/m³
Description	COD concentration of the wastewater entering the new anaerobic digester system
Measured/calculated/ default	The test was done and recorded in mg/l by the Quality Control staff. The value was later converted to kg COD/m³
Source of data	Log sheet
Value(s) of monitored parameter	**Monitoring period** / **Average value (kg COD/m³)** 01/05/2016 – 31/12/2016: 23.81 01/01/2017 – 31/12/2017: 16.16 01/01/2018 – 24/05/2018: 18.68
Monitoring equipment	SCADA representation/tag no.: n/a/PD-CL-001 Equipment type: Portable Colorimeter Manufacturer: Hach Model: DR/890 Maximum permissible error: ±0.24% Serial no.: 070890C64902 Calibration frequency: Annually Date of previous calibration: 03/09/2015, 22/07/2016, 11/04/2017, 03/10/2017 Date of latest calibration: 18/09/2018
Measuring/reading/recording frequency	Composite sampling and analysis were performed on a daily basis. This procedure was followed during the monitoring period.
Calculation method (if applicable)	The daily COD data in kg COD/m³ was multiplied by the daily wastewater flow to estimate the COD load on a daily basis. The approach was transparently applied in the Excel sheet.
QA/QC procedures	Periodic tests were carried out by an accredited laboratory/company in order to provide quality assurance.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	The calibration was conducted in line with the calibration frequency.

Data/Parameter	**AM0022 ID 4** **Wastewater organic material concentration leaving the project treatment facility**
Unit	kg COD/m³
Description	COD concentration of the wastewater leaving the new anaerobic digester system
Measured/calculated/ default	The test was done and recorded in mg/l by the quality control staff. The value was later converted to kg COD/m³
Source of data	Log sheet

Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Average value (kg COD/m³)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>2.74</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>2.17</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>2.70</td></tr></table>
Monitoring equipment	<table><tr><td>SCADA representation/tag no.</td><td>n/a/PD-CL-001</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>Maximum permissible error</td><td>±0.24%</td></tr><tr><td>Serial no.</td><td>070890C64902</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of previous calibration</td><td>03/09/2015 22/07/2016 11/04/2017 03/10/2017</td></tr><tr><td>Date of latest calibration</td><td>18/09/2018</td></tr></table>
Measuring/reading/recording frequency	Composite sampling and analysis were performed on a daily basis. This procedure was followed during the monitoring period.
Calculation method (if applicable)	The daily COD data in kg COD/m^3 was multiplied by the daily wastewater flow to estimate the COD load on a daily basis. The approach was transparently applied in the Excel sheet.
QA/QC procedures	Periodic tests were carried out by an accredited laboratory/company in order to provide quality assurance.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	The calibration was conducted in line with the calibration frequency.

Data/Parameter	**AM0022 ID 5** **Volume of biogas sent to facility heaters**
Unit	Nm^3 biogas
Description	Volume of biogas sent to facility heaters
Measured/calculated/ default	Measured continuously (normalized to take into account pressure and temperature) by gas flow meters
Source of data	Boiler log sheet
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Total value (Nm³)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>2,819,056</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>3,818,430</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>1,799,125</td></tr></table>
Monitoring equipment	<table><tr><td>SCADA representation/tag no.</td><td>FT501/PD-DM-006</td></tr><tr><td>Equipment type</td><td>Differential flow meter</td></tr><tr><td>Manufacturer</td><td>Binder</td></tr><tr><td>Model</td><td>E7A-S100000-1MA200-D1104501-21CS2410</td></tr><tr><td>Maximum permissible error</td><td>±0.04%</td></tr><tr><td>Serial no.</td><td>C140397</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of previous calibration</td><td>25/08/2015 13/07/2016 25/05/2017</td></tr><tr><td>Date of latest calibration</td><td>30/08/2018</td></tr></table>
Measuring/reading/recording frequency	The meter continuously monitored the biogas flow sent to boiler. The meter readings were taken and logged in the electronic file by the operator on a daily basis.

Calculation method (if applicable)	n/a
QA/QC procedures	Gas flow meter underwent maintenance/calibration according to appropriate industry standards. In the event of technical problems with the meter, the value could have been calculated based on a mass balance using the other installed gas meters (biogas sent to heaters = total biogas produced – biogas sent to flare – biogas sent to engine). However, this approach was not applied during the monitoring period since there were no problems with the meter.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The calibration was conducted in line with the calibration frequency.

Data/Parameter	**AM0022 ID 7** **Electricity generated from collected biogas**
Unit	MWh
Description	Electricity generated from the biogas collected in the anaerobic treatment facility and consumed on site or sent to the grid
Measured/calculated/ default	Measured continuously in kWh
Source of data	Log sheet
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Total value (MWh)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>2,392</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>-77</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>-154</td></tr></table> During the year 2017 and 2018, the net amount of electricity generated was negative due to less exported electricity.
Monitoring equipment	<table><tr><td>Equipment type</td><td>Power meter - export</td></tr><tr><td>Manufacturer</td><td>EDMI</td></tr><tr><td>Model</td><td>Genius Series Mk6N</td></tr><tr><td>Maximum permissible error</td><td>Class 0.5s, ±0.5%</td></tr><tr><td>Serial no.</td><td>212606672</td></tr><tr><td>Date of calibration</td><td>13/03/2017</td></tr></table> <table><tr><td>Equipment type</td><td>Power meter - import</td></tr><tr><td>Manufacturer</td><td>EDMI</td></tr><tr><td>Model</td><td>Genius Series Mk6N</td></tr><tr><td>Maximum permissible error</td><td>Class 0.5s, ±0.5%</td></tr><tr><td>Serial no.</td><td>206500531</td></tr></table>
Measuring/reading/recording frequency	The electricity exported was continuously measured using a power meter installed and owned by PEA. The readings were based on monthly joint meter readings between PEA and the project representative.
Calculation method (if applicable)	n/a
QA/QC procedures	The calibration of the meter was under the control of PEA.
Purpose of data/parameter	Calculation of project emissions
Additional comments	The calibration was conducted as per the request by PEA. There was less power exported to the grid from May 2017 onwards, thus the PEA did not require any calibration of the equipment.

Data/Parameter	**AM0022 ID 8** **Fossil fuel volume equivalent to generate same amount of heat generated from the biogas collected in the anaerobic treatment facility**
Unit	m^3

<table>
<tr><td>Description</td><td>Fossil fuel volume equivalent to generating same amount of heat generated by the biogas collected in the anaerobic treatment facility</td></tr>
<tr><td>Measured/calculated/ default</td><td>Calculated</td></tr>
<tr><td>Source of data</td><td>Value in m³ unit
Calculated based on amount of biogas sent to the boiler (ID 5), 0.5743 kg of HFO/m³ biogas (referred to section B.6.1 of the registered PDD) and heavy fuel density of 0.995 kg/l (referred to section B.6.1 of the registered PDD).

Value in ton unit
Calculated based on amount of biogas sent to the boiler (ID 5), NCV of heavy fuel oil and NCV of biogas.

As per page 27 of the registered PDD, the above value needs to be compared with historical average of 0.03303 tHFO/t dry starch.</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th rowspan="2">Monitoring period</th><th colspan="2">Total value</th></tr>
<tr><th>Calculated in m³</th><th>Calculated in tons</th></tr>
<tr><td>01/05/2016 – 31/12/2016</td><td>1,627.12</td><td>1,687.72</td></tr>
<tr><td>01/01/2017 – 31/12/2017</td><td>2,203.94</td><td>1,989.46</td></tr>
<tr><td>01/01/2018 – 24/05/2018</td><td>1,038.43</td><td>1,033.94</td></tr>
</table>

The above values in tons used for the calculation of baseline emissions were calculated using a conservative approach based on a comparison between the fossil fuel amount (calculation based on biogas equivalent) and the historical value of 0.03303 tHFO/t dry starch. Furthermore, the amount of fossil fuel consumed during the monitoring period was deducted in order to be even further conservative. Further details can be found in the calculation sheet.</td></tr>
<tr><td>Monitoring equipment</td><td>The calculation of this parameter was based on the amount of biogas sent to the boiler which was measured by using the same equipment as ID 5</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>The calculation for the data was done on a daily basis. The approach was transparently applied in the Excel sheet.</td></tr>
<tr><td>Calculation method (if applicable)</td><td>The quantity of biogas used at boiler was multiplied by 0.5743, then divided by the density of heavy fuel oil to get the volume of heavy fuel oil in m³.

The quantity of biogas used at boiler was multiplied by the NCV of biogas, then divided by NCV of heavy fuel oil to get the volume of heavy fuel oil in tons.</td></tr>
<tr><td>QA/QC procedures</td><td>n/a</td></tr>
<tr><td>Purpose of data/parameter</td><td>The data (in tons) was used for calculation of baseline emissions</td></tr>
<tr><td>Additional comments</td><td>n/a</td></tr>
</table>

Data/Parameter	**AM0022 ID 9** **Biogas sent to flares (V1)**
Unit	Nm³ biogas
Description	Surplus biogas sent to flare system (dry basis)
Measured/calculated/ default	Measured continuously (normalized to take pressure temperature into account) by gas flow meters. In the monitoring data sheet, the data in Nm³/day can be done using the following formula: Data in day ‘x’ = (totalizer in day ‘x’) - (totalizer in day ‘x-1’)
Source of data	Log sheet

Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Total value (Nm³)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>286,792</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>342,552</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>1,335</td></tr></table>
Monitoring equipment	<table><tr><td>SCADA representation/tag no.</td><td>FT105/PD-DM-002</td></tr><tr><td>Equipment type</td><td>Differential flow meter</td></tr><tr><td>Manufacturer</td><td>ABB</td></tr><tr><td>Model</td><td>265DS CCFA6B1</td></tr><tr><td>Maximum permissible error</td><td>±0.04%</td></tr><tr><td>Serial no.</td><td>265DS6600065941</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of previous calibration</td><td>25/08/2015 12/07/2016 25/05/2017</td></tr><tr><td>Date of latest calibration</td><td>30/08/2018</td></tr></table>
Measuring/reading/recording frequency	The meter continuously monitored the biogas flow sent to the flare system. The accumulated reading was taken from the SCADA screen and logged into the electronic file by the operator on a daily basis.
Calculation method (if applicable)	n/a
QA/QC procedures	Flow meter underwent maintenance/calibration according to appropriate industry standards. In the event of technical problems with the meter, the value could have been calculated based on a mass balance using the other installed gas meters (biogas sent to flare = total biogas produced – biogas sent to boiler – biogas sent to engines). However, this approach was not applied during the monitoring period since there were no problems with the meter.
Purpose of data/parameter	Calculation of project emissions
Additional comments	The calibration was conducted in line with the calibration frequency.

Data/Parameter	**AM0022 ID 10** **Biogas sent to generation**
Unit	Nm³ biogas
Description	Biogas sent to generation facility and used for electricity generation
Measured/calculated/ default	Measured continuously (normalized to take pressure temperature into account) by gas flow meters. In the monitoring data sheet, the data in Nm³/day can be done using the following formula: Data in day ‘x’ = (totalizer in day ‘x’) - (totalizer in day ‘x-1’)
Source of data	Log sheet
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Total value (Nm³)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>1,961,068</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>2,242,984</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>145,346</td></tr></table>

Monitoring equipment	<table><tr><td>Location</td><td>Generator A</td></tr><tr><td>SCADA representation/tag no.</td><td>FT501A/PD-DM-004</td></tr><tr><td>Equipment type</td><td>Differential flow meter</td></tr><tr><td>Manufacturer</td><td>ABB</td></tr><tr><td>Model</td><td>265DS CCFA6B1</td></tr><tr><td>Maximum permissible error</td><td>±0.04%</td></tr><tr><td>Serial no.</td><td>265DS6600032493</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of previous calibration</td><td>25/08/2015 12/07/2016 25/05/2017</td></tr><tr><td>Date of latest calibration</td><td>30/08/2018</td></tr></table> <table><tr><td>Location</td><td>Generator B</td></tr><tr><td>SCADA representation/tag no.</td><td>FT501B/PD-DM-005</td></tr><tr><td>Equipment type</td><td>Differential flow meter</td></tr><tr><td>Manufacturer</td><td>ABB</td></tr><tr><td>Model</td><td>265DS CCFA6B1</td></tr><tr><td>Maximum permissible error</td><td>±0.04%</td></tr><tr><td>Serial no.</td><td>265DS6600028459</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of previous calibration</td><td>25/08/2015 12/07/2016 25/05/2017</td></tr><tr><td>Date of latest calibration</td><td>30/08/2018</td></tr></table>
Measuring/reading/recording frequency	The meters continuously monitored the biogas flow sent to the generation facility. The accumulated reading was taken from the SCADA screen and logged in the electronic file by the operator on a daily basis.
Calculation method (if applicable)	n/a
QA/QC procedures	Flow meters underwent maintenance/calibration according to appropriate industry standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	The calibration was conducted in line with the calibration frequency.

Data/Parameter	**AM0022 ID11** **Biogas methane concentration**
Unit	%
Description	Methane concentration in biogas
Measured/calculated/ default	Measured continuously. The average of data was calculated to represent the data for each day.
Source of data	Log sheet
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Average value (%)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>66.96</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>66.57</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>69.86</td></tr></table>

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Period of use</td><td>06/10/2013 to 13/06/2017</td></tr>
<tr><td>SCADA representation/tag no.</td><td>AIT101/n/a</td></tr>
<tr><td>Equipment type</td><td>CH4 Analyzer</td></tr>
<tr><td>Manufacturer</td><td>Drager</td></tr>
<tr><td>Model</td><td>Polytron IR EX</td></tr>
<tr><td>Maximum permissible error</td><td>±1.00%</td></tr>
<tr><td>Serial no.</td><td>ARBM-0023</td></tr>
<tr><td>Calibration frequency</td><td>Annually</td></tr>
<tr><td>Date of previous calibration</td><td>23/08/2015</td></tr>
<tr><td>Date of latest calibration</td><td>09/07/2016</td></tr>
</table>
<table>
<tr><td>Period of use</td><td>13/06/2017 to present</td></tr>
<tr><td>SCADA representation/tag no.</td><td>n/a/PD-GA-001</td></tr>
<tr><td>Equipment type</td><td>CH4 Analyzer</td></tr>
<tr><td>Manufacturer</td><td>Binder</td></tr>
<tr><td>Model</td><td>Combimass GA-m</td></tr>
<tr><td>Maximum permissible error</td><td>±1.50%</td></tr>
<tr><td>Serial no.</td><td>11609</td></tr>
<tr><td>Calibration frequency</td><td>Annually</td></tr>
<tr><td>Date of previous calibration</td><td>17/05/2017
16/12/2017</td></tr>
<tr><td>Date of latest calibration</td><td>23/10/2018</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>The percentage of methane in the gas was monitored continuously. The readings were taken from the SCADA screen and were recorded in the logbook on a daily basis, and the averaged value was transferred to the electronic file by the operator.</td></tr>
<tr><td>Calculation method (if applicable)</td><td>n/a</td></tr>
<tr><td>QA/QC procedures</td><td>The gas analyzer underwent maintenance/calibration according to appropriate industry standards.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline and project emissions</td></tr>
<tr><td>Additional comments</td><td>The calibration was conducted in line with the calibration frequency.</td></tr>
</table>

<table>
<tr><td>Data/Parameter</td><td>AM0022 ID 12
Project emissions from flaring of the residual gas stream (PE_{flare})</td></tr>
<tr><td>Unit</td><td>tCO_2e</td></tr>
<tr><td>Description</td><td>Project emissions from flaring of the residual gas stream</td></tr>
<tr><td>Measured/calculated/ default</td><td>Calculated based on amount of biogas sent to the flare (ID 9), the flare efficiency, the methane concentration of biogas (ID 11), density of methane and GWP_{CH4}</td></tr>
<tr><td>Source of data</td><td>Calculation</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th>Monitoring period</th><th>Total value (tCO_2e)</th></tr>
<tr><td>01/05/2016 – 31/12/2016</td><td>3,603</td></tr>
<tr><td>01/01/2017 – 31/12/2017</td><td>4,240</td></tr>
<tr><td>01/01/2018 – 24/05/2018</td><td>17</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>The monitoring equipment for the amount of biogas sent to the flare was the same as for ID 9.
The monitoring equipment for the methane concentration of biogas was the same as for ID 11.</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>The calculation for the data was carried out on a daily basis. The approach was transparently applied in the Excel sheet.</td></tr>
</table>

Calculation method (if applicable)	The parameter was calculated according to the "Tool to determine project emissions from flaring gases containing methane", step 7 where the mass flow rate of methane in the residual gas ($TM_{RG,h}$) was calculated from ID 9, ID 11 and the density of methane.
QA/QC procedures	n/a
Purpose of data/parameter	Calculation of project emissions
Additional comments	n/a

Data/Parameter	**AM0022 ID 13** **Amount of chemical oxidizing agents entering system boundary**
Unit	tonnes/m^3
Description	Amount of chemical oxidizing agents entering the system boundary
Measured/calculated/ default	Measured by the Quality Control Operator
Source of data	Log sheet
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Average value (tonnes/m³)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>0.000280</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>0.000170</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>0.000166</td></tr></table>
Monitoring equipment	<table><tr><td>SCADA representation/Tag no.</td><td>-/PD-CL-001</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>Maximum permissible error</td><td>±0.24%</td></tr><tr><td>Serial no.</td><td>070890C64902</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of previous calibration</td><td>03/09/2015 22/07/2016 11/04/2017 03/10/2017</td></tr><tr><td>Date of latest calibration</td><td>18/09/2018</td></tr></table>
Measuring/reading/recording frequency	Daily test for wastewater samples was carried out to determine the amount of oxidizing agent entering the wastewater system. The daily test result was recorded in the log sheet on a daily basis
Calculation method (if applicable)	n/a
QA/QC procedures	Regular samples were tested for the concentration of oxidising agents where they are identified as likely to be present in wastewater; this was part of the process.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	The calibration was conducted in line with the calibration frequency.

Data/Parameter	**AM0022 ID 14** **Gen set combustion efficiency (f)**
Unit	%
Description	Proportion of biogas combusted by the generation facility
Measured/calculated/ default	Measured and calculated by the project developer or the default value in the registered PDD could also be used. The lowest value was applied in the project emission calculation for the sake of conservativeness.
Source of data	Reports by third party or the registered PDD

Value(s) of monitored parameter	<table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Measured value (%)</th></tr><tr><th>Generator A</th><th>Generator B</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>99.9976%</td><td>99.9929%</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>99.9857%</td><td>99.9746%</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>99.9948%</td><td>99.9943%</td></tr></table>
Monitoring equipment	<table><tr><th colspan="3">Generator A</th></tr><tr><th>Year</th><th>Date of measurement</th><th>Done by</th></tr><tr><td>2016</td><td>17/03/2016</td><td rowspan="3">United Analyst and Engineering Consultant Co.,Ltd.</td></tr><tr><td>2017</td><td>18/02/2017</td></tr><tr><td>2018</td><td>17/08/2018</td></tr></table> <table><tr><th colspan="3">Generator B</th></tr><tr><th>Year</th><th>Date of measurement</th><th>Done by</th></tr><tr><td>2016</td><td>17/03/2016</td><td rowspan="3">United Analyst and Engineering Consultant Co.,Ltd.</td></tr><tr><td>2017</td><td>18/02/2017</td></tr><tr><td>2018</td><td>17/08/2018</td></tr></table>
Measuring/reading/recording frequency	The measurement was conducted once a year.
Calculation method (if applicable)	The reports showed the results in ppm. The value of the combustion efficiency was calculated as follows: • conversion of unit from ppm to percentage of non-combusted methane and; • the figure was deducted from 100% to determine the combustion efficiency of the generators during the monitoring period.
QA/QC procedures	Measurements were conducted on the basis of standard industry practice
Purpose of data/parameter	Calculation of project emissions
Additional comments	There were measurement delays in 2018 as the company conducting measurement was not available at the time requested. However, the measurement results for 2018 were compared with the previous results and found within the range[7]. The measurement results for generators during the monitoring period were also higher than the default value of 99% for generators. Therefore, the adjustment of values was not conducted as per paragraph 366 of the VVS and the default values were applied in the calculation of emission reductions for the sake of conservativeness.

Data/Parameter	**AM0022 ID 15 Heating system combustion efficiency**
Unit	%
Description	Combustion efficiency of boilers using biogas for heat generation
Measured/calculated/ default	Measured and calculated by the project developer or the default value in the registered PDD could be used. The lowest value was applied in the project emission calculation for the sake of conservativeness.
Source of data	Reports by third party or the registered PDD
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Measured value (%)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>99.9930%</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>99.9997%</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>99.9954%</td></tr></table>

[7] The supportive evidence has been provided to the DOE.

Monitoring equipment	<table><tr><th>Year</th><th>Date of measurement</th><th>Done by</th></tr><tr><td>2016</td><td>16/03/2016</td><td rowspan="3">United Analyst and Engineering Consultant Co.,Ltd.</td></tr><tr><td>2017</td><td>18/02/2017</td></tr><tr><td>2018</td><td>18/08/2018</td></tr></table>
Measuring/reading/recording frequency	The measurement was conducted once a year
Calculation method (if applicable)	The report showed the results in ppm. The value of the combustion efficiency was calculated as follows: • conversion of unit from ppm to percentage of non-combusted methane and; • the figure was deducted from 100% to determine the combustion efficiency of the generators during the monitoring period.
QA/QC procedures	Measurements to be conducted on the basis of standard industry practice
Purpose of data/parameter	Calculation of project emissions
Additional comments	There were measurement delays in 2018 as the company conducting measurement was not available at the time requested. However, the measurement results for 2018 were compared with the previous results and found within the range[8]. The measurement results for boiler during the monitoring period were also higher than the default value of 98.5% for boiler. Therefore, the adjustment of values was not conducted as per paragraph 366 of the VVS and the default values were applied in the calculation of emission reductions for the sake of conservativeness.

Data/Parameter	**AM0022 ID 16** Flow of wastewater directly to the current wastewater treatment system
Unit	m^3
Description	Volume of flow of wastewater directly to the current wastewater treatment system and bypassing the new wastewater treatment facility
Measured/calculated/ default	Measured continuously by the flow meter In the monitoring data sheet, the data in m^3/day can be calculated according to the following formula: Data in day 'x' = (totalizer in day 'x') - (totalizer in day 'x-1')
Source of data	Log sheet
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Total value (m^3)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>0</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>0</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>0</td></tr></table>
Monitoring equipment	Monitoring equipment was not applicable as no wastewater was bypassed during the monitoring period.
Measuring/reading/recording frequency	n/a
Calculation method (if applicable)	n/a
QA/QC procedures	n/a
Purpose of data/parameter	Calculation of project emissions
Additional comments	All the wastewater was sent to the biogas facility, thus there was no wastewater directly flowing into the current wastewater treatment system.

[8] The supportive evidence has been provided to the DOE.

Data/Parameter	**AAM0022 ID 17** **Loss of biogas from pipeline**
Unit	%
Description	Loss of biogas from pipeline
Measured/calculated/ default	The biogas pipeline was checked using a mobile gas detector
Source of data	Report by the project developer
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Average value (%)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>0</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>0</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>0</td></tr></table>
Monitoring equipment	<table><tr><td>SCADA representation/tag no.</td><td>-/PD-GD-001</td></tr><tr><td>Equipment type</td><td>Portable gas detector</td></tr><tr><td>Manufacturer</td><td>Industrial Scientific</td></tr><tr><td>Model</td><td>MX4</td></tr><tr><td>Maximum permissible error</td><td>±5%</td></tr><tr><td>Serial no.</td><td>10110R4-006</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of previous calibration</td><td>05/06/2015 09/07/2016 17/05/2017</td></tr><tr><td>Date of latest calibration</td><td>01/10/2018</td></tr></table>
Measuring/reading/recording frequency	Periodic test for gas leakage was carried out by the operator once a week with the test readings were recorded in the test report accordingly.
Calculation method (if applicable)	n/a
QA/QC procedures	Periodic test was carried out according to international standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	The calibration of the equipment was delayed during 05/06/2016 to 08/07/2016 and 17/05/2018 to 24/05/2018. However, the adjustment of values was not conducted as per paragraph 366 of the VVS, Version 02.0 since there was no gas leakage detected during the delay period.

Data/Parameter	**AM0022 ID 18** **Organic material removed from wastewater facility**
Unit	tCOD
Description	Organic material removed from wastewater facility
Measured/calculated/ default	Measured using weighing machine
Source of data	Log sheet
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Value (tCOD)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>0</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>0</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>0</td></tr></table>

Monitoring equipment	SCADA representation/tag no.: n/a Equipment type: Weighing machine Manufacturer: Commander Model: HP01 Maximum permissible error: ±20 kg Serial no.: 0000237 Calibration frequency: Once every two years Date of previous calibration: 16/02/2016 Date of latest calibration: 14/02/2018 SCADA representation/tag no.: n/a Equipment type: Weighing machine Manufacturer: Commander Model: HP01 Maximum permissible error: ±20 kg Serial no.: 0001905 Calibration frequency: Once every two years Date of previous calibration: 16/02/2016 Date of latest calibration: 14/02/2018
Measuring/reading/recording frequency	The measurement shall be made when the organic material is removed from the reactors using the weighing machine at the starch plant.
Calculation method (if applicable)	n/a
QA/QC procedures	The weighing machine at the starch plant underwent maintenance/calibration according to appropriate industry standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	There was no removal of organic material during the monitoring period.

Data/Parameter	**AM0022 ID 19** **Biogas calorific value**
Unit	J/Nm^3
Description	Calorific value of biogas
Measured/calculated/ default	Calculation based on the methane concentration of biogas (ID 11) and NCV of methane
Source of data	ID 11 and NCV of methane
Value(s) of monitored parameter	The value in MJ/Nm^3 was used for the calculation of baseline emissions. **Monitoring period** / **Value (J/Nm^3)** / **Value (MJ/Nm^3)** 01/05/2016 – 31/12/2016 / 24,470,000 / 24.47 01/01/2017 – 31/12/2017 / 24,070,000 / 24.07 01/01/2018 – 24/05/2018 / 25,110,000 / 25.11
Monitoring equipment	The biogas calorific value was calculated based on the methane concentration of biogas (ID 11) and the NCV of methane (fixed parameter), therefore, the monitoring equipment was same as ID 11.
Measuring/reading/recording frequency	The calculation for the data was done on a daily basis. The approach was transparently applied in the Excel sheet.
Calculation method (if applicable)	The methane concentration of biogas is multiplied by the NCV of methane
QA/QC procedures	n/a
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	**Flame detection period**
Unit	Minutes (min)

Description	Number of minutes per hour where a flame is detected, whenever biogas is sent to the flare. If flame is detected for less than 20 minutes in an hour (whenever biogas is sent to flare), flare efficiency is assumed to be 0%. Otherwise flare efficiency is assumed to be 50%.
Measured/calculated/ default	Measured based on flame detection signals by flare
Source of data	Electronic files from data logger
Value(s) of monitored parameter	**Monitoring period** / **Value (min)** 01/05/2016 – 31/12/2016: No record 01/01/2017 – 31/12/2017: No record 01/01/2018 – 24/05/2018: No record
Monitoring equipment	The flare system was an automated system and ensured that the biogas was not sent to the flare, if the flame was not detected. The details of the biogas going to the flare system and flame detection were available as part of the automated monitoring system at the project site.
Measuring/reading/recording frequency	The flame detection period was compared to the period of biogas being sent to the flare. The flare efficiency was determined based on the ratio of these two values in relation to the default value determination method.
Calculation method (if applicable)	n/a
QA/QC procedures	n/a
Purpose of data/parameter	Calculation of project emissions
Additional comments	Since the data was not available during the monitoring period, the flaring efficiency is assumed as zero percent in order to calculate the project emission for the sake of conservativeness.

Data/Parameter	**Period of biogas being sent to the flare**
Unit	Min
Description	Number of minutes per hour where biogas is sent to the flare
Measured/calculated/ default	Measured/calculated based on SCADA records of biogas flow meter at the entrance of the flare
Source of data	Electronic files from data logger
Value(s) of monitored parameter	**Monitoring period** / **Value (min)** 01/05/2016 – 31/12/2016: No record 01/01/2017 – 31/12/2017: No record 01/01/2018 – 24/05/2018: No record
Monitoring equipment	The flare system was an automated system and ensured that the biogas was not sent to the flare, if the flame was not detected. The details of the biogas going to the flare system and flame detection were available as part of the automated monitoring system at the project site.
Measuring/reading/recording frequency	Whenever biogas flow was registered by the SCADA system for the biogas plant, the time was also recorded, which allowed for the calculation of the time period of biogas being sent to the flare.
Calculation method (if applicable)	n/a
QA/QC procedures	n/a
Purpose of data/parameter	Calculation of project emissions
Additional comments	Since the data was not available during the monitoring period, the flaring efficiency was assumed to be zero percent in order to calculate the project emissions following the principle of conservativeness.

D.3. Implementation of sampling plan

The section is not applicable since there was no sampling plan used for the monitoring of the project activity.

SECTION E. Calculation of emission reductions or net anthropogenic removals

E.1. Calculation of baseline emissions or baseline net removals

The baseline scenario is based on what would have happened in the absence of the project activity. In this case, the baseline scenario is the continued operation of the open anaerobic lagoon system, consumption of HFO for thermal energy generation and of electricity from the grid:

Formula (8) AM0022 v4, baseline scenario:

$$E_{BL} = E_{CH4\_lagoons\_BL} + E_{CO2\_heat\_BL} + E_{CO2\_power\_BL} \quad (8)$$

Where:

E_{BL}	are the total baseline emissions (tCO_2e)
$E_{CH4\_lagoons\_BL}$	are the fugitive methane emissions from lagoons in the baseline case (tCO_2e). They are calculated using baseline data based on equation 2 in the section on project emissions.
$E_{CO2\_heat\_BL}$	are the CO_2 emissions from on-site fossil heat and/or power generation in the baseline case (tCO_2) which are displaced by generation based on biogas collected in the anaerobic treatment facility.
$E_{CO2\_power\_BL}$	are the CO_2 emissions related electricity supplied by the grid in the baseline case (tCO_2) that are displaced by generation based on biogas collected in the anaerobic treatment facility

1) <u>Fugitive methane emissions from lagoons ($E_{CH4\_lagoon\_BL}$)</u>

Methane emissions from lagoons are calculated using equations (2), (3), (5) and (6). In the baseline case, without the new anaerobic treatment facility, no wastewater material degrades before entering the lagoon system and all the organic material to be treated enters the lagoons system. Therefore, equation (4) has to be changed for the baseline calculations, as shown below:

Formula (11) AM0022 v4, baseline scenario:

$$M_{lagooon\_input\_BL} = M_{input\_total} \quad (11)$$

Where:

$M_{lagooon\_input\_BL}$	is the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system
M_{input_total}	is the total amount of organic material fed into the baseline wastewater treatment facility

All emission factors for surface aerobic losses of organic material, aerobic degradation, deposition or removal as well as chemical oxidation are determined in the same way as described for project emissions calculations.

2) <u>On site heat generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility ($E_{CO2\_heat\_BL}$)</u>

In calculating CO_2 emissions from onsite heat displaced by biogas collected in the anaerobic treatment, the use of fossil fuels (HFO) is considered:

Formula (9) AM0022 v4, baseline scenario:

$$E_{CO2\_heat} = F * NCV * EF \quad (9)$$

Where:

F	is the corresponding amount of fossil fuel used for onsite heat generation (tons of HFO)
NCV	is the net calorific value of the fossil fuel considered (HFO) in (TJ/t). The default IPCC value of 0.0404 TJ/t from the 2006 IPCC guidelines for National GHG Inventories is applied.
EF	is the carbon emission factor of the fossil fuel considered (HFO) in (tCO_2/TJ). According to the 2006 IPCC guidelines for National GHG Inventories, this value is 77.40 tCO_2/TJ.

3) Off-site grid power generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility ($E_{CO2\_power\_BL}$)

Formula (10) AM0022 v4, baseline scenario:

$$E_{CO2\_power} = EL * CEF \quad (10)$$

Where:

EL	is the amount of electricity displaced by the electricity generation from the biogas collected from the anaerobic treatment facility. This is estimated as a product of: (1) average specific electricity consumption for the output of the facility, estimated using three years of historical data: and (2) the annual production.
CEF	is the carbon emission factor for the electricity displaced by the electricity generated from the biogas (tCO_2e/MWh)

E.2. Calculation of project emissions or actual net removals

Total estimated project emissions are the sum of fugitive methane emissions from the existing lagoon-based water treatment system, possible methane emissions from the new anaerobic wastewater treatment facility, and emissions from incomplete biogas combustion and biogas leaks.

Formula (1) AM0022 v4, project scenario:

$$E_{project} = E_{CH4\_lagoons} + E_{CH4\_NAWTF} + E_{CH4\_IC + Leaks} \quad (1)$$

Where:

$E_{project}$	are the total project emissions (tCO_2e)
$E_{CH4\_lagoons}$	are the fugitive methane emissions from the new anaerobic wastewater treatment facility (tCO_2e)
$E_{CH4\_IC+Leaks}$	are the methane emissions from inefficient combustion and leaks (tCO_2e)

The calculations for each component of equation (1) are provided below.

1) Fugitive methane emissions from lagoons in the project scenario ($E_{CH4\_lagoons}$)

The treated digester effluent is discharged into the old lagoon-based system for final treatment. While the residual organic load of the digester is low, removal of the residual COD in the lagoons is expected to occur under aerobic conditions. Fugitive methane emissions from the lagoons are calculated assuming mostly anaerobic conditions, which is a conservative assumption.

Formula (2) AM0022 v4, project scenario:

$$E_{CH4\_lagoons} = M_{lagoon\_anaerobic} * EF_{CH4} * GWP_{CH4} / 1000 \quad (2)$$

Where:

$M_{lagoon\_anaerobic}$	is the amount of organic material removed by anaerobic processes in the lagoon system (kgCOD).
EF_{CH4}	is the methane emission factor ($kgCH_4$/kgCOD). 0.21 $kgCH_4$/kgCOD of COD to methane conversion factor is used.
GWP_{CH4}	is the Global Warming Potential (GWP) of methane (GWPCH4 = 25[9])

Amount of organic material removed by anaerobic processes in the lagoon system ($M_{lagoon\_anaerobic}$)

Formula (3) AM0022 v4, project scenario:

$$M_{lagoon\_anaerobic} = M_{lagoon\_total} - M_{lagoon\_aerobic} - M_{lagoon\_chemical\_ox} - M_{lagoon\_deposit} \quad (3)$$

[9] The value of 25 is effective from 01/01/2013

Where:

M_{lagoon_total}	is the total amount of organic material removed in the lagoon system from equation (5) (kgCOD)
$M_{lagoon\_aerobic}$	is the amount of organic material degraded aerobically in the lagoon system (kg COD). Surface aerobic losses of organic material in pond-based systems equal to 254 kg COD per hectare of pond surface area and per day is assumed to be lost through aerobic processed.
$M_{lagoon\_chemical\_ox}$	is the amount of organic material lost through chemical oxidation in the lagoon system (kg COD)
$M_{lagoon\_deposit}$	is the amount of organic material lost through deposition in the lagoon system from equation (6) (kg COD)

Amount of organic material removed in the lagoon system (M_{lagoon_total})

Formula (5) AM0022 v4, project scenario:

$$M_{lagoon\_total} = M_{lagoon\_input} * R_{lagoon} \quad (5)$$

with Formula (4) AM0022 v4, project scenario:

$$M_{lagoon\_input} = M_{input\_total} * (1 - R_{NAWTF}) \quad (4)$$

Where:

M_{lagoon_input}	is the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system (kgCOD)
R_{lagoon}	is the total organic material removal ratio of the lagoon. This is a project specific factor and is equal to the proportion of organic material removed (through any route) within the boundaries of the lagoon system under consideration.
M_{input_total}	is the total amount of organic material fed into the new project wastewater treatment facility (kgCOD)
R_{NAWTF}	is the total organic material removal efficiency of the new project wastewater treatment facility. The manufacture's guaranteed COD removal ratio of 90% (according to the technical proposal) is used as a project-specific value.

The Total Organic Removal Ratio (R_{lagoon}) factor has been determined according to Appendix 2 of AM0022, Version 04 by undertaking a series of chemical analyses based on COD samples at the inlet and the outlet of the lagoon system boundary. Based on the results of the chemical analysis, the Total Organic Removal Ratio is calculated as an average value of the test series as follows:

$$R_{lagoon} = ((COD_{in} - COD_{out}) / COD_{in})_{average}$$

Where:

COD_{in}	is the COD concentration of the wastewater at the inlet of the lagoon system
COD_{out}	is the COD concentration of the wastewater at the outlet of the lagoon system

The series of collected COD samples at the inlet and outlet of the lagoon system indicate an average total organic removal ratio (R_{lagoon}) of 98.9% (see Annex 1 of the registered PDD for more details).

Amount of organic material degraded aerobically in the lagoon system ($M_{lagoon\_aerobic}$)

The amount of organic material degraded aerobically in the lagoon system is calculated as the product of the AM0022, Version 04 default value for surface aerobic losses of organic material in pond-based systems (254 kgCOD/ha/day), total surface area of the lagoons (25.18 ha) and number of days in a year (365 days). Although no explicit equation is provided in AM0022, Version 04, the following formula is applied:

$$M_{lagoon\_aerobic} = COD_{loss\_aerobic} \times A_{lagoon\_surface} \times dd_{year}$$

Where:

$COD_{loss\_aerobic}$	is the default value for surface aerobic losses of organic material (254 kgCOD/ha/day)
$A_{lagoon\_surface}$	is the total surface area of the lagoon-based wastewater treatment system (in ha)
dd_{year}	is the number of days per year (in days)

$$M_{lagoon\_aerobic} = 254 \text{ (kgCOD/ha/day)} \times 25.18 \text{ (ha)} \times 365 \text{ day/yr} = 2,334,438 \text{ kgCOD/year}$$

As per the methodology, sensitivity analysis is conducted in order to determine the effect of change in the surface aerobic loss of COD to the emission reductions. The results of the sensitivity analysis indicate that the default value of 254 kgCOD/ha/day is appropriate for emission reduction calculations (see Annex 1 of the registered PDD for details).

Amount of organic material lost through chemical oxidation in the lagoon system ($M_{lagoon\_chemical\_ox}$)

The amount of organic material lost through chemical oxidation in the lagoon system is calculated based on guidance provided in Appendix 2 of AM0022, Version 04. Although no explicit equation is provided, the following formula is applied:

$$M_{lagoon\_chemical\_ox} = WW_{in} \times SO_4^{2-}{}_{\_concentration} \times COD_{loss\_chem\_ox}$$

Where:

WW_{in}	wastewater flow entering system boundaries in m^3/yr
$SO_4^{2-}{}_{\_concentration}$	sulfate (Q_{ox}) concentration in kg Q_{ox} /m^3
$COD_{loss\_chem\_ox}$	COD removal factor in kg COD/kg Q_{ox} (0.651 kg COD/kg SO_4^{2-})

Amount of organic material lost through deposition in the lagoon system ($M_{lagoon\_deposition}$)

Formula (6) AM0022 v4, project scenario:

$$M_{lagoon\_deposition} = M_{lagoon\_input} * R_{deposition} \quad (6)$$

Where:

$R_{deposition}$	is the organic material deposition ratio of the lagoon. It is equal to the proportion of organic material physically sedimented in lagoons within the project boundaries. It is a project specific factor derived by assessing the relative ability of COD in the wastewater stream to sediment the project boundaries, through pre project analysis.

A series of experiments described in detail under Annex 1 of the registered PDD show that the average organic material deposition ratio ($R_{deposition}$) is determined based on a conservative approach as 7.05%.

2) Methane emissions from new anaerobic wastewater treatment facility (E_{CH4_NAWTF})

Methane emissions from the specific anaerobic wastewater treatment facilities that are installed by the project, are assessed and estimated based on monitoring measurements, technology supplier data and expert estimates. They may be disregarded if documented evidence for their insignificance is given.

The technology provider, GLOBAL WATER ENGINEERING (GWE) LTD., has estimated, based on its experience, that the physical leakage from the UASB system is less than 1% for systems of a similar size and design to the project activity. To ensure conservativeness, a physical leakage factor of 1% of total biogas production was used for the project activity.

Although no explicit formula is provided under AM0022, Version 04 for calculation of methane emissions from the new anaerobic wastewater treatment facility (E_{CH4_NAWTF}), following formula is applied:

$$E_{CH4\_NAWTF} = (E_{CH4\_lagoon\_BL} - E_{CH4\_lagoon}) \times F_{leakage\_NAWTF}$$

Where:

$E_{CH4\_lagoon\_BL}$	are the fugitive methane emissions from lagoons in the baseline scenario (tCO_2e)
E_{CH4_lagoon}	are the fugitive methane emissions from lagoons in the project scenario (tCO_2e)
$F_{leakage\_NAWTF}$	is the leakage factor for the new wastewater treatment system (1%)

3) Methane emissions from inefficient combustion emissions ($E_{CH4\_IC+Leaks}$)

The project involves on-site heat and electricity generation and biogas flaring (in case of excess biogas production or technical problems related to the heat and electricity generation equipment).

Formula (7) AM0022 v4, project scenario:

$$E_{CH4\_IC + Leaks} = (\sum_r V_r * C_{CH4\_r} * (1- f_r) * GWP_{CH4}) + PE_{flare} \quad (7)$$

Where:

the sum	is made over two routes r for methane destruction (heating and power generation)
V_r	is the biogas combustion process volume in route r (Nm^3)
C_{CH4_r}	is the methane concentration in biogas (tCH_4/Nm^3)
f_r	is the proportion of biogas destroyed by combustion (-)
PE_{flare}	are the project emissions from flaring of the residual gas stream (tCO_2e) calculated following the procedures described in the "Tool to determine project emissions from flaring gases containing methane". PE_{flare} can be calculated on an annual basis or for the required period of time using this tool.

The values applied as "proportion of biogas destroyed by combustion" are 98.5% for the heat generation equipment (f_{boiler}) and 99% for the electricity generation equipment (f_{engine}).

Among the options for flaring systems, an open flare system is chosen by the project participants. For the determination of the flare efficiency, the default values for open flares proposed in the "Tool to determine project emissions from flaring of gases containing methane" are used for the calculation of project emissions from flaring gases. Following equations from the flaring tool are used to determine the project emissions from the flaring of the residual gas stream.

$PE_{flare,y} = (\sum TM_{RG,h} * (1- \eta_{flare,h}) * GWP_{CH4}/1000$

As per the registered PDD, the flaring efficiency of the project activity shall be estimated by using the data of flame detection period and period of biogas sent to flare. However, the data was not available during the monitoring period, the flaring efficiency is assumed as zero percent in order to calculate the project emission.

f_{heat}: the test was done as per following details for the exhaust gas analysis, providing the percentage of un-burnt hydrocarbon in the exhaust gas.

Date of test report	Test result (ppm)	Combustion efficiency (%)[10]
16/03/2016	70.32	99.9930%
18/02/2017	3.02	99.9997%
14/08/2018	45.71	99.9954%

The ex-ante value of the PDD (98.5%) being lower than the test report value results in higher project emissions. The PDD value is thus used for conservativeness.

f_{elec}: the test for two generators was done as per the following details for the exhaust gas analysis, providing the percentage of unburnt hydrocarbon in the exhaust gas.

Date of test report	Test result (ppm)	Combustion efficiency (%)
Generator A		
17/03/2016	24.09	99.9976%
18/02/2017	143	99.9857%
17/08/2018	52.09	99.9948%
Generator B		
17/03/2016	70.58	99.9929%
20/02/2017	254	99.9746%
17/08/2018	56.78	99.9943%

The ex-ante value of the PDD (99%) being lower than the test report value results in higher project emissions. The PDD value is thus used for conservativeness.

4) <u>Methane emissions from leaks in biogas system</u>

[10] **Calculation method**
The result from the report is 3.02 ppm at actual oxygen levels
3.02 ppm = 3.02 in 1,000,000 units = 0.00000302 = 0.000302% of non-combustion
Therefore, the combustion efficiency is 99.9997%.

Leaks in the biogas system include leaks from the anaerobic digester and leaks from the biogas pipeline delivery system. The UASB reactor gas collection system consists of a gas-tight concrete, coated gas dome and the biogas pipeline is made of stainless steel (AISI 304) and approximately 385 m long. Given the short length of the biogas pipeline (as compared to the reference value of 2 km provided in AM0022, Version 04) and the utilization of high-quality materials, emissions from leaks in the biogas system are assumed to be negligible.

E.3. Calculation of leakage emissions

As determined in AM0022, Version 04, leakage is considered to be negligible.

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	144,516	11,221	0	0	133,295	133,295

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante for this monitoring period in the PDD (t CO_2e)
133,295	212,362

E.5.1. Explanation of calculation of “amount estimated ex ante for this monitoring period in the PDD”

The annual amount estimated ex-ante in the PDD was calculated using the annual estimated ex ante (97,468 tCO_2e) and number of operation days (330 days) per year in the PDD. Therefore, the amount estimated ex ante for each monitoring period is as follows.

Monitoring period	Number of operation days	Calculation	Amount estimated ex ante
01/05/2016 – 31/12/2016	235	= (97,468/330) x 235	69,409
01/01/2017 – 31/12/2017	352	= (97,468/330) x 352	103,966
01/01/2018 – 24/05/2018	132	= (97,468/330) x 132	38,987
Total amount estimated ex ante for this entire monitoring period			**212,362**

E.6. Remarks on increase in achieved emission reductions

The actual GHG emission reductions achieved were less than the amount based on the ex-ante estimation in the registered PDD as per the values addressed under section E.5.

E.7. Remarks on scale of small-scale project activity

The project activity is a large-scale project. Thus, this section is not applicable.

Appendix 1. Gold Standard monitored parameters

The GS CDM "CYY Biopower Wastewater treatment plant including biogas reuse for thermal oil replacement and electricity generation Project, Thailand" was a retroactive project and registered on 24/03/2010. According to the GS 560 Gold Stand Annex version 2.1 date 21/08/2008, the following indicators were monitored and reported as per section Gold Standard Monitoring.

<table>
<tr><td colspan="2">No</td><td>1</td></tr>
<tr><td colspan="2">Indicator</td><td>Water quality and quantity</td></tr>
<tr><td colspan="2">Chosen parameter</td><td>COD concentration in wastewater at the outlet of the UASB reactor (in kg COD/m³)</td></tr>
<tr><td colspan="2">Implications on monitoring requirements and justification</td><td>The aim of the project is to improve the current wastewater treatment facilities and avoid any harm or threat to the environment or people. The installed wastewater treatment system is more efficient and robust (from a process control perspective) than the open anaerobic lagoon system (baseline scenario). The biogas reactor system reduces 90% to 98% of the COD load in the wastewater. The effluent from the biogas reactor is still diverted to the old lagoon system, for a final treatment, which further reduces the COD load to a value well below the Thai wastewater discharge limits.
The lagoon system at CYY is designed in such a way that there is no effluent leaving the lagoon system. Most of the produced wastewater is constantly re-circulated as wash water for the starch production process. The rest is stored in the aerobic lagoons at the end of the cascading lagoon system, where part of the water evaporates, keeping a hydrological balance.
The wastewater treatment plant includes safety and monitoring devices as well as safety and quality control procedures in order to avoid abnormal operating conditions, which could lead to abnormal wastewater discharges. Wastewater quality format the outlet of the reactor is already subject to continuous monitoring under CDM and periodic controls by environmental authorities.
Given the fact that the treated wastewater cannot be discharged and is constantly re-circulated and re-used in the starch plant, which was already done prior to the project, the project activity does not have a significant impact on water quantity.
From this, it is evident that the impact on the water quality is the only crucial factor for an overall positive impact on sustainable development and its monitoring would thus be required in the verification period.</td></tr>
<tr><td rowspan="3">Way of monitoring</td><td>How</td><td>Daily sampling of the UASB reactor effluent. COD concentration was analyzed daily at the project site. The Colorimetric Method was applied in the wastewater analysis.</td></tr>
<tr><td>When</td><td>Daily</td></tr>
<tr><td>By who</td><td>CYY plant operator</td></tr>
<tr><td colspan="2">QA/QC procedures to be applied</td><td>The Standard Solution Method is used for accuracy to check the on-site measurements. Periodic tests were carried out by an accredited laboratory (ISO/IEC 17025) in order to provide quality assurance.</td></tr>
<tr><td colspan="2">Monitored Value & Frequency</td><td><table><tr><th>Monitoring period</th><th>Average value (kg COD/m³)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>2.74</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>2.17</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>2.70</td></tr></table></td></tr>
</table>

No	2
Indicator	Air quality: *Odor from the wastewater treatment plant*
Chosen parameter	Volume of biogas production and combustion (Nm^3)

<table>
<tr><td colspan="2">Implications on monitoring requirements and justification</td><td>As explained by the project owner during the public consultation, the odor is reduced as a result of the project activity, because the new system is a closed system and the biogas produced is utilized for electricity and heat generation. Any gases that would lead to odour emissions (mainly H_2S and other sulfur compounds) are captured with the biogas and either destroyed in the boilers or removed in the desulfurization system (gas scrubber) prior to reaching the engine, without release of odor emissions to the atmosphere. Given this fact, the monitoring of biogas production and utilization would be sufficient to demonstrate a reduction in odor emissions from the project.</td></tr>
<tr><td rowspan="3">Way of monitoring</td><td>How</td><td>Measured using gas flow meters at the reactor outlet and at the inlet of the boiler, engine/generator sets and flare system. Combustion of the biogas, and consequently the destruction of any gases that would lead to odour emissions, is monitored through measuring the energy output of the boiler and engine/generator systems as well as the flame detection period of the flare system. More details on all these parameters are provided in the monitoring plan (Section B.7) of the registered PDD.</td></tr>
<tr><td>When</td><td>Continuously using totalizer meters</td></tr>
<tr><td>By who</td><td>CYY plant operator</td></tr>
<tr><td colspan="2">QA/QC procedures to be applied</td><td>Meters will undergo maintenance/calibration subject to appropriate industry standards. In the event of technical problems with a biogas flowmeter, the value can be calculated based on a mass balance using the other installed gas meters (e.g. biogas sent to boilers = total biogas produced – biogas sent to flare – biogas sent to engine).</td></tr>
<tr><td colspan="2">Monitored Value & Frequency</td><td>The following values are derived from the parameters, AM0022 ID 5 (volume of biogas sent to boiler), AM0022 ID 9 (volume of biogas sent to flare) and AM0022 ID 10 (volume of biogas sent to gas engines). The details of the parameters can be found in section D.2 of the monitoring report.

<table>
<tr><th rowspan="2">Monitoring period</th><th colspan="3">Amount of biogas (Nm³) [11]</th></tr>
<tr><th>To boiler</th><th>To flare</th><th>To gas engine</th></tr>
<tr><td>01/05/2016 – 31/12/2016</td><td>2,819,056</td><td>286,792</td><td>1,961,068</td></tr>
<tr><td>01/01/2017 – 31/12/2017</td><td>3,818,430</td><td>342,552</td><td>2,242,984</td></tr>
<tr><td>01/01/2018 – 24/05/2018</td><td>1,799,125</td><td>1,335</td><td>145,346</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td colspan="2">No</td><td>3</td></tr>
<tr><td colspan="2">Indicator</td><td>Employment (numbers)</td></tr>
<tr><td colspan="2">Chosen parameter</td><td>Number of employed staffs and the level of income generation</td></tr>
<tr><td colspan="2">Implications on monitoring requirements and justification</td><td>To date, the job creation has been at the higher end of the range and the owner expects it to increase. Reference to the organizational chart is also made available.</td></tr>
<tr><td rowspan="3">Way of monitoring</td><td>How</td><td>Number of employees and the level of income generation are recorded through salary payment records.</td></tr>
<tr><td>When</td><td>Monthly</td></tr>
<tr><td>By who</td><td>CYY</td></tr>
<tr><td colspan="2">QA/QC procedures to be applied</td><td>Careful monitoring of salary payments and expenditures is a general practice at the company and required for financial accounting as per Thai regulations.</td></tr>
<tr><td colspan="2">Monitored Value & Frequency</td><td>Monthly records for list of employees and income generation are provided as attachments.</td></tr>
</table>

[11] Monitored values

	Number of employees is provided as follows. <table><tr><th>Monitoring period</th><th>Number of employees</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>24</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>7</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>7</td></tr></table>Remark: The number of employees was decreased in 2017 – 2018 as they moved to report under the starch factory entity. The level of income generation is provided as follows. According to the detail provided, the project paid employees the minimum local level for Na province. In addition, some employees are paid more than the minimum wage because of a few reasons, such as experience, position, diligence allowance. <table><tr><th>Monitoring period</th><th>Income level (THB/day)[1]</th><th>Minimum local level[2] (THB/day)</th></tr><tr><td>01/05/2016 – 31/12/2016</td><td>300 – 755</td><td>300</td></tr><tr><td>01/01/2017 – 31/12/2017</td><td>308 – 808</td><td>308</td></tr><tr><td>01/01/2018 – 24/05/2018</td><td>320 – 808</td><td>320</td></tr></table>[1] Minimum income level was referred to the daily wage of the employees of the project. Maximum was calculated by using highest salary divided by number of days (30). [2] Minimum local level in Nakorn Ratchasima province of 2016, 2017 and 2018 was referred to the Notification of the wage on the minimum wage No.7, 8 and 9, respectively, where the documents were provided to the VVB.

No		4
Indicator		Technological self-reliance
Chosen parameter		Training records
Implications on monitoring requirements and justification		The project contributes to technology transfer and has a great replication potential in the starch sector in Thailand and other countries. In Thailand, the technology provider, GWE, for this particular project, implements the technology along with special training for operators at the project site.
Way of monitoring	How	Training records are archived at the end of each training
	When	Periodical (depending on the frequency of training)
	By who	CYY
QA/QC procedures to be applied		All training plans are approved by the plant manager prior to implementation.
Monitoring Value and Frequency		Following training, further training programs have been provided to operators. Furthermore, a summary of the training with attendees and trainer has been submitted to the verification team. • Operation and maintenance of biogas system • Safety in biogas operation • Knowledge of biogas • Wastewater analysis

No		-
Indicator		Sludge application
Chosen parameter		Type of sludge application
Implications on monitoring requirements and justification		This parameter is included as an addition to the monitoring plan to satisfy comment/request 2 of the GS registration review process.
Way of monitoring	How	The logbook of the operator tracks the sludge application at the plant. In the case that the sludge is sold to farmers, a confirmation on the sludge application must be given by the purchasers. Note that the sludge will only be used for soil application as fertilizer.

	When	Plant records every time sludge is removed from the system
	By who	CYY
QA/QC procedures to be applied		Plant manager's signature is required on the record
Monitored Value & Frequency		There was no sludge removed during the monitoring period.

Additional information about the monitoring period:
In line with the GS regulations for the registered project under GS version 1, in the current monitoring period, the methane utilization ratio for biogas averaged at 96.31%, which was over 65%.