Monitoring report form for CDM project activity

(Version 06.0)

Complete this form in accordance with the instructions attached at the end of this form.

MONITORING REPORT		
Title of the project activity	Double A Ethanol Wastewater Treatment Plant	
UNFCCC reference number of the project activity	9394	
Version number of the PDD applicable to this monitoring report	Version 3.1	
Version number of this monitoring report	Version 01	
Completion date of this monitoring report	19/10/2017	
Monitoring period number	Second monitoring period	
Duration of this monitoring period	01/07/2016 to 30/06/2017	
Monitoring report number for this monitoring report	-	
Project participants	Double A Ethanol Company Limited.	
Host Party	Thailand	
Sectoral scopes	13	
Applied methodologies and standardized baselines	ACM0014 – Treatment of Wastewater, version 05	
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}	91,784 tCO_{2e}
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	170,983 tCO_{2e}	

SECTION A. Description of project activity

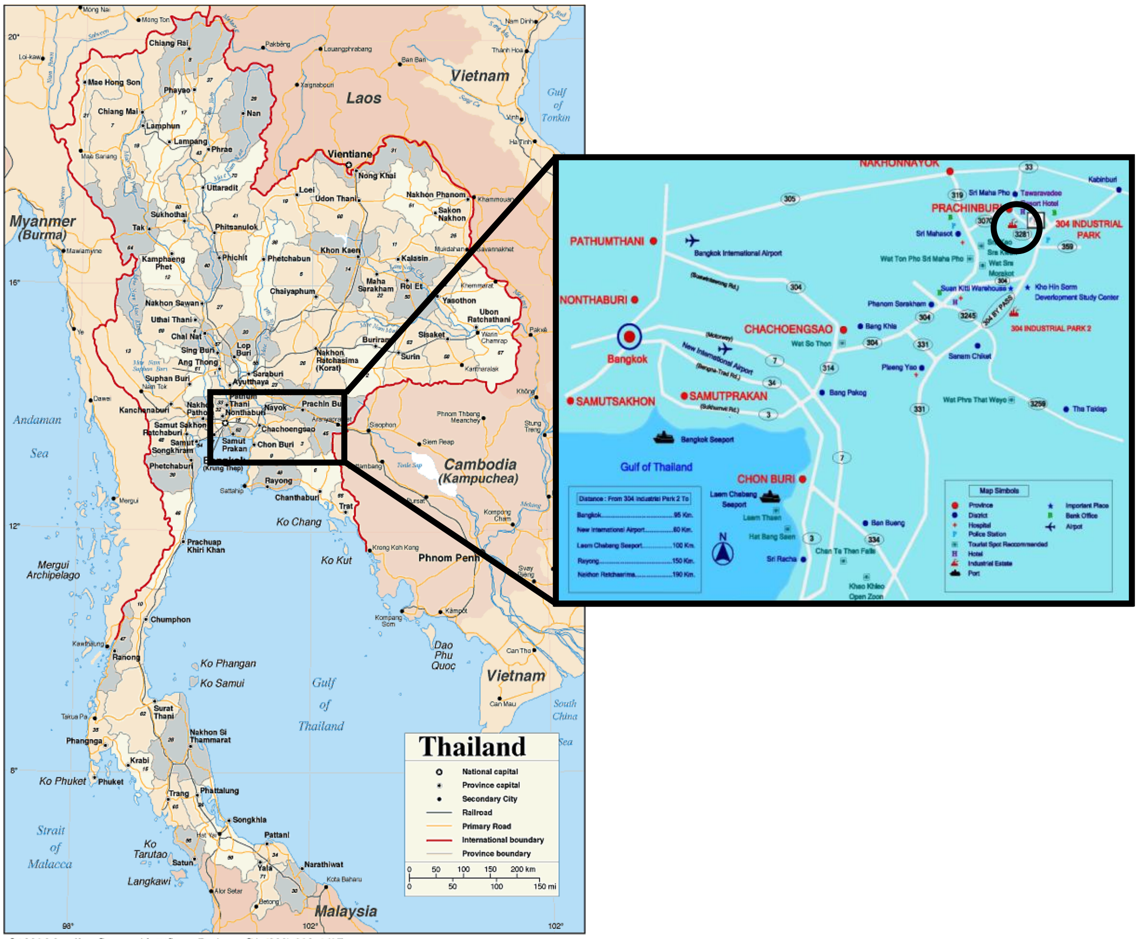
A.1. General description of project activity

"Double A Ethanol wastewater treatment plant", hereafter referred to as 'the Project' is implemented by Double A Ethanol Company Limited (aAE) for treating industrial wastewater from the aAE Ethanol plant. The project is located in Prachinburi, Thailand. This is Greenfield project activity.

The purpose of project activity is to treat the wastewater from the ethanol plant to generate biogas. The project activity entails the installation of an anaerobic digester system with biogas collection equipment and utilising biogas for thermal generation. The biogas recovered is supplied to the boiler of an adjacent limekiln which is partly replacing fuel oil (Bunker C) for heat generation. The project activity results to GHG emission reductions due to methane avoidance from anaerobic open lagoons and avoidance of carbon dioxide emissions from fuel oil combustion in the limekiln.

A.2. Location of project activity

The project is located within 304 Industrial Estate in Prachinburi, Thailand. The physical address is 1 Moo 2Tha-toom sub-district, Srimaphote District, Prachinburi Province, Thailand. Figure 1 shows the project location map. The geo graphical location is below;
Latitude: N 13 54 53.3
Longitude: E 101 34 20.4



©1992 Magellan Geographix[SM] Santa Barbara, CA (800) 929-4627

Figure 1: Project Location

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 Party)	Double A Ethanol Company Limited. (Private entity)	No
Sweden	Swedish Energy Agency (Public entity)	No

A.4. Reference to applied methodologies and standardized baselines

The applied methodology is ACM0014 – "Treatment of wastewater" version 05 (EB68).
Reference to the methodology applied in the project activity:
http://cdm.unfccc.int/methodologies/DB/AUUM6YRNM6XUV213IOGNI1G9ITGRN1

Tools applied in the project activity are;

- Tool for the demonstration and assessment of additionality (version 06.1)
- Project emission from flaring (version 2)
- Project and leakage emissions from anaerobic digesters (version 01)
- Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 2)
- Tool to calculate baseline, project and/or leakage emission from electricity consumption (version 01)
- Tool to calculate emission factor for an electricity system (version 02.2.1)

Reference to the tools applied in the project activity:
http://cdm.unfccc.int/methodologies/PAmethodologies/tools/

A.5. Crediting period type and duration

Type of crediting period: fixed crediting period
Start date of crediting period: 01/04/2014 to 31/03/2024
Length of crediting period: 10 years
Current monitoring period: 01/07/2016 to 30/06/2017
Length of the current monitoring period: 1 year

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

The ethanol plant has a production capacity of 500,000 Liters per day from cassava. The wastewater from ethanol production process is 5,000 m^3/day with COD of 42,000 mg/L. In the baseline scenario, the wastewater would have been treated in an open anaerobic lagoon system. The traditional open system would be sufficient to treat the wastewater and not have any biogas recovery.

In the project activity, the wastewater is treated in an anaerobic digester system combined with an aerobic treatment. The biogas captured is used for thermal generation in the limekiln. In any emergency case, the excess biogas is flared in the flaring system. The proposed project activity results in emission reductions from the avoidance of methane emissions from the anaerobic open lagoon and the avoidance of carbon dioxide emissions from the combustion of fuel oil in the limekiln.

Technical description:

The technology installed under the project activity is the combination of anaerobic and aerobic treatment. The major components of project activity as follows;

Wastewater treatment:
Wastewater from the ethanol plant is initially directed to an Internal Circulation Reactor (IC Reactor) anaerobic digester system. There are three IC reactor tanks. The tanks perform anaerobic fermentation where most of COD and organic suspended solid substance are converted into biogas. The removal rate of COD under this system is 90%. The IC Reactor treatment stage can recover 59,505 m^3 of methane per day.

The wastewater is then forwarded to an aerobic treatment system that consists of three aerobic tanks. In the process of aerobic treatment, most of organic substances are decomposed; the treatment efficiency of COD is 90% of COD input[1]. After the aerobic treatment wastewater will pass through a clarifier. Then, the treated wastewater is discharged into the irrigation pond of the 304 industrial park.

Sludge:
Sludge is party refluxed into the aerobic and anaerobic treatment stages to enhance wastewater treatment conditions. The excess sludge is collected in a sludge-thickening tank that separates wastewater and sludge by gravitational sedimentation. This sludge is pumped to a belt press. Then, a conveyor transfers the sludge to a storage area where sludge is transported to farmers and collectors for further processing as fertilizer or for land application on the field. The wastewater from the sludge thickening tank and belt press is also treated to meet the wastewater discharge standard.

Biogas recovery:
The biogas production is 79,340m^3/day with methane content of 59,505 m^3/day. The biogas recovered is treated in the biogas treatment system. The biogas is utilised in the boiler of the adjacent limekiln for thermal generation that partly displace the fuel oil (bunker oil C). Any excess biogas is flared in the flaring system.

The brief description of the installed technologies is provided in the table 1. The project diagram is shown in the figure 2.

[1] EPC contract AGT007-2550 (pg 69)

Implementation status of the project activity during the monitoring period:

The details of implementation and actual operation of project activity, which conducted in this monitoring period, is provided in the table 1. The data monitoring of the project activity was carried out as described in the registered PDD.

Table 1: the operation status of project activity

Event	Date	References
The project owner signed contract with the technology provider.	24/12/2007	Contract between Double A Ethanol Co., Ltd. and Siemens.
Registration under CDM scheme	31/12/2012	UNFCCC website
Commissioning of project activity (COD – Commercial operation date)	21/03/2014	Acceptance of performance certificates
1st monitoring period	01/04/2014 to 30/06/2016	Refer to the first monitoring report version 02
Installation of additional enclosed flare system	10/09/2016	Refer to purchase order document
2nd monitoring period	01/07/2016 to 30/06/2017	Refer to this report

Further information in this period, the calibration of the equipment was conducted as per the registered monitoring plan. In case of calibration delay, the measured values during the delay period are adjusted by applying an identified error or maximum permissible error as the case may be in a calibration report in a conservative manner, which is in line with the latest version of clean development mechanism validation and verification standard (VVS).

Table 2: The description of the installed technology and equipment;

Equipment	Manufacturer / Technology provider	Type/Model	Specifications
Wastewater treatment system	Siemens Thailand	• Anaerobic digester system: an Internal Circulation Reactor (IC Reactor) • Aerobic treatment system	The biogas system has a designed COD reduction efficiency of 90%. The expected biogas production is around 79,340 m^3 per day (at 59,505 m^3 of CH_4).
Flaring system	Siemens/Verec	Open flare (3 units)	Model: 244WL0391200 A maximum capacity of 2,530 Nm^3/hr for each unit
	Napatr Service	Enclosed flare (2 units)	Model: NS-500 Bio A capacity of 500 Nm^3/hr for each unit

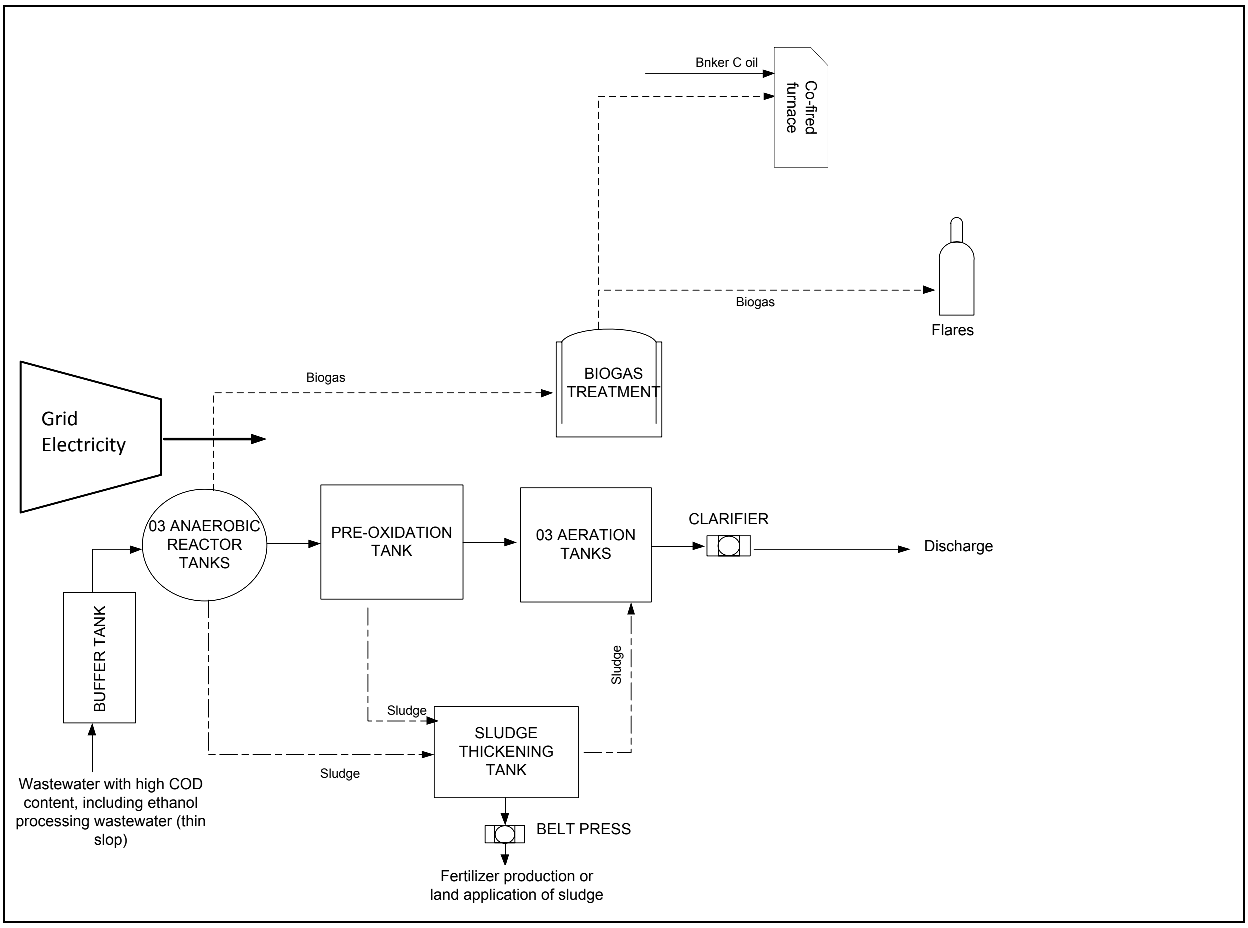


Figure 2: Project Diagram

B.2. Post-registration changes

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

No temporary deviations from registered monitoring plan or applied methodology during the monitoring period.

B.2.2. Corrections

No corrections to project implementation or parameters fixed at validation during the monitoring period.

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

The start date of crediting period is changed from “31/03/2013 - 30/03/2023” to “01/04/2014 - 31/03/2024”. The notification has been sent to CDM registration team on 18/10/2016.

B.2.4. Inclusion of monitoring plan

None of inclusion of a monitoring plan to registered PDD is considered during this current monitoring period.

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

No permanent changes in the monitoring plan during the current monitoring period.

B.2.6. Changes to project design

There is a change that is being submitted with this monitoring report as part of the request for issuance (post – registration change – issuance track) as applicable from this monitoring period. The change detail is presented in the revised PDD, version 01 on 29/09/2017. The short description of change can be found as following.

The installation of additional enclosed flare system was done in September 2016. The purpose of this installation is to increase security of flaring activity in the biogas system. Some amount of biogas produced was not sent to the limekiln because no operation required during a period of time. Some biogas quantity accounted as 20% - 40% of total production approximately was destroyed through flaring activity in the last period. Therefore, the project owner decided to include two units of enclosed flare system in the project. This change has no impact to applicability and additionality of project activity as well as the registered monitoring plan. The justification details of this change have been provided the revised PDD as mentioned above.

SECTION C. Description of monitoring system

Monitoring Procedure:
Monitoring data is recorded/downloaded monthly and stored electronically in a database. Any problem with the monitoring equipment is noted in an operation and maintenance log-book and entered into the database. A monitoring data report is produced containing the monthly monitoring data files and details of any equipment faults and/or loss of data. The monitoring data report is submitted to the plant manager to review and acceptance. All records are retained for at least two years after the end of the crediting period. In case no monitoring records are available, no emission reduction is claimed for that specific period.

Quality Assurance:
The following quality assurance measures are taken relating to the monitoring equipment and it installation and operation;

- All meters, sensing and sampling equipment are designed and manufactured to International standards.
- Prior to operation, aAE validated that the monitoring equipment is calibrated according to the appropriate standards.
- The central control system for managing the data requirement of the biogas plant is located in a secure, sealed hosing to prevent damage or tampering.
- Routine maintenance and calibration including inspection of all monitoring equipment are performed in accordance with the manufacturer's specification if applicable to ensure that the data remains accurate.

To ensure the quality of the recorded data, all personnel are trained in accordant with this monitoring plan. The following quality assurance measures are taken relating to the storage and recorded of the monitored data.

- A paper backup of the monthly electronic data file is stored in a secure location onsite.
- The monitored data files are included as part of the operation report and electronic backup of the report is reviewed and approved by plant manager.

Data storage:
All the data are transferred online to the computer. Storage of data is onsite, on digital storage devices/media with hardcopies as physical backup. The monitoring data is weekly backup to secondary digital storage devices. The data is approved by plant manager and kept for a minimum two years following end of crediting period.

Quality control procedure:
To ensure malfunction is identified promptly, all monitoring equipment is manually inspected on a monthly data. Any equipment faults or loss of data are recorded in the database with detail of the fault and length of time over which data was affected.

Operational and Management Structure:
AAE is responsible for the on-site monitoring and implementation of the quality assurance and quality control procedures and compiling the CDM monitoring report for Verification. The operational and management structure that are implemented to monitor emission reductions described in the following diagram.

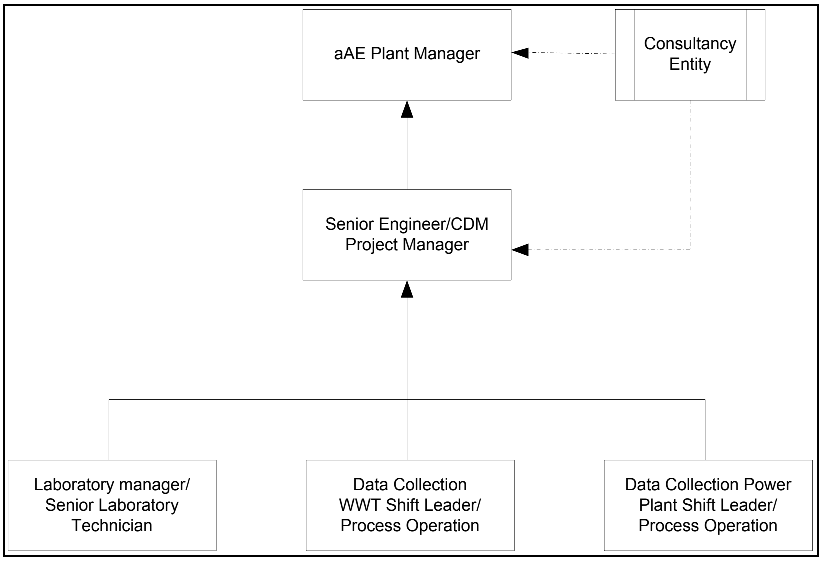


Figure 3: Monitoring organization

Flow diagram of current implementation of project activity

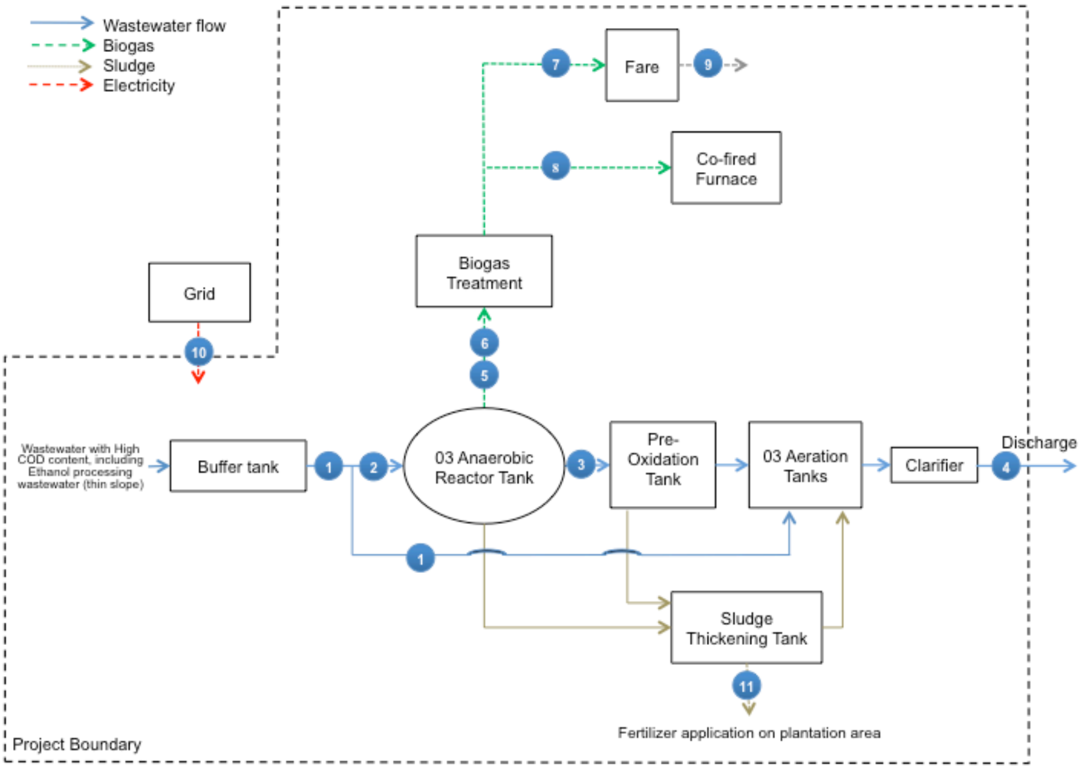


Figure 4: Monitoring Diagram

Table 3: Monitoring points

No.	Parameters	Description
1	$F_{PJ,dig,m}$	Quantity of wastewater that is treated in the anaerobic digester system
2	$COD_{dig,m}$	Chemical oxygen demand in the wastewater that is treated in the anaerobic digester
3	$COD_{eff,m}$	Chemical oxygen demand in the wastewater after treatment in the anaerobic digester
4	$COD_{discharge,m}$	Chemical oxygen demand in the wastewater discharged
5	$F_{biogas,y}/V_{t,db}$	Total amount of biogas collected in the outlet of the new digester
6	$W_{CH4,biogas,y}$	Concentration of methane in the total biogas supply in the outlet of the new digester
7	$F_{biogas,flare,y}$	Total amount of biogas sent to flare
8	$F_{biogas,KLIN,y}$	Total amount of biogas sent to boiler
9	T_{flare}	Temperature in the exhaust gas of the flare
10	$EC_{PJ,y}$	Amount of electricity in the year y that is consumed at the project site for the project activity
11	$S_{LA,y}$	Amount of sludge applied to land in month

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	**$COD_{out,x}$**
Unit	Ton COD
Description	COD of the effluent in the period x
Source of data	As per Report on Anaerobic Lagoon, the design COD inflow for COD in and the design effluent COD flow for COD out are used for corresponding to the design features of the lagoon system identified in the procedure for the selection of the baseline scenario
Value(s) applied	120 mg/L
Choice of data or measurement methods and procedures	The proposed project activity involves the installation of new anaerobic digester and biogas facilities as Greenfield facilities. The design value in the baseline lagoon design in the section “Identification of alternative scenarios” is used. The unit of parameter will be converted to ton COD/year with the simple unit conversion factor.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	**$COD_{in,x}$**
Unit	ton COD
Description	COD directed to the open lagoons (Scenario 1)
Source of data	As per Report on Anaerobic Lagoon, the design effluent COD flow for COD out is used for corresponding to the design features of the lagoon system identified in the procedure for the selection of the baseline scenario
Value(s) applied	42,000 mg/L
Choice of data or measurement methods and procedures	The proposed project activity involves the installation of new anaerobic digester and biogas facilities as Greenfield facilities. The design value in the baseline lagoon design in the section “Identification of alternative scenarios” is used. The unit of parameter is converted to ton COD/year with the simple unit conversion factor.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	**B_o**
Unit	$tCH_4/tCOD$
Description	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand (COD)
Source of data	ACM0014 (version 05.0.0) 2006 IPCC Guidelines default value.
Value(s) applied	0.21
Choice of data or measurement methods and procedures	No measurement procedure. The default IPCC value for B_0 is 0.25 kgCH4/kg COD. If the methodology is used for wastewater containing materials not akin to simple sugars, a CH_4 emissions factor different from 0.21 $tCH_4/tCOD$ has to be estimated and applied.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	Taking into account the uncertainty of this estimate, a value of 0.21 $kgCH_4/kgCOD$ is used as a conservative assumption for B_0 and the unit is converted to $tCH_4/tCOD$ with the simple unit conversion factor.

Data/Parameter	f_d
Unit	%
Description	Factor expressing the influence of the depth of the lagoon or sludge pit on methane generation
Source of data	ACM0014 (version 05.0.0) Apply the following values for the corresponding average depth of the open lagoon: If D < 1m - 0 If 1m < D < 2m - 0.5 If D > 2m - 0.7
Value(s) applied	0.7 (As the Report on Anaerobic lagoon specifies the depth of lagoon to be D = 6m)
Choice of data or measurement methods and procedures	No measurement procedure
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	The project activity implemented in Greenfield facilities where the baseline is a new to be built anaerobic lagoon, use the depth as defined in the baseline lagoon design in the section “Identification of alternative scenarios”.

Data/Parameter	$EF_{grid,y}$ / $EF_{EL,j,y}$
Unit	tCO_2/MWh
Description	Grid emission factor in year (Combined Emission factor)
Source of data	Tool to calculate the emission factor for an electricity system (version 02.2.1)
Value(s) applied	0.5113
Choice of data or measurement methods and procedures	Tool to calculate emission factor for an electricity system (version 02.2.1) The study of emission factor for an electricity system in Thailand 2011, http://www.tgo.or.th/english/index.php?option=com_content&view=artic l e&id=178:thailand-grid-emission-2010-report&catid=50:tgos-research-projects&Itemid=40
Purpose of data/parameter	Calculation of project emissions
Additional comments	Included as a part of this PDD as Annex 3

Data/Parameter	D
Unit	m
Description	Average depth of the lagoon or sludge pit
Source of data	Report on Anaerobic lagoon. For project activities implemented in Greenfield facilities: As per the baseline lagoon design as identified in Step 1 of the section “Procedure for the identification of the most plausible baseline scenario Identification of alternative scenarios”
Value(s) applied	6
Choice of data or measurement methods and procedures	Determine the average depths of the whole lagoon/sludge pit under normal operating condition.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The project activity implemented in Greenfield facilities where the baseline is a new to be built anaerobic lagoon, use the depth as defined in the baseline lagoon design in the section “Procedure for the identification of the most plausible baseline scenario Identification of alternative scenarios”

Data/Parameter	**ρ**
Unit	-
Description	Discount factor for historical information
Source of data	ACM0014 (version 05.0.0) For existing plants: • If one year of historical data is available ρ = 1; • If a measurement campaign of at least 10 days is available ρ = 0.89. For Greenfield projects: ρ = 1
Value(s) applied	1
Choice of data or measurement methods and procedures	The value of 0.89 for the case where there is no one year historical data is to account for the uncertainty range (of 30% to 50%) associated with this approach as compared to one-year historical data.
Purpose of data/parameter	Calculation of project emissions
Additional comments	Normal conditions are defined as 20oC and 1 atm pressure

Data/Parameter	**TDL_y**
Unit	%
Description	Average technical transmission and distribution losses for providing electricity to source in year y
Source of data	Tool to calculate baseline, project and/or leakage emissions from electricity consumption (version 01)
Value(s) applied	20
Choice of data or measurement methods and procedures	Scenario C, Case C.III applies to the project. No data is available from the host country and the project activity electricity consumption is greater than. Therefore the default value of 20% is applied.
Purpose of data/parameter	Calculation of project emissions
Additional comments	-

Data/Parameter	**$EF_{N2O,LA,sludge}$**
Unit	tN_2O/tN
Description	N_2O emission factor for nitrogen from sludge applied to land
Source of data	ACM0014 (version 05.0.0) Stehfest, E. and Bouwman, A.F. N_2O and NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modelling of global annual emissions. Nutr. Cycl. 29 Agroecosyst., in press. The average emission factor used is 0.01 kg N_2O-N / kg N (= 0.016 kg N2O / kg N)
Value(s) applied	0.016
Choice of data or measurement methods and procedures	No measurement procedures.
Purpose of data/parameter	Calculation of project emissions
Additional comments	Applicable if sludge is applied on land under the project activity.

Data/Parameter	**$MCF_{sludge, LA}$**
Unit	-
Description	Methane conversion factor for the application of sludge to lands
Source of data	ACM0014 (version 05.0.0)
Value(s) applied	0.05

Choice of data or measurement methods and procedures	No measurement procedures. Value to be applied 0.05
Purpose of data/parameter	-
Additional comments	-

Data/Parameter	**GWP_{CH4}**
Unit	tCO_{2e}/tCH_4
Description	Global warming potential for CH_4
Source of data	IPCC
Value(s) applied	25 – for the second commitment period
Choice of data or measurement methods and procedures	Default value
Purpose of data/parameter	Calculation of project and baseline emissions
Additional comments	*According EB 69 - Annex 3, the 2nd commitment period GWP shall be effective from 01/01/2013.

Data/Parameter	**GWP_{N2O}**
Unit	tCO_{2e}/N_2O
Description	Global warming potential for N_2O
Source of data	IPCC
Value(s) applied	296
Choice of data or measurement methods and procedures	Default value
Purpose of data/parameter	Calculation of project emissions
Additional comments	This parameter shall be update according to any future COP/MOP decisions.

Data/Parameter	**$f_{CH4,default}$**
Unit	Nm^3 CH_4 / Nm^3 biogas
Description	Default value for the fraction of methane in the biogas
Source of data	Project and leakage emissions from anaerobic digesters (version 01.0.0) The default value was derived based on reported values from registered projects and research papers (Davidsson, 2007)
Value(s) applied	0.6
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	This value is used for Option 2 of the step. Determination of the quantity of methane produced in the digester.

Data/Parameter	**ρCH_4**
Unit	t CH_4 / Nm^3 CH_4
Description	Density of methane at normal conditions
Source of data	Project and leakage emissions from anaerobic digesters (version 01.0.0) Technical literature
Value(s) applied	0.00072

Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	Normal conditions are defined as 20°C and 1 atm pressure

Data/Parameter	**$EF_{CH4,default}$**
Unit	t CH4 leaked / t CH_4 produced
Description	Default emission factor for the fraction of CH_4 produced that leaks from the anaerobic digester
Source of data	Project and leakage emissions from anaerobic digesters (version 01.0.0) IPCC (2006), Flesch et al. (2011) and Kurup (2003)
Value(s) applied	Use the default value corresponding to the type of digester used in the project activity. The digester type shall be identified by manufacturer information. If this is not possible, then the factor 0.1 shall be applied (upper range of the IPCC values). • 0.028: Digesters with steel or lined concrete or fiberglass digesters and a gas holding system (egg shaped digesters) and monolithic construction; • **0.05:** UASB type digesters, floating gas holders with no external water seal; (This value is applied as the IC reactor is a type of UASB type digester) • 0.10: Digesters with unlined concrete/ferrocement/brick masonry arched type gas holding section; monolithic fixed dome digesters, covered anaerobic lagoon.
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of project emissions
Additional comments	-

Data/Parameter	**Ru**
Unit	Pa.m^3/kmol.K
Description	Universal ideal gases constant
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 2.0.0)
Value(s) applied	8,314
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline/project emissions
Additional comments	-

Data/Parameter	**MMi**
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i (CH_4)
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 2.0.0)

Value(s) applied	Compound / Structure / Molecular mass (kg/mol): Carbon dioxide / CO_2 / 44.01 Methane / CH_4 / 16.04 Nitrous oxide / N_2O / 44.02
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline/project emissions
Additional comments	-

Compound	Structure	Molecular mass (kg/mol)
Carbon dioxide	CO2	44.01
Methane	CH4	16.04
Nitrous oxide	N2O	44.02

Data/Parameter	**P_n**
Unit	Pa
Description	Total pressure at normal conditions
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 2.0.0)
Value(s) applied	101,325 Pa
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline/project emissions
Additional comments	-

Data/Parameter	**T_n**
Unit	K
Description	temperature at normal conditions
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 2.0.0)
Value(s) applied	273.15 K
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline/project emissions
Additional comments	-

Data/Parameter	**T_1**
Unit	K
Description	Temperature
Source of data	ACM0014 (version 05.0.0) (page 12)
Value(s) applied	303.16 K (273.16 K + 30 K)
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	R
Unit	cal/K mol
Description	Ideal gas constant
Source of data	ACM0014 (version 05.0.0) (page 12)
Value(s) applied	1.987
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	E
Unit	cal/mol
Description	Activation energy constant
Source of data	ACM0014 (version 05.0.0) (page 12)
Value(s) applied	15,175
Choice of data or measurement methods and procedures	-
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

D.2. Data and parameters monitored

Data/Parameter	$F_{PJ,dig,m}$
Unit	m^3
Description	Quantity of wastewater that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m
Measured/calculated/ default	Measured (Continuously)
Source of data	Plant records
Value(s) of monitored parameter	see table below

Monitoring period	Total value (m^3)
01/07/2016 – 31/12/2016	1,247,687
01/01/2017 – 30/06/2017	1,182,241

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<tr><td>Equipment Type</td><td>Magnetic flow meter</td></tr>
<tr><td>Manufacturer</td><td>Siemens</td></tr>
<tr><td>Model</td><td>FM MAG6000</td></tr>
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<tr><td>Calibration Frequency</td><td>Once in three years</td></tr>
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</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>The monitoring data was measured continuously using magnetic flow meters. The data were recorded daily into the log-sheets during this monitoring period. The daily data were summarised and integrated into the spreadsheets monthly. The daily data were applied in the calculation of emission reductions. In addition, the monitoring value was also recorded by computer control system as data backup.</td></tr>
<tr><td>Calculation method (if applicable)</td><td>There were two flow meters measured quantity of wastewater that was treated in anaerobic digester system in the project. The meter tags were FT -153 and FT -155. The meter: FT-153 monitored untreated wastewater from the ethanol production before entering to digester system. In case the digester system was not able to receive untreated effluent, the meter: FT-155 monitored untreated wastewater that bypassed to the secondary aerobic system. The meter FT-155 was installed after the meter FT-153 but before the aeration tank. Therefore, the quantity wastewater that was treated in the anaerobic digester system was considered as the volume of untreated wastewater measured by FT-153 minus the volume of untreated wastewater measured by FT-155.</td></tr>
<tr><td>QA/QC procedures</td><td>As per the registered PDD, the flow meter shall be calibrated once in three years or as per the manufactures specification in accordance to appropriate industry standards to ensure accuracy.</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 certificates of two meters were valid in this monitoring period.</td></tr>
</table>

Data/Parameter	**$COD_{dig,m}$**
Unit	$tCOD/m^3$

[2] http://w3.siemens.com/mcms/sensor-systems/en/process-instrumentation/flow-measurement/electromagnetic/pulsed-dc-meters/transmitters/Pages/sitrans-f-m-mag-6000.aspx#Description
[3] Commercial operation date

Description	Chemical oxygen demand in the wastewater that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m.
Measured/calculated/ default	Measured
Source of data	Laboratory test (internal and external)
Value(s) of monitored parameter	(see table below)

Month	Average value ($tCOD/m^3$)	
	2016	2017
1	-	0.03
2	-	0.04
3	-	0.04
4	-	0.04
5	-	0.03
6	-	0.04
7	0.03	-
8	0.02	-
9	0.02	-
10	0.02	-
11	0.02	-
12	0.02	-

Monitoring equipment:

Equipment Type	VIS Spectrophotometer
Manufacturer	HACH
Model	DR3900
Maximum permissible error	±1%[4]
Serial No.	1443372
Calibration Frequency	Annually*
Date of latest calibration	12/10/2015
Date of validity	11/10/2016

Measuring/reading/recording frequency	The measurement was conducted onsite laboratory. The COD content was analysed by the close reflux method in compliance with the international standard. The major equipment involved with the analysis was a spectrophotometer – DR3900. The samples of wastewater were taken and analysed on a daily basis. Also, the analysis results were daily logged in the plant operation report.
Calculation method (if applicable)	n/a
QA/QC procedures	The calibration of relevant monitoring shall be conducted at least once a year. The monthly samples were collected and analysed by accredited laboratory using a similar or an equal standard in order to obtain the accuracy of the crosschecked results.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	$COD_{eff,dig,m}$
Unit	$tCOD/m^3$

[4] The document of equipment specification is submitted to the verification team.

Description	Average chemical oxygen demand in the effluent from the digester in month m
Measured/calculated/ default	Measured
Source of data	Laboratory test (internal and external)
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Average value (tCOD/m³)</th></tr><tr><td>01/07/2016 – 31/12/2016</td><td>0.0025</td></tr><tr><td>01/01/2017 – 30/06/2017</td><td>0.0018</td></tr></table>
Monitoring equipment	<table><tr><td>Equipment Type</td><td>VIS Spectrophotometer</td></tr><tr><td>Manufacturer</td><td>HACH</td></tr><tr><td>Model</td><td>DR3900</td></tr><tr><td>Maximum permissible error</td><td>±0.24%</td></tr><tr><td>Serial No.</td><td>143372</td></tr><tr><td>Calibration Frequency</td><td>Annually*</td></tr><tr><td>Date of latest calibration</td><td>12/10/2015</td></tr><tr><td>Date of validity</td><td>11/10/2016</td></tr></table>
Measuring/reading/recording frequency	The measurement was conducted onsite laboratory. The COD content was analysed by the close reflux method in compliance with the international standard. The major equipment involved with the analysis was a spectrophotometer – DR3900. The samples of wastewater were taken and analysed on a daily basis. Also, the analysis results were daily logged in the plant operation report.
Calculation method (if applicable)	n/a
QA/QC procedures	The calibration of relevant monitoring shall be conducted at least once a year. The monthly samples were collected and analysed by accredited laboratory using a similar or an equal standard in order to obtain the accuracy of the crosschecked results.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	$COD_{discharge,m}$
Unit	$tCOD/m^3$
Description	Average chemical oxygen demand in the effluent discharged in month m
Measured/calculated/ default	Measured
Source of data	Laboratory test (internal and external)
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Average value (tCOD/m³)</th></tr><tr><td>01/07/2016 – 31/12/2016</td><td>0.0003</td></tr><tr><td>01/01/2017 – 30/06/2017</td><td>0.0002</td></tr></table>

Monitoring equipment	Equipment Type: VIS Spectrophotometer Manufacturer: HACH Model: DR3900 Serial No.: 1443372 Calibration Frequency: Annually* Date of latest calibration: 12/10/2015 Date of validity: 11/10/2016
Measuring/reading/recording frequency	The measurement was conducted onsite laboratory. The COD content was analysed by the close reflux method in compliance with the international standard. The major equipment involved with the analysis was a spectrophotometer – DR3900. The samples of wastewater were taken and analysed on a daily basis. Also, the analysis results were daily logged in the plant operation report.
Calculation method (if applicable)	n/a
QA/QC procedures	The calibration of relevant monitoring shall be conducted at least once a year. The monthly samples were collected and analysed by accredited laboratory using a similar or an equal standard in order to obtain the accuracy of the crosschecked results.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	$F_{biogas,y}$ / $V_{t,db}$ / $F_{CH4,RG,m}$ / $Q_{biogas,y}$
Unit	Nm^3/yr
Description	Total amount of biogas collected at the outlet of the digester tanks, Volumetric flow of the gaseous stream /(biogas) in minute
Measured/calculated/ default	Measured
Source of data	Plant records
Value(s) of monitored parameter	**Monitoring period** — **Total value (Nm^3)** 01/07/2016 – 31/12/2016: 5,726,129 01/01/2017 – 30/06/2017: 5,395,810
Monitoring equipment	The detail of monitoring equipment is referred to parameter $F_{biogasKILN,y}$ and parameter $F_{biogasFLARE,y}$ as below.
Measuring/reading/recording frequency	The biogas was monitored using continuous flow meters. The measurement has been taken on an hourly basis. The flow meter was integrated with online system to have real time data monitoring and control. The biogas flow meter displays output as normalized flow of biogas. The monitored data were recorded on logsheets as well as on digital storage device. The recorded values are aggregated annually for emission reduction calculation.
Calculation method (if applicable)	The monitored value are based on the sum value of parameter $F_{biogasKILN,y}$ and parameter $F_{biogasFLARE,y}$.
QA/QC procedures	The magnetic flow meter shall be calibrated periodically based on manufacturer's specification from a certified testing agency but at least once every 3 years.
Purpose of data/parameter	Calculation of baseline emissions

Additional comments	-

Data/Parameter	$F_{biogasKILN,y}$
Unit	Nm^3/yr
Description	Volumetric flow of biogas to the boiler
Measured/calculated/ default	Measured
Source of data	Plant records
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Total value (Nm³)</th></tr><tr><td>01/07/2016 – 31/12/2016</td><td>4,483,917</td></tr><tr><td>01/01/2017 – 30/06/2017</td><td>4,545,876</td></tr></table>
Monitoring equipment	<table><tr><td>Tag</td><td>FT101G</td></tr><tr><td>Equipment Type</td><td>Mass flow meter</td></tr><tr><td>Manufacturer</td><td>Endress+Hauser</td></tr><tr><td>Model</td><td>Proline t-mass I</td></tr><tr><td>Maximum permissible error</td><td>±1%</td></tr><tr><td>Serial No.</td><td>HA076802000</td></tr><tr><td>Calibration Frequency</td><td>Once in three years</td></tr><tr><td>Date of latest calibration</td><td>03/07/2015</td></tr><tr><td>Date of validity</td><td>02/07/2018</td></tr><tr><td>Installation date</td><td>COD to present</td></tr></table>
Measuring/reading/recording frequency	The biogas was monitored using continuous flow meter. The measurement has been taken on an hourly basis. The flow meter was integrated with online system to have real time data monitoring and control. The biogas flow meter displays output as normalized flow of biogas. The monitored data were recorded on logsheets as well as on digital storage device. The recorded values are aggregated annually for emission reduction calculation.
Calculation method (if applicable)	n/a
QA/QC procedures	As per the registered PDD, the magnetic flow meter shall be calibrated periodically based on manufacturer's specification from a certified testing agency but at least once every 3 years.
Purpose of data/parameter	Calculation of baseline emissions/project emissions
Additional comments	In this monitoring period, the calibration of monitoring equipment was conducted ontime.

Data/Parameter	$F_{biogasFLARE,y}$
Unit	Nm^3/yr
Description	Volumetric flow of Biogas to flare
Measured/calculated/ default	Measured
Source of data	Plant records
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Total value (Nm³)</th></tr><tr><td>01/07/2016 – 31/12/2016</td><td>1,242,212</td></tr><tr><td>01/01/2017 – 30/06/2017</td><td>849,934</td></tr></table>

Monitoring equipment	Tag: FT105G Equipment Type: Mass flow meter Manufacturer: Endress+Hauser Model: Proline t-mass I Maximum permissible error: ±1% Serial No.: H7100C02000 Calibration Frequency: Once in three years Date of latest calibration: 03/07/2015 Date of validity: 02/07/2018 Installation date: COD to present
Measuring/reading/recording frequency	The biogas was monitored using continuous flow meter. The measurement has been taken on an hourly basis. The flow meter was integrated with online system to have real time data monitoring and control. The biogas flow meter displays output as normalized flow of biogas. The monitored data were recorded on logsheets as well as on digital storage device. The recorded values are aggregated annually for emission reduction calculation.
Calculation method (if applicable)	n/a
QA/QC procedures	The magnetic flow meter was calibrated periodically based on manufacturer's specification from a certified testing agency but at least once every 3 years.
Purpose of data/parameter	Calculation of project emissions
Additional comments	-

Data/Parameter	$\mathbf{W_{CH4,biogas,\,y}}$ $\mathbf{V_{i,t,db}}$
Unit	kg CH_4/m^3 , m^3 CH_4/ m^3 biogas
Description	Concentration of methane in the total biogas supply, Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis
Measured/calculated/ default	Measured
Source of data	Plant records
Value(s) of monitored parameter	see table below

Monitoring period	**%CH_4**	
	Higher value	Lower value
01/07/2016 – 31/12/2016	77.92%	65.19%
01/01/2017 – 30/06/2017	72.87%	72.87%

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Equipment Type</td><td>Gas Analyzer</td></tr>
<tr><td>Manufacturer</td><td>Fuji</td></tr>
<tr><td>Model</td><td>ZKJ</td></tr>
<tr><td>Maximum permissible error</td><td>±1%</td></tr>
<tr><td>Serial No.</td><td>8AE54367</td></tr>
<tr><td>Calibration Frequency</td><td>3 years as per PDD</td></tr>
<tr><td>Date of latest calibration</td><td>12/12/2016</td></tr>
<tr><td>Date of validity</td><td>11/12/2019</td></tr>
<tr><td>Installation date</td><td>03/01/2016 to present</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>The methane percentage was measured using continuous gas analyser. The monitored data were recorded on logsheets as well as on digital storage device. The average monitoring values were applied for emission reduction calculation. In this monitoring period, two gas analyzers involve with the monitoring data of methane in biogas. The gas analyzer with Siemens brand was installed since the date of commissioning completed to 02/01/2016. Then, the gas analyzer with Fuji brand was replaced the Siemens one on 03/01/2016.</td></tr>
<tr><td>Calculation method
(if applicable)</td><td>n/a</td></tr>
<tr><td>QA/QC procedures</td><td>Accuracy of equipment is based on manufacturer standards and regular calibration is provided by manufacturer or approved company (frequency of calibration as recommended by manufacturer).</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline and project emissions.</td></tr>
<tr><td>Additional comments</td><td>As a result of error applied with the monitored data of methane in biogas, the higher value is used for project emission, while the lower value is used for baseline emission.</td></tr>
</table>

<table>
<tr><th>Data/Parameter</th><th>Other flare operation parameters – Flame detector</th></tr>
<tr><td>Unit</td><td>On/Off or numeric value indicating On/Off</td></tr>
<tr><td>Description</td><td>Detection unit</td></tr>
<tr><td>Measured/calculated/
default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>Plant records</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th>Monitoring period</th><th>Value</th></tr>
<tr><td>01/07/2016 – 31/12/2016</td><td>No data record</td></tr>
<tr><td>01/01/2017 – 30/06/2017</td><td>No data record</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Equipment Type</td><td>UV Flame detector/sensor</td></tr>
<tr><td>Manufacturer</td><td>Siemen</td></tr>
<tr><td>Model</td><td>316SS</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>The sensor was installed and linked to computer display to show status of the flame. Continuously, it displayed on/off status on the computer display. This was accompanied by a record of the time during operation of flare.</td></tr>
<tr><td>Calculation method
(if applicable)</td><td>n/a</td></tr>
<tr><td>QA/QC procedures</td><td>The calibration shall be conducted as per technical or manufacturers specification.</td></tr>
</table>

Purpose of data/parameter	Calculation of project emission
Additional comments	This parameter is used for determination of the flare efficiency. Due to the monitored data was not available during this monitoring period. Therefore, the value of flare efficiency is assumed as zero % for calculating the project emission. This is conservative.

Data/Parameter	**$EC_{PJ,y}$**
Unit	MWh/yr
Description	Amount of electricity in the year y that is consumed at the project site for the project activity
Measured/calculated/ default	Measured
Source of data	Plant records
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>MWh</th></tr><tr><td>01/07/2016 – 31/12/2016</td><td>5,012</td></tr><tr><td>01/01/2017 – 30/06/2017</td><td>5,265</td></tr></table>
Monitoring equipment	<table><tr><td>Tag</td><td>MDB</td></tr><tr><td>Equipment Type</td><td>Power meter</td></tr><tr><td>Manufacturer</td><td>AMPTRON</td></tr><tr><td>Model</td><td>Ai205 Pro</td></tr><tr><td>Maximum permissible error</td><td>±0.5%</td></tr><tr><td>Serial No.</td><td>AT12051374</td></tr><tr><td>Calibration Frequency</td><td>Not specified in the guideline.</td></tr><tr><td>Date of latest calibration</td><td>30/12/2016</td></tr><tr><td>Date of validity</td><td>29/12/2017</td></tr><tr><td>Installation date</td><td>COD to present</td></tr></table>
Measuring/reading/recording frequency	The electricity consumption in the project was monitored by using power meter. The daily measurement was continuously conducted. The monitored data were recorded on logsheets as well as on digital storage device.
Calculation method (if applicable)	n/a
QA/QC procedures	The electricity meter was calibrated as per appropriate industrial standards or manufacture's recommendation.
Purpose of data/parameter	Calculation of project emission
Additional comments	-

Data/Parameter	**$S_{LA,y}$**
Unit	m^3 /month
Description	Quantity of sludge applied to land
Measured/calculated/ default	Measured
Source of data	Plant records
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>ton</th></tr><tr><td>01/07/2016 – 31/12/2016</td><td>0</td></tr><tr><td>01/01/2017 – 30/06/2017</td><td>0</td></tr></table>

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Equipment Type</td><td>Weighbridge</td></tr>
<tr><td>Manufacturer</td><td>FILTEC</td></tr>
<tr><td>Model</td><td>SK-11</td></tr>
<tr><td>Serial No.</td><td>000172</td></tr>
<tr><td>Maximum permissible error</td><td>±0.2%</td></tr>
<tr><td>Calibration Frequency</td><td>Two years</td></tr>
<tr><td>Date of previous calibration</td><td>03/04/2015</td></tr>
<tr><td>Date of latest calibration</td><td>14/03/2017</td></tr>
<tr><td>Date of validity</td><td>13/03/2019</td></tr>
</table>
<table>
<tr><td>Equipment Type</td><td>Weighbridge</td></tr>
<tr><td>Manufacturer</td><td>FILTEC</td></tr>
<tr><td>Model</td><td>SK-11</td></tr>
<tr><td>Serial No.</td><td>000176</td></tr>
<tr><td>Maximum permissible error</td><td>±0.2%</td></tr>
<tr><td>Calibration Frequency</td><td>Two years</td></tr>
<tr><td>Date of previous calibration</td><td>03/04/2015</td></tr>
<tr><td>Date of latest calibration</td><td>14/03/2017</td></tr>
<tr><td>Date of validity</td><td>13/03/2019</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>The sludge generated by the digester and secondary treatment system was pumped to a belt press. Then a conveyor transferred them to a storage area where the sludge transported for further utilization. The measurement of sludge was conducted by weighbridge. The monitoring data was recorded on the log-sheet and aggregated monthly.</td></tr>
<tr><td>Calculation method
(if applicable)</td><td>n/a</td></tr>
<tr><td>QA/QC procedures</td><td>The equipment calibration shall be conducted as per technical or manufacturers specification.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of project emission</td></tr>
<tr><td>Additional comments</td><td>The sludge was collected and stored for some period of time. But it ensured that the anaerobic condition was not developed in the storage facility. The sludge was distributed to farmers or collectors for fertilizer utilization in the eucalyptus plantation area or soil improvement under aerobic condition.</td></tr>
</table>

Data/Parameter	$T_{2,m}$
Unit	K
Description	Average temperature at the project site in month m
Measured/calculated/ default	Measured
Source of data	Thai Meteorological Department. Reference link: http://www.tmd.go.th/programs/uploads/yearlySummary/annual2015_e.pdf

Value(s) of monitored parameter	<table><tr><th>Month</th><th>2016</th><th>2017</th></tr><tr><td>1</td><td>-</td><td>301.15</td></tr><tr><td>2</td><td>-</td><td>301.55</td></tr><tr><td>3</td><td>-</td><td>303.05</td></tr><tr><td>4</td><td>-</td><td>305.85</td></tr><tr><td>5</td><td>-</td><td>305.05</td></tr><tr><td>6</td><td>-</td><td>302.35</td></tr><tr><td>7</td><td>301.65</td><td>-</td></tr><tr><td>8</td><td>302.35</td><td>-</td></tr><tr><td>9</td><td>301.45</td><td>-</td></tr><tr><td>10</td><td>301.15</td><td>-</td></tr><tr><td>11</td><td>301.35</td><td>-</td></tr><tr><td>12</td><td>301.25</td><td>-</td></tr></table>
Monitoring equipment	The monitoring data were based on monthly information by national or regional weather statistics during this monitoring period.
Measuring/reading/recording frequency	Monthly measurement.
Calculation method (if applicable)	n/a
QA/QC procedures	Data was obtained from the regional weather department for eastern region where the project activity is located.
Purpose of data/parameter	Calculation of baseline emission
Additional comments	Applicable for the methane conversion factor method.

Data/Parameter	T_{flare}
Unit	°C
Description	Temperature in the exhaust gas in the flare
Measured/calculated/ default	Measured
Source of data	Plant records
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Value (°C)</th></tr><tr><td>01/07/2016 – 31/12/2016</td><td>No data record</td></tr><tr><td>01/01/2017 – 30/06/2017</td><td>No data record</td></tr></table>
Monitoring equipment	<table><tr><td>Equipment Type</td><td>Thermocouple</td></tr><tr><td>Manufacturer</td><td>Varec Biogas</td></tr><tr><td>Model</td><td>316 SS</td></tr></table>
Measuring/reading/recording frequency	Continuously measurement of temperature of the exhaust gas stream in the flare was carried out by thermocouple. A temperature above 200 ^{o}C indicates that a significant amount of biogas was burnt and that the flare was under operation.
Calculation method (if applicable)	n/a
QA/QC procedures	The calibration shall be conducted as per technical or manufacturers specification.
Purpose of data/parameter	Calculation of project emission

Additional comments	This parameter is used for determination of the flare efficiency. Due to the monitored data was not available during this monitoring period. Therefore, the value of flare efficiency is assumed as zero % for calculating the project emission. This is conservative.

Data/Parameter	**$Flame_m$**
Unit	Flame on or Flame off
Description	Flame detection of flare in the minute m
Measured/calculated/ default	Measured
Source of data	Plant records
Value(s) of monitored parameter	<table><tr><th>Monitoring period</th><th>Value</th></tr><tr><td>01/07/2016 – 31/12/2016</td><td>No data record</td></tr><tr><td>01/01/2017 – 30/06/2017</td><td>No data record</td></tr></table>
Monitoring equipment	<table><tr><td>Equipment Type</td><td>UV Flame detector/sensor</td></tr><tr><td>Manufacturer</td><td>Siemen</td></tr><tr><td>Model</td><td>316SS</td></tr></table>
Measuring/reading/recording frequency	Measure using a fixed installation optical flame detector: Ultra Violet detector. The flame detection shall be recorded as a minute during the flame was on, otherwise recorded as a minute that the flame was off.
Calculation method (if applicable)	n/a
QA/QC procedures	The calibration shall be maintained and calibrated as per technical or manufacturers specification.
Purpose of data/parameter	Calculation of project emission
Additional comments	This parameter is used for determination of the flare efficiency. Due to the monitored data was not available during this monitoring period. Therefore, the value of flare efficiency is assumed as zero % for calculating the project emission. This is conservative.

D.3. Implementation of sampling plan

This section is not applicable.

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

The proposed project activity involves the installation of a new anaerobic digester system for the treatment of wastewater. In comply with ACM0014, the baseline emissions are determined as following equations;

Baseline emissions are calculated using the following formula:

$$BE_y = BE_{CH4,y} + BE_{EL,y} + BE_{HG,y} \quad (1)$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2/yr)
$BE_{CH4,y}$	=	Methane emissions from anaerobic treatment of the wastewater in open lagoons (Scenario 1) (tCO_2/yr)
$BE_{EL,y}$	=	CO_2 emissions associated with electricity generation that is displaced by the project activity in year *y* (tCO_2/yr)
$BE_{HG,y}$	=	CO_2 emissions associated with fossil fuel combustion for heating equipment that is displaced by the project in year *y* (tCO_2/yr)

Baseline emissions are calculated in three steps, as follows:

Step 1: Calculation of baseline emissions from anaerobic treatment of the wastewater;
Step 2: Calculation of baseline emissions from generation and consumption of electricity;
Step 3: Calculation of baseline emissions from heat generation.

Step 1: Calculation of baseline emissions from anaerobic treatment of the wastewater

The methodology proposes to use the minimum value between the methane produced after the implementation of the project activity and methane conversion factor method for the estimation of methane emissions from open lagoons in case of the wastewater lagoons.

$$BE_{CH4,} = \min \{Q_{CH4,y} ; BE_{CH4,MCF,y}\} \quad (2)$$

Methane produced

Projects proponent shall use Step 1"Determination of the quantity of methane produced in the digester ($Q_{CH4,y}$)"of the latest version of the tool "Project and leakage emissions from anaerobic digesters" to determine the amount of methane produced after the implementation of the project activity ($Q_{CH4,y}$) is used. This is discussed in the section below.

Methane conversion factor

The baseline methane emissions from anaerobic treatment of the wastewater in open lagoons (Scenario 1) is estimated based on the chemical oxygen demand (COD) of the wastewater that would enter the lagoon in the absence of the project activity ($COD_{BL,y}$), the maximum methane producing capacity (B_o) and a methane conversion factor ($MCF_{BL,y}$) which expresses the proportion of the wastewater that would decay to methane, as follows:

$$BE_{CH4,MCF,y} = GWP_{CH4} * MCF_{BL,y} * B_o * COD_{BL,y} \quad (3)$$

Where:

$BE_{CH4,MCF,y}$	=	Methane emissions from anaerobic treatment of the wastewater in open lagoons (Scenario 1) (tCO_2/yr)
GWP_{CH4}	=	Global Warming Potential of methane valid for the commitment period (tCO_2/tCH_4)
B_o	=	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand (tCH_4/tCOD)
$MCF_{BL,y}$	=	Average baseline methane conversion factor (fraction) in year *y*, representing the fraction of ($COD_{PJ,y}$ x B_o) that would be degraded to CH_4 in the absence of the project activity
$COD_{BL,y}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons (Scenario 1) in the absence of the project activity in year *y* (tCOD/yr)

Determination of $COD_{BL,y}$

In the absence of the project activity, wastewater would be treated to the open lagoon system. Therefore the baseline COD treated in open lagoons is equal to COD treated under the project activity minus any effluent COD that would have flowed from the outlet of the lagoons. The effluent COD in the baseline is accounted from through the use of an effluent adjustment factor as follows;

$$COD_{BL,y} = \rho*(1-(COD_{out,x}/COD_{in,x}))*COD_{PJ,y} \quad (4)$$

Where:

$COD_{BL,y}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons (Scenario 1) in the absence of the project activity in year *y* (t COD/yr)
$COD_{PJ,y}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in year *y* (t COD/yr)
$COD_{out,x}$	=	COD of the effluent in the period *x* (t COD)
$COD_{in,x}$	=	COD directed to the open lagoons (Scenario 1) in the period *x* (t COD)
x	=	Representative historical reference period
ρ	=	Discount factor for historical information

$COD_{PJ,y}$ is determined as follows:

$$COD_{PJ,y} = \sum F_{PJ,dig,m} * COD_{dig,m} \quad (5)$$

Where:

$COD_{PJ,y}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester in the project activity in year *y* (t COD/yr)
$F_{PJ,dig,m}$	=	Quantity of wastewater that is treated in the anaerobic digester in the project activity in month *m* (m^3/month)
$COD_{dig,m}$	=	Chemical oxygen demand in the wastewater that is treated in the anaerobic digester in the project activity in month *m* (t COD / m^3)
m	=	Months of year *y* of the crediting period

Determination of $MCF_{BL,y}$

The quantity of methane generated from COD disposed to the open lagoon (Scenario 1) depends mainly on the temperature and the depth of the lagoon. Accordingly, the methane conversion factor is calculated based on a factor f_d, expressing the influence of the depth of the lagoon on methane generation, and a factor $f_{T,y}$ expressing the influence of the temperature on the methane generation. In addition, a conservativeness factor of 0.89 is applied to account for the considerable uncertainty associated with this approach. $MCF_{BL,y}$ is calculated as follows:

$$MCF_{BL,y} = f_d * f_{T,y} * 0.89 \quad (6)$$

Where:

$MCF_{BL,y}$	=	Average baseline methane conversion factor (fraction) in year *y*, representing the fraction of ($COD_{PJ,y}$ x B_o) that would be degraded to CH_4 in the absence of the project activity
f_d	=	Factor expressing the influence of the depth of the lagoon on methane generation
$f_{T,y}$	=	Factor expressing the influence of the temperature on the methane generation in year *y*
0.89	=	Conservativeness factor

Determination of fd

f_d represents the influence of the average depth of the lagoons on methane generation.

$$f_d = \begin{cases} 0; & if\ D < 1\,m \\ 0.5; & if\ 1m \le D < 2m \\ 0.7; & if\ D \ge 2m \end{cases}$$

Where:

f_d	=	Factor expressing the influence of the depth of the lagoons on methane generation
D	=	Average depth of the lagoons (m)

As per the registered PDD, the depth of lagoon is 6 m. Therefore, the value of 0.7 is chosen for f_d.

Determination of $f_{T,y}$

In some regions, the ambient temperature varies significantly over the year. Therefore, the factor $f_{T,y}$ is calculated with the help of a monthly stock change model which aims at assessing how much COD degrades in each month. For each month m, the quantity of wastewater directed to the lagoon, the quantity of organic compounds that decay and the quantity of any effluent water from the lagoon is balanced, giving the quantity of COD that is available for degradation in the next month: The amount of organic matter available for degradation to methane ($COD_{available,m}$) is assumed to be equal to the amount of organic matter directed to the open lagoon, less any effluent, plus the COD that may have remained in the lagoon from previous months, as follows:

$$COD_{available,m} = COD_{BL,m} + (1-f_{T,m-1}) * COD_{available,m-1} \quad (7)$$

Where:

$COD_{available,m}$	=	Quantity of chemical oxygen demand available for degradation in the open lagoon in month *m* (t COD/month)
$COD_{BL,m}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons (Scenario 1) in the absence of the project activity in month *m* (t COD/month)
$f_{T,m-1}$	=	Factor expressing the influence of the temperature on the methane generation in previous month (*m-1*)
m	=	Months of year *y* of the crediting period
T	=	Temperature of the lagoon in the month (deg K)
$COD_{avialable,\ m-1}$	=	Quantity of chemical oxygen demand that may have remained in the lagoon from previous month m-1 (tCOD/month)

$$COD_{BL,m} = (1- (COD_{out,x} / COD_{in,x}))* COD_{PJ,m} \quad (8)$$

Where:

$COD_{out,x}$	=	COD of the effluent in the period *x* (t COD)
$COD_{in,x}$	=	COD directed to the open lagoons (Scenario 1) in the period *x* (t COD)
$COD_{PJ,m}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or in the project activity in month *m* (t COD/month)
x	=	Representative historical reference period

and

$$COD_{PJ,m} = F_{PJ,dig,m} * COD_{dig,m} \quad (9)$$

Where:

$COD_{PJ,m}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or in the project activity in month *m* (t COD/month)
$F_{PJ,dig,m}$	=	Quantity of wastewater that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (m^3/month)
$COD_{dig,m}$	=	Chemical oxygen demand in the wastewater that is treated in the anaerobic digester in the project activity in month *m* (t COD/m^3)

The carry-over calculations are limited to a maximum of one year. In case the residence time in the open lagoon is less than one year. The accumulation of organic matter restarts with the next inflow and the COD available from the previous month should be set to zero.

In the case of project activities implement in Greenfield facilities, where the baseline is a new to be built anaerobic lagoon, use the residence time of organic matter according to the design features of the lagoon that was identified as the baseline in Step 1 of the section “Procedure for the identification of the most plausible baseline scenario”.

The monthly factor to account for the influence of the temperature on methane generation is calculated based on the following “van't Hoff-Arrhenius” approach:

$$f_{T,m} = \begin{cases} 0 & if \quad T_{2,m} < 278K \\ e^{\left(\frac{E \times (T_{2,m} - T_1)}{R \times T_1 \times T_{2,m}}\right)} & if \quad 278K \leq T_{2,m} \leq 302.5K \\ 0.95 & if \quad T_{2,m} > 302.5K \end{cases} \tag{10}$$

Where:

$f_{T,m}$	=	Factor expressing the influence of the temperature on the methane generation in month *m*
E	=	Activation energy constant (15,175 cal/mol)
$T_{2,m}$	=	Average temperature at the project site in month *m* (K)
T_1	=	303.16 K (273.16 K + 30 K)
R	=	Ideal gas constant (1.987 cal/K mol)
m	=	Months of year *y* of the crediting period

As indicated in equation above, the value of $f_{T,m}$ cannot exceed 1 and should be assumed to be zero if the ambient temperature is below 10°C.

The annual value $f_{T,y}$ is calculated as follows:

$$f_{T,y} = \frac{\sum_{m=1}^{12} f_{T,m} \times COD_{available,m}}{\sum_{m=1}^{12} COD_{BL,m}} \tag{11}$$

Where:

$f_{T,y}$	=	Factor expressing the influence of the temperature on the methane generation in year *y*
$f_{T,m}$	=	Factor expressing the influence of the temperature on the methane generation in month *m*
$COD_{available,m}$	=	Quantity of chemical oxygen demand available for degradation in the open lagoon in month *m* (t COD/month)
$COD_{BL,m}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons (Scenario 1) in the absence of the project activity in month *m* (t COD/month)
m	=	Months of year *y* of the crediting period

Step 2: Baseline emissions from generation and/or consumption of electricity

As per the registered PDD, the project participant may neglect one or both emission sources. Since there is no electricity generation in the project activity and for simplification and conservativeness the electricity part is neglected for this proposed project activity.

Step 3: Baseline emissions from the generation of heat

The limekiln that utilizes the biogas of the project activity is not included into the project boundary. Hence, baseline emissions from the generation of heat are not claimed. This is a conservative approach.

Table of calculation of baseline emissions

Baseline emissions		**2016**	**2017**
		01/07 to 31/12	**01/01 to 30/06**
BE_{Q_CH4}	**tCO_2**	66,785	70,344
$BE_{CH4,MCF,y}$	**tCO_2**	89,933	136,809
BE_{CH4}	**tCO_2**	66,785	70,344
BE_y	**tCO_2**	66,784	70,343

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

Emissions attributed to the project activity under scenario 1 include the following:

(a) In the case of project activities that introduce an anaerobic digester for the treatment of wastewater, solid materials or sludge. Use the latest approved version of the tool "Project and leakage emissions from anaerobic digesters" to calculate project emissions;

The project emissions associated with the anaerobic digester are determined as follows:

Project participants should document and justify in the CDM-PDD which emission sources are applicable in the context of their project activity. Project emissions are calculated as follows:

$$PE_{AD,y} = PE_{EC,y} + PE_{FC,y} + PE_{CH4,y} + PE_{flare,y} \quad (12)$$

Where:

$PE_{AD,y}$ = Project emissions associated with the anaerobic digester in year *y* (tCO_2)

$PE_{EC,y}$ = Project emissions from electricity consumption associated with the anaerobic digester in year *y* (tCO_2)

$PE_{FC,y}$ = Project emissions from fossil fuel consumption associated with the anaerobic digester in year *y* (tCO_2)

$PE_{CH4,y}$ = Project emissions of methane from the anaerobic digester in year *y* (tCO_2)

$PE_{flare,y}$ = Project emissions from flaring of biogas in year *y* (tCO_2)

These parameters are determined through the steps outlined below.

Step 1: Determination of the quantity of methane produced in the digester ($Q_{CH4,y}$)

There are two different procedures to determine the quantity of methane produced in the digester in year y. For large-scale projects only Option 1 shall be used. For small-scale projects, project participants may choose between Option 1 or Option 2.

Option 1: Procedure using monitored data
To determine the quantity of methane produced in digester in the project activity will be monitored and calculated as per the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream. When applying the tool, the following applies:

- The gaseous stream to which the tool is applied is the biogas collected from the digester
- CH_4 is the greenhouse gas for which the mass flow should be determined
- The flow of the gaseous stream should be measured on an hourly basis or a smaller time interval; and then accumulated for the year.

Option A of tool to determine the mass flow of a greenhouse gas in a gaseous stream is selected to calculate mass flow of methane in the residual gaseous stream on dry basis which is provided below in the section below **in Step 5.** The quantity of methane produced in digester ($Q_{CH4,y}$) is referred to the determination of the mass flow of methane ($F_{CH4,RG,m}$) as kg unit in the residue gaseous stream in the minute "m".

Step 2: Determination of project emissions from electricity consumption ($PE_{EC,y}$)

This emission source includes CO_2 emissions from the consumption of electricity or combustion of fossil fuels for the operation of the project activity. As the project activity consumes electricity, the "Tool to calculate baseline, project and/or leakage emission from electricity consumption" Version 01 is applied to calculate project emission from electricity consumption ($PE_{EC,y}$).

Option 1: Procedure using monitored data

As per the tool, the *Scenario A – Option A1: Electricity consumption from the grid* is applied to the project activity for the amount of electricity imported from the grid. The generic approach is used to calculate the project emissions as follows:

$$PE_{EC,y} = \sum EC_{PJ,j,y} \times EF_{EL,j,y} \times (1+TDL_{j,y}) \qquad (13)$$

Where:

$PE_{power,y}$	=	Project emissions from electricity consumption in year y (tCO_2)
$EC_{PJ,j,y}$	=	Quantity of electricity consumed by the project electricity consumption source j in year y (MWh)
$EF_{EL,j,y}$	=	Emission factor for electricity generation source j in year y (tCO_2/MWh)
$TDL_{j,y}$	=	Average technical transmission and distribution losses for providing electricity to source j in year y. A default value of 20% shall be assumed as conservative assumption as per applied tool.
j	=	Source of electricity consumption in the project

Determination of emission factor for the electricity generation ($EF_{EL,j,y}$)
Option A1 has been used to determine emission factor. This option proposes to calculate the combined margin emission factor of the applicable electricity system, using the procedures in the latest approved version of the "Tool to calculate the emission factor for an electricity system, version 02.2.1" ($EF_{EL,j,y} = EF_{CO2,grid,y}$). The grid emission factor details are further explained in Appendix 4 of the registered PDD.

Determination of average technical transmission and distribution losses

As per the registered PDD, $TDL_{j,y}$ has been taken from the recent data available within the host country.

Step 3: Determination of project emissions from fossil fuel consumption ($PE_{FC,y}$)

There is no fossil fuel consumption at the project site therefore; project emissions from fossil fuel consumption are not determined.

Step 4: Determination of project emissions of methane from the anaerobic digester ($PE_{CH4,y}$)

Project emissions of methane from the anaerobic digester include emissions during maintenance of the digester, physical leaks through the roof and sidewalls, and release through safety valves due to excess pressure in the digester. These emissions are calculated using a default emission factor as follows:

$$PE_{CH4,y} = Q_{CH4,y} \times EF_{CH4,default} \times GWP_{CH4} \quad (14)$$

Where:

$PE_{CH4,y}$	=	Project emissions of methane from anaerobic digester in year *y* (tCO_2)
$Q_{CH4,y}$	=	Quantity of methane produced in the anaerobic digester in year *y* (tCH_4)
$EF_{CH4,defaut}$	=	Default emission factor for the fraction of CH_4 produced that leaks from the anaerobic digester (fraction)
GWP_{CH4}	=	Global warming potential of CH_4 (tCO_2/tCH_4)

Step 5: Determination of project emissions from flaring of biogas ($PE_{flare,y}$)

This step is applicable for proposed project activity because the biogas is generated in a new anaerobic digester is flared partly. Methane may be released as a result of incomplete combustion in the flare. To calculate project emission from flaring of the biogas (PE_{flare}) apply the latest approved version of the tool “Project emissions from flaring”. In general all of the biogas produced by the project is utilized for heat generation. However, a small amount of the biogas produced will be flared in an open flare, for instance during maintenance of the boilers or excess biogas. So the flaring system will be installed by the project activity to combust the biogas.

Methane may be released as a result of incomplete combustion in the flare. To calculate project emissions from flaring of the biogas (PE_{flare}), the tool “Project emissions from flaring” (version 02.0.0) is applied.

For determination of the flare efficiency, a default value of 50% shall be used for the calculation of project emissions from flaring gases, based on the fact that an open flare will be employed in the project activity.

The project emissions calculation procedure is given in the following steps:

STEP 1 Determination of the methane mass flow of the residual gas

The “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” is used to determine the following parameter:

$F_{CH4,RG,m}$: Mass flow of methane in the residual gaseous stream in the minute m (kg)

$F_{CH4,RG,m}$, which is measured as the mass flow during minute *m*, shall then be used to determine the mass of methane in kilograms fed to the flare in minute *m* ($F_{CH4,RG,m}$). $F_{CH4,RG,m}$ shall be

determined on a dry basis. Therefore, the measurement option A as per the table 1 of the tool is selected in order to determine the volume flow and the volumetric fraction of the residue gaseous stream on the dry basis. The temperature of the gaseous stream is less than 60 deg C at the flow measurement point. Therefore as per Option A (b), the gaseous stream is considered dry.

$F_{CH4,RG,m}$ is determined as following equation;

$$F_{CH4,RG,m} = V_{m,db} * v_{CH4,m,db} * \rho_{CH4,m} \quad (15)$$

Where:

$F_{CH4,RG,m}$	=	Mass flow of greenhouse gas CH4 in the residual gaseous stream in the minute m
$V_{m,db}$	=	Volumetric flow of the residual gaseous stream in minute m on dry basis (Nm3)
$v_{CH4,m,db}$	=	Volumetric fraction of the greenhouse gas CH4 in the gaseous stream in minute m on dry basis (%).
$\rho_{CH4,m}$	=	Density of greenhouse gas CH4 in the gaseous stream in minute m at normal conditions

Density of methane ($\rho_{CH4,m}$) is determined at the normal condition in line with below equation. The measurement of biogas flow is conducted in normalized unit (Nm^3).

$$\rho_{i,t} = \frac{P_t \times MM_i}{R_u \times T_t}$$

Where:

$\rho_{CH4,m}$	=	Density of greenhouse gas (CH_4) in the gaseous stream in minute m
P_t	=	Absolute pressure of the gaseous stream in time interval t (Pa)
MM_{CH4}	=	Molecular mass of CH_4 (kg/kmol)
R_u	=	Universal ideal gases constant ($Pa.m^3/kmol.K$)
T_i	=	Temperature of the gaseous stream in time interval t(K)

STEP 2 Determination of flare efficiency

In case of emergency only, biogas will be sent for open flaring. In the case of open flares, the flare efficiency in the minute m (n flare,m) is 50% when the flame is detected in the minute m (Flame m) and otherwise the flare efficiency is 0%.

STEP 3 Calculation of project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions for each minute *m* in year *y*, based on the methane mass flow in the residue gas ($F_{CH4,RG,m}$) and the flare efficiency ($\eta_{flare,m}$), as follow:

$$PE_{flare,\,y} = \sum F_{CH4,RG,h} * (1 - \eta_{flare\text{-}h}) * GWP_{CH4} / 1000 \quad (16)$$

Where:

$PE_{flare,y}$	=	Project emissions from flaring of the residual gas in year *y* (tCO_2)
GWP_{CH4}	=	Global warming potential of methane valid for the commitment period (tCO_2/tCH_4)
$F_{CH4,RG,m}$	=	Mass flow of methane in the residue gas in the minute *m* (kg)
$\eta_{flare,m}$	=	Flare efficiency in minute *m*

(i) Project emissions from land application of sludge

This emission source is only applicable if under the project activity sludge is applied on lands. For conservativeness, an MCF of 0.05 is to be used to estimate possible methane emissions from the land application treatment process to account for any possible anaerobic pockets. These emissions are to be estimated from the following equations:

$$PE_{sludge,LA,y} = COD_{sludge,\ LA,y} * B_o * MCF_{sludge,LA} * GWP_{CH4} + S_{LA,y} * w_{N,sludge,y} * EF_{N2O,\ LA,\ sludge} * GWP_{N2O} \quad (17)$$

Where:

$PE_{sludge,LA,y}$	=	Project emissions from land application of sludge in year *y* (tCO_2/yr)
$COD_{sludge,\ LA,y}$	=	Chemical oxygen demand (COD) of the sludge applied to land after the dewatering process in year *y* (tCOD/yr)
B_o	=	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand ($tCH_4/tCOD$)
$MCF_{sludge,LA}$	=	Methane conversion factor for the application of sludge to lands
GWP_{CH4}	=	Global Warming Potential of methane valid for the applicable commitment period (tCO_2/tCH_4)
$W_{sludge,COD,m}$	=	Average chemical oxygen demand in the sludge applied to land after the dewatering process in month *m* (t COD/t sludge)
$S_{LA,m}$	=	Amount of sludge applied to land in month *m* (t sludge/month)
$N_{Sludge,LA,y}$	=	Amount of nitrogen in the sludge applied to land in year *y* (t N/yr)
$W_{N,sludge,m}$	=	Mass fraction of nitrogen in the sludge applied to land in month *m* (t N/t sludge)
$EF_{N2O,\ LA,\ sludge}$	=	N_2O emission factor for nitrogen from sludge applied to land (t N_2O/t N)
GWP_{N2O}	=	Global Warming Potential of nitrous dioxide (tCO_2/tN_2O)

In this monitoring, the sludge from the project activity is directly applied on the plantation area and is not stored under anaerobic conditions at any point of time. Thus, the project emissions from land application of sludge shall not be accounted and shall be zero inline with the tool and the methodology.

(ii) Project emissions from land application of dewatered

According to ACM0014, version 05.0.0, this emission source is only applicable if under the project activity wastewater is dewatered and directed to land applicable. In the proposed project activity, the wastewater is not dewatered and directed to land. Therefore, project emissions from land application of wastewater are neglected.

Table of calculation of project emissions

Project emissions		**2016**	**2017**
		01/07 to 31/12	**01/01 to 30/06**
$PE_{AD,y}$	**tCO_2**	24,386	17,828
$PE_{sludge,LA,y}$	**tCO_2**	0	0
$PE_{WW,LA,y}$	**tCO_2**	0	0
PE_y	**tCO_2**	24,386	17,828

E.3. Calculation of leakage emissions

As per ACM0014 Version 05, project activities that introduce an anaerobic digester for the treatment of wastewater, solid materials or sludge leakage emissions are accounted using the tool "Project and leakage emissions from anaerobic digesters". The following equation is considered;

$$LE_y = LE_{AD} = LE_{storage} + LE_{comp,y} \quad (18)$$

Where:

LE_{AD}	=	Leakage emissions associated with the anaerobic digester in year y (tCO_2e/yr)
$LE_{storage}$	=	Leakage emissions associated with storage of digestate in year y (tCO_2e/yr)
$LE_{comp,y}$	=	Leakage emissions associated with composting digestate in year y (tCO_2e/yr)

As per the tool, the leakage emissions associated with the anaerobic digester ($LE_{AD,y}$) depend on how the digestate is managed. In this monitoring period, the wastewater treated at the outlet of the project was supplied to open ponds. This effluent treated was considered as the digestate. Therefore, the leakage emission is only determined the leakage emission associated with storage of digestate ($LE_{storage}$). The option 1 of procedure using monitored data is chosen as following equation;

$$LE_{AD} = LE_{storage} = Q_{stored,y} \times P_{COD,y} \times B_o \times MCF_P \times GWP_{CH4} \quad (19)$$

Where:

LE_{AD}	=	Leakage emissions associated with the anaerobic digester in year y (tCO_2e/yr)
$LE_{storage}$	=	Leakage emissions associated with storage of digestate in year y (tCO_2e/yr)
$Q_{stored,y}$	=	Amount of liquid digestate stored anaerobically in year y (m^3)
$P_{COD,y}$	=	Average chemical oxygen demand (COD) of the liquid digestate in year y ($tCOD/m^3$)
MCF_P	=	Leakage emissions associated with composting digestate in year y (tCO_2e/yr)
B_o	=	Maximum methane producing capacity of the COD applied (tCH4/tCOD)
GWP_{CH4}	=	Global warming potential of CH_4 (tCO_2/tCH_4)

The monitoring detail of $Q_{stored,\ y}$ is referred to the monitoring parameter $F_{PJ,dig,m}$. While, the monitoring detail of P_{COD} is referred to the monitoring parameter $COD_{discharge,m}$. As per this tool, parameter B_o value - the maximum CH_4 producing capacity of the COD applied of 0.25 is applied in the emission reduction calculation.

Table of calculation of Leakage

Leakage		**2016**	**2017**
		01/07 to 31/12	**01/01 to 30/06**
LE_y	**tCO_2**	2,142	987

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	137,127	42,214	3,129	0	91,784	91,784

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 (t CO_2e)
91,784	170,983

E.6. Remarks on increase in achieved emission reductions

As per the above calculation detail, the actual GHG emission reduction achieved in the monitoring period is lower than the amount based on the ex-ante estimation in the registered PDD. This section is not applicable.