

MONITORING REPORT OF P.S.C STARCH WASTEWATER TREATMENT AND BIOGAS UTILIZATION PROJECT



Document Prepared By Swiss Carbon Value Ltd.

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

P.S.C. Starch Products wastewater treatment and biogas utilization project, hereafter the project activity, involves biogas recovery and its utilization as a fuel in hot oil boiler and steam boilers. The project involves wastewater generation from two different manufacturing units turning out three products (i.e. starch, sweetener and ethanol).

The project was implemented at P.S.C Starch Products Public Company Limited in 28/04/2005 (project start date). In the starch unit, raw tapioca is fed into the processes to produce wet starch. For further processing, the wet starch is then separated into two parts, namely native tapioca starch and starch sugar. These two products are manufactured using different procedures. This process generates wastewater which is generated irrespective of the fact if wet starch is converted to native tapioca starch or used as raw material for sweetener products. The production capacity of the starch factory is 200 tonnes of dry starch equivalent products per day, and 240 tonnes of sweetener products per day.

The UASB reactor, designed and controlled by the Biogas Advisory Union Foundation, was the first system to be implemented in April 2005. The UASBs are assigned to treat wastewater from starch factory. During the early stage of operation, the UASBs reactor could not reach expected performance and the project owner decided to install a covered lagoon (CL1) in order to pre-treat the wastewater before feeding to UASBs. The CL1 was put on a newly constructed lagoon. Later, in 2006, a covered sheet at the existing first open anaerobic lagoon was installed to collect the biogas generated and turned to be covered lagoon 2 (CL2). This covered lagoon was designed to receive wastewater from sweetener factory together with the effluent from the UASBs reactor.

In October 2009, an ethanol plant started operation in line with these existing facilities. In the absence of the project activity, the wastewater from the ethanol plant would have been treated in an open pond anaerobic system. The project activity involves the construction of a new covered lagoon (CL3) with biogas recovery.

The biogas generated by the overall system (UASB + CL1 + CL2 + CL3) is being used at sweetener plant (steam boilers), starch plant (hot oil boiler) and sweetener plant (electricity generation). It was mentioned during the project validation that due to unsteady fuel mixture of biomass and coal, the components of electricity production and fuel replacement have not been claimed for emission reduction. Though only biomass has been used as additional fuel in this monitoring period of project activity.

Table 1 : Brief description of equipment in the project activity

Project / Baseline Component	Brief description
Lagoon system	The lagoon system consists of 8 open lagoons.
UASB	Up-flow Anaerobic Sludge Blanket has a volumetric capacity of 8,000m ³ .
Covered Lagoon (CL1)	The first covered lagoon has a volumetric capacity of 32,400m ³ . This covered lagoon receives the wastewater coming from the starch factory.
Covered Lagoon (CL2)	The second covered lagoon was constructed through a modification of the existing open lagoon. It has a volumetric capacity of 32,400m ³ . This covered lagoon receives the wastewater coming from the sweetener factory and from the UASBs.
Covered Lagoon (CL3)	The third covered lagoon has a volumetric capacity of 32,400m ³ . This covered lagoon receives the wastewater coming from the ethanol plant.

Gas storage device (or Gas Holder)	Acidification pond is covered with the HDPE sheet to serve as gas storage device or gas holder. The covered lagoons system can also be used for the purpose of gas storage.
Auxiliary drives	Total capacity of the auxiliary drives amount to an approximate of 245.06 kW.

This monitoring report is for the forth verification of this project. The project activity can achieve 58,924 tCO₂e in this monitoring period. The monitoring period starts from 01/01/2018 to 31/12/2018. Further background information on this project activity can be found on the VCS website: http://vcsprojectdatabase.org/#/project_details/417.

1.2 Sectoral Scope and Project Type

The project activity involves recovery of fugitive biogas from the wastewater released from a starch factory, a sweetener plant and an ethanol plant, using an Upflow Anaerobic Sludge Blanket (UASB) system and covered lagoons. The biogas generated is utilized as fuel in a hot oil boiler and steam boilers to produce electricity and heat. Prior to project implementation, a fuel mix based on biomass and coal was used. A conservative approach for the calculation of GHG emission reduction is taken by not claiming emission reductions for the heat and electricity generated.

The project activity generates emission reductions less than 60ktCO₂e per year for the type III component. The type/category of the project activity is thus according to Appendix B, *Simplified Modalities and Procedures for Small-Scale CDM Project Activities*, as follow:

Methane avoidance component:

Type III: Other Project Activities
 Category III.H: Methane Recovery in Wastewater Treatment
 Sectoral Scope 13: Waste Handling and Disposal
 Version: 13

1.3 Project Proponent

Organization name	P.S.C Starch Products Public Company Limited
Contact person	Sarun Sereethoranakul
Title	Mr.
Address	999 Moo.5 Nongyai, Chonburi Thailand
Telephone	+66 38 219 730 - 4
Email	N/A

1.4 Other Entities Involved in the Project

Organization name	Swiss Carbon Value Ltd.
Role in the project	Emission Reduction project developer/consultant
Contact person	Ladaporn Khunikakorn
Title	Miss

Address	Technoparkstrasse 1, 8005 Zurich Switzerland
Telephone	+66 2 678 6979
Email	registration@southpole.com

1.5 Project Start Date

Project start date: 28/04/2005 (the date when emissions reduction began).

1.6 Project Crediting Period

Crediting period start date: 01/12/2009 to 30/11/2019 (in accordance with the installation of monitoring equipment).

1.7 Project Location

The project site is located in P.S.C Starch factory, located at address: 999 Nongyai – Bothong road, Nongyai District, Chonburi Province, Thailand, about 150km away from Bangkok. Geographical coordinates: Latitude 13°18'6.50"N and Longitude 101° 21'49.47"E.



Figure 1 Project location

1.8 Title and Reference of Methodology

Approved CDM methodology is applied to this project activity. According to Appendix B of the *Simplified Modalities and Procedures for Small-Scale CDM Project Activities*, the project type and category are defined as follows:

Methane avoidance component:

Type III: Other project activities
Category III.H: Methane Recovery in Wastewater Treatment
Sectoral Scope 13: Waste handling and disposal
Version: 13

AMS-III.H refers to:

- AMS.I.D “Grid connected renewable electricity generation” version 14 for estimating project emissions from electricity consumption by the project activity.

AMS.I.D refers to:

- “Tool to calculate the emission factor for an electricity system” version 1.1.

For Greenfield project, the “Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories”, version 12.1 refers to: “*Combined tool to identify the baseline scenario and demonstrate additionality*” version 2.2

1.9 Other Programs

Not Applicable.

1.10 Sustainable Development

Economic:

New jobs are created during the construction and operation phases of the biogas reactor system and of the cover lagoons. As well, regional economic development can foster through contracts to local firms. In addition, not only partial reimbursement on the vast investment cost can be made through utilization of the captured biogas, the additional revenue from the sale of VCUs has also made the project financially feasible.

Sectoral:

This project is a good example of an effective waste to energy project which in turn improves the long-term sustainability of the Thai starch industry.

Social:

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

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

Environmental:

Due to higher efficiency and improved process control, the quality of treated wastewater is expected to improve substantially with the implementation of the project activity. Thus, wastewater leakage is unlikely. It must be mentioned that the project activity has zero discharge to the river or other natural sources such as soils and groundwater. The project has positive impacts on the local environment by improving air quality through reduction in odour and cleaner emissions. This can in turn improve the standard of living of the local population. The capacity of this technological process to replace fuel oil and generate electricity can also be regarded as a potential for reducing dependency on fossil fuels and for promoting diversification of energy resources. Ensuring energy security in this way can be seen as a contribution to sustainable development, particularly during this era of growing fuel prices.

Note that wastewater overflow might happen during the rainy season if the precipitation rate is higher than the outflow rate of the final pond for a sustained period of time. Wastewater overflow can lead to a variety of problems that have significant environmental impacts. Excess nutrients in the wastewater stimulate excessive plant growth which can disrupt normal functioning of the ecosystem, known as Eutrophication. Such problem could lead to social conflicts within the community. While wastewater can overflow from any ponds in the old anaerobic lagoon, the overflow can only happen from the post-treatment ponds in the closed anaerobic system. Since the average water quality at the outlet of the project activity is better than that in the anaerobic lagoon ponds, the environmental impacts from overflow of wastewater has been significantly reduced. Overall, the project has positive impacts on the local environment by improving air quality through reduction in odor and cleaner emissions. This can in turn improve the standard of living of the local population.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The starting date of each treatment units are summarized in below.

Project Components	Date of operation start / Commissioning
UASB	Year 2005
CL1	Year 2006
CL2	Year 2007
CL3	Oct - 2009

- The biogas treatment system, UASBs and covered lagoons have been completely operated since 2009 (first monitoring period) as per information in the registered PD.
- After the implementation of covered lagoon no.3, the wastewater treatment process has been reconfigured from design in the registered PD. Since the wastewater discharged from ethanol plant has very high temperature and cannot be cooled down in the covered lagoon. The anaerobic digestion cannot be occurred under high temperature ambient. Hence the CL3 cannot work properly and the effluent from this lagoon still has very high COD content. The effluent from CL3 is retreated at CL1 instead of discharging to open lagoons. This reconfiguration has been started in October 2009, one weeks after starting feeding wastewater into CL3. This changing affects the calculation of $PE_{\text{ww,discharge,PJ,y}}$ in equation 8 of the registered PD, the description for this scenario is provided in deviation 1. The same approach has been provided and approved in the previous verification.

2.2 Deviations

2.2.1 Methodology Deviations

There is no methodology deviation proposed in this monitoring period.

2.2.2 Project Description Deviations

Deviation 1

Description of deviation

The $COD_{ww,discharge,PJ,y}$ is the COD of water coming out of from CL2 instead of the wastewater coming out from CL3.

Period of deviation

This deviated approach is applied for this whole monitoring period.

Deviated approach

The $COD_{ww,discharge,PJ,y}$ is the COD of the treated wastewater discharged into the sea , river or lake in the project scenario. In this case, the wastewater treated by anaerobic project activity which ended by CL2, is discharged into the pond.

Although the additional amount of biogas generated from the treating of effluent from CL3 at CL1 increases the amount of biogas combusted. The amount of biogas combusted is used for MD_y calculation and the result of MD_y is raised up in the same way. As per equation 13, in line with conservative principle, the final result of ER_{expost} is from the COD approach which is lower than MD_y approach. Hence, this changing has no effect to the achieved emission reductions in this monitoring period.

Justification for deviated approach

The $PE_{ww,discharge,y}$, methane emissions from degradable organic carbon in treated wastewater , is the methane emission from the digestion of residue COD , COD remained after anaerobic digestion with biogas recovery system , in the open system which methane can freely release into the environment.

In the monitoring diagram shown in the registered PD, the treated wastewater from CL3 is sent to pond system. The $COD_{ww,discharge,PJ,y}$ is the COD at the outlet of CL3.

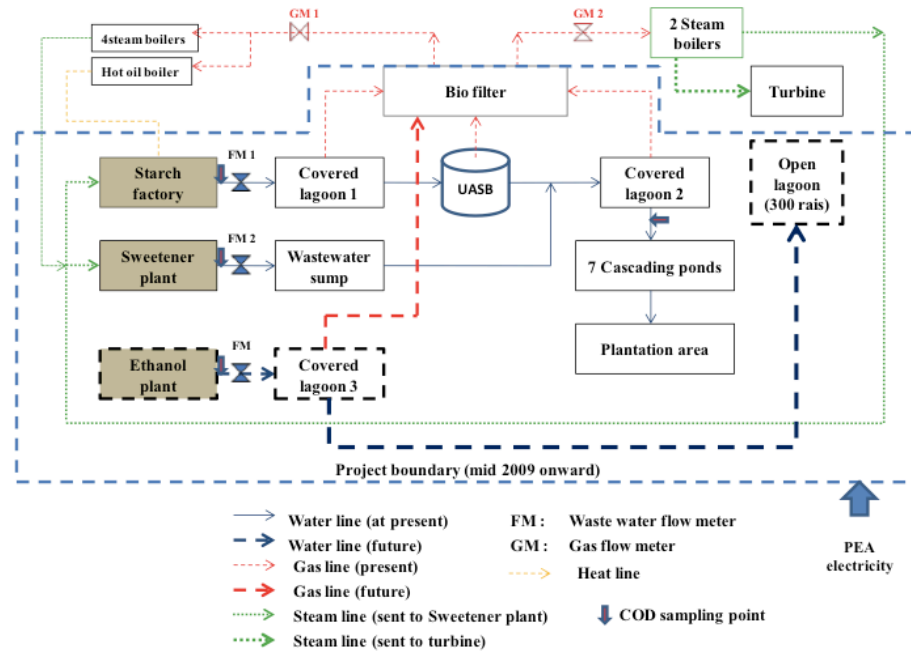


Figure 2 Monitoring diagram as per registered PD

As per the plant reconfiguration, the treated wastewater from CL3 is sent to CL1. Then the last unit for closed anaerobic system is CL2 before discharge to pond system. The COD_{ww,discharge.PJ.y} is changed to be the COD of treated wastewater from CL2 as per the new monitoring diagram below.

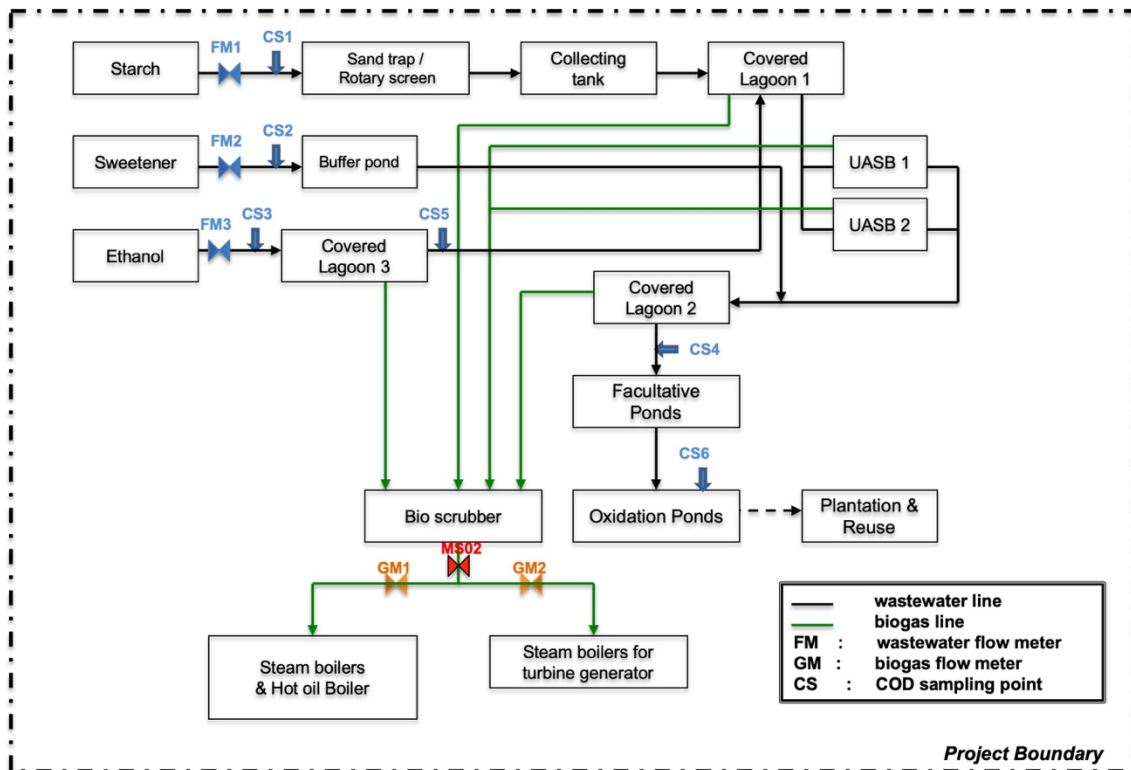


Figure 3 Monitoring diagram implementing at the project activity

Deviation 2Description of deviation

The $COD_{y,ww,untreated,starch}$, $COD_{y,ww,untreated,sweetener}$, $COD_{y,ww,untreated,ethanol}$, $COD_{y,ww,reated,CL2}$, $COD_{y,ww,reated,CL3}$ and $COD_{y,ww,treated,lagoon}$ are not measured on daily basis which determined in the monitoring plan for COD parameters in the registered VCS PD.

Period of deviation

This deviated approach is applied for the monitoring period.

Deviated approach

The wastewater analysis of the samples were carried out by internal laboratory, but not on every operational days. Refer to AMS III.H version 18, for COD parameters: Average value may be used through sampling with the confidence/precision level 90/10. The example of calculating step from Annex 13 of EB 48 which is followed the standard statistical calculation is applied.

- 1) Calculate sample mean (μ).

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

Where :

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

$COD_{y,ww}$ = Monitored $COD_{y,ww}$ in measurement m in year y

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

- 2) Calculate the sample standard deviation (σ).

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

Where :

$\sigma_{COD,y}$ = Standard deviation of COD_y in year y

- 3) Calculate the 95% confidence interval.

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

Where :

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

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

¹ <http://www.stat.tamu.edu/~lzhou/stat302/T-Table.pdf>

The above calculating is performed in the ER calculation spreadsheet.

Justification for deviated approach

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

2.3 Grouped Project

This project activity is not a grouped project.

2.4 Safeguards

2.4.1 No Net Harm

The project activity does not have potential to create any negative environmental and socio-economic impact.

2.4.2 Local Stakeholder Consultation

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

Invitation procedure

The project owner of P.S.C. Starch Products PCL has conducted the stakeholder consultation with assistance from South Pole Carbon Asset Management Limited (Switzerland based company responsible for VER project development).

Stakeholder groups have been identified and informed through oral means about the meetings.

Place and date of the meetings

The stakeholder consultation was held in the factory compound on December 9, 2008. All participants were able to examine the location where the proposed project was take place.

Meeting Participants on December 9, 2008

Local residents and representatives attended the meeting from following stakeholder categories:

1. Local residents
2. Local government representatives
3. Employees

20 participants have followed the invitation and attended the meeting.

Language

Meeting was conducted and documented in Thai (local language).

Meeting procedures

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

Meeting documents and protocols

On completion of the meeting the documentation in following subjects was collected and attested by the signatures of the stakeholders that were present:

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

Compilation of comments received:

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

No adverse reactions or comments have been received during the stakeholder consultation process. The project participants did not recognize any need to make changes to the project design or monitoring plan.

Short description:

The proposed project is implemented at P.S.C. Starch Products PLC.; a starch plant with a total production capacity of 200 t of native starch per day, 400 m³ per day of sweetener products and expected ethanol of 1600 m³ per day, generating an average of 350,000 m³, 240,000 m³ and 380,000 m³ per year respectively.

The proposed project activity entails the installation of an anaerobic wastewater treatment facility. Upflow anaerobic sludge blanket (UASB) biogas reactor technology, at the existing starch manufacturing plant, replaces the open anaerobic lagoon-based system (composed of 12 cascading lagoons with a retention time of more than one year). The biogas reactor system generates and recovers biogas for energy generation purposes, avoiding methane emissions to the atmosphere. The captured methane is used as fuel in existing heat generating devices in the starch plant replacing heavy fuel oil, which lead to further CO₂ reductions by replacing a fossil fuel. Any surplus methane is flared in an open flare.

A diagram summarising the technology installed is provided below:

Environmental impacts:

The quality of the treated water, which is subject to effluent standards regulated by the environmental authorities, improve substantially due to higher efficiency and improved process control of the biogas reactor as compared to open lagoons. In fact, the biogas reactor system allows the starch factory to reuse the treated effluent in the tapioca production process at more regular intervals and with less loss during storage, contributing to water conservation. Further, the project avoids odour emissions as compared to an uncovered anaerobic lagoon, which contributes significantly to an improved life quality around the project site.

Contribution to sustainable development:

The project activity does also contribute to technology transfer from Thailand and efficiency improvement of the agro-industry, which is beneficial to a rural and underdeveloped region of the country. New jobs are created during the construction and operation of the biogas reactor system and regional economic development is fostered through contracts to local firms related to construction, operation, and maintenance of the plant.

Current Practice

The project proponent maintains a register at the plant, to make sure any current feedback is provided by local people in fair and transparent manner

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	GWP _{CH4}
Data unit	-
Description	Global warming potential of methane gas
Source of data	AMS III.H version 13
Value applied:	25
Justification of choice of data or description of measurement methods and procedures applied	Intergovernmental Panel on Climate Change, Climate Change 1995: The Science of Climate Change (Cambridge, UK: Cambridge University Press, 1996).
Purpose of the data	This parameter is used for baseline and project emission calculations.
Comments	The default value is changed as per VCS standard, v.3.7.

Data / Parameter	B _{o,ww}
Data unit	kg CH ₄ / kg COD
Description	Methane generation capacity of COD in wastewater
Source of data	IPCC default value, corrected as per methodology AMS –III.H is used for estimation
Value applied:	0.21
Justification of choice of data or description of measurement methods and procedures applied	IPCC default value , based on AMS III.H.
Purpose of the data	This parameter is used for baseline emission calculations.
Comments	-

Data / Parameter	UF _{BL}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS –III.H version 13
Value applied:	0.94
Justification of choice of data or description of measurement methods and procedures applied	Reference: FCCC/SBATA/2003/10/Add2, page 25. Based on AMS III.H.
Purpose of the data	This parameter is used for baseline emission calculations.
Comments	-

Data / Parameter	UF _{PJ}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS –III.H version 13
Value applied:	1.06
Justification of choice of data or description of measurement methods and procedures applied	Reference: FCCC/SBATA/2003/10/Add2, page 25. Based on AMS III.H.
Purpose of the data	This parameter is used for project emission calculations.
Comments	-

Data / Parameter	MCF _{ww,treatment,BL,lagoon}
Data unit	-
Description	Methane correction factor for the baseline anaerobic wastewater treatment system
Source of data	Table II.H 1 from AMS III.H version 13
Value applied:	0.8
Justification of choice of data or description of measurement methods and procedures applied	The baseline wastewater treatment system consists in a succession of deep lagoons (depth more than 4.5 metres) therefore MCF value is chosen as 0.8.
Purpose of the data	This parameter is used for baseline emission calculations.
Comments	IPCC Default values from chapter 6 of volume 5 page no 6.21. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Data / Parameter	MCF _{ww,treatment,PJ,k}
Data unit	-
Description	Methane correction factor for the project wastewater treatment system k equipped with the biogas recovery
Source of data	Table II.H 1 from AMS III.H version 13
Value applied:	$MCF_{ww, treatment, PJ, UASB} = 0.8$ $MCF_{ww, treatment, PJ, CL1} = 0.8$ $MCF_{ww, treatment, PJ, CL2} = 0.8$ $MCF_{ww, treatment, PJ, CL3} = 0.8$
Justification of choice of data or description of measurement methods and procedures applied	All MCF values have been chosen in accordance with table III.H.1 from methodology AMS III.H., version 13. The project wastewater treatment system equipped with biogas recovery consists of a UASB system and covered lagoons, therefore MCF value is chosen as 0.8.
Purpose of the data	This parameter is used for project emission calculations.
Comments	-

Data / Parameter	MCF _{ww,treatment,PJ,lagoon}
Data unit	-
Description	Methane correction factor for the project wastewater treatment system not equipped with biogas recovery
Source of data	Table II.H 1 from AMS III.H version 13
Value applied:	0.8
Justification of choice of data or description of measurement methods and procedures applied	All MCF values have been chosen in accordance with table III.H.1 from methodology AMS III.H., version 13. The project wastewater treatment system not equipped with biogas recovery consists of anaerobic lagoons, therefore MCF value is chosen as 0.8.
Purpose of the data	This parameter is used for project emission calculations.
Comments	-

Data / Parameter	MCF _{ww,PJ,discharge}
Data unit	-
Description	Methane correction factor based on discharge pathway in the project situation
Source of data	Table II.H 1 from AMS III.H version 13
Value applied:	0.8
Justification of choice of data or description of measurement methods and procedures applied	The wastewater coming out of the covered lagoon CL3 was discharged into a series of anaerobic lagoons. A value of 0.8 is chosen for conservativeness.
Purpose of the data	This parameter is used for project emission calculations.
Comments	-

Data / Parameter	CFE _{ww}
Data unit	-
Description	Capture and utilization/combustion/flare efficiency of the methane recovery and combustion/utilization equipment in the wastewater treatment.
Source of data	Equation 10 in AMS III.H, Version 13 methodology
Value applied:	0.9
Justification of choice of data or description of measurement methods and procedures applied	Default value is used here. Based on AMS III.H., applicable for equation(s) (5) in the methodology.
Purpose of the data	This parameter is used for project emission calculations.
Comments	-

Data / Parameter	$\eta_{BL, starch}$
Data unit	%
Description	COD removal efficiency of baseline wastewater treatment system for the starch and sweetener plants
Source of data	Historical data
Value applied:	98.61%
Justification of choice of data or description of measurement methods and procedures applied	The COD removal efficiency is based on monitored historical COD values for baseline system before implementation of project activity.
Purpose of the data	This parameter is used for baseline emission calculations.
Comments	-

Data / Parameter	$\eta_{BL, ethanol}$
Data unit	%
Description	COD removal efficiency of baseline wastewater treatment system for the ethanol plants
Source of data	Historical data
Value applied:	87.76%
Justification of choice of data or description of measurement methods and procedures applied	The COD removal efficiency is based on COD values for open lagoons system multiply by 0.89.
Purpose of the data	This parameter is used for baseline emission calculations.
Comments	-

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

Data / Parameter	P_{el}
Data unit	kW

Description	Total electrical capacity of the equipment installed in the project activity
Source of data	Plant data
Value applied:	245.1
Justification of choice of data or description of measurement methods and procedures applied	The total installed capacity of the present equipment is used.
Purpose of the data	This parameter is used for project emission calculations.
Comments	-

Data / Parameter	EF _y
Data unit	tCO ₂ /MWh
Description	CO ₂ emission factor for grid power
Source of data	"The calculation of emission factor for an electricity system in Thailand 2007", DEDE.
Value applied:	0.5057
Justification of choice of data or description of measurement methods and procedures applied	EF _y 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. version 14).
Purpose of the data	This parameter is used for project emission calculations.
Comments	-

3.2 Data and Parameters Monitored

Data / Parameter	Q _{y,ww,starch}				
Data unit	m ³				
Description	Volume of wastewater treated in the year y from the starch plant				
Source of data	Measured - Volumetric flow meter : FM1				
Description of measurement methods and procedures to be applied	Monitoring: Volumetric flow meter Data type: Records in both hard files (log sheets) and soft files.				
Frequency of monitoring/recording	Frequency: Continuous measurements Recording: Cumulative readings are recorded daily.				
Value monitored:	<table border="1"> <tr> <th>Monitoring period</th><th>Value (m³)</th></tr> <tr> <td>01/01/2018 to 31/12/2018</td><td>791,093</td></tr> </table>	Monitoring period	Value (m ³)	01/01/2018 to 31/12/2018	791,093
Monitoring period	Value (m ³)				
01/01/2018 to 31/12/2018	791,093				

Monitoring equipment	Meter name	FM1
	Serial Number	3K672016320307
	Brand	ABB
	Model	FEV11
	Accuracy	0.4%
	Calibration Frequency	Once in 3 years
	Calibration Date	16/08/2016 05/03/2018
	Validity	04/03/2021
QA/QC procedures to be applied	Periodic calibrations (Once in three years) for wastewater flow meter are ensured via an external agency.	
Purpose of the data	Calculation of baseline and project emissions	
Calculation method	-	
Comments	-	

Data / Parameter	Q _{y,ww,sweetener}					
Data unit	m ³					
Description	Volume of wastewater treated in the year y from the sweetener plant					
Source of data	Measured - Volumetric flow meter : FM2					
Description of measurement methods and procedures to be applied	Monitoring: Volumetric flow meter Data type: Records in both hard files (log sheets) and soft files.					
Frequency of monitoring/recording	Frequency: Continuous measurements Recording: Cumulative readings are recorded daily.					
Value monitored:	<table><tr><td>Monitoring period</td><td>Value (m³)</td></tr><tr><td>01/01/2018 to 31/12/2018</td><td>451,361</td></tr></table>		Monitoring period	Value (m ³)	01/01/2018 to 31/12/2018	451,361
Monitoring period	Value (m ³)					
01/01/2018 to 31/12/2018	451,361					
Monitoring equipment	Meter name	FM2				
	Serial Number	6201472				
	Brand	Rosemount				
	Model	M4Q4				
	Accuracy	0.35%				
	Calibration Frequency	1 / 3 years				
	Calibration Date	26/12/2017				
	Validity	25/12/2020				

QA/QC procedures to be applied	Periodic calibrations (Once in three years) for wastewater flow meter are ensured via an external agency.
Purpose of the data	Calculation of baseline and project emissions
Calculation method	-
Comments	-

Data / Parameter	$Q_{y,ww,Ethanol}$																																
Data unit	m ³																																
Description	Volume of wastewater treated in the year y from the ethanol plant																																
Source of data	Measured - Volumetric flow meter : FM3																																
Description of measurement methods and procedures to be applied	Monitoring: Volumetric flow meter Data type: Records in both hard files (log sheets) and soft files.																																
Frequency of monitoring/recording	Frequency: Continuous measurements Recording: Cumulative readings are recorded daily.																																
Value monitored:	<table border="1"> <thead> <tr> <th>Monitoring period</th><th>Value (m³)</th></tr> </thead> <tbody> <tr> <td>01/01/2018 to 31/12/2018</td><td>422,362</td></tr> </tbody> </table>	Monitoring period	Value (m ³)	01/01/2018 to 31/12/2018	422,362																												
Monitoring period	Value (m ³)																																
01/01/2018 to 31/12/2018	422,362																																
Monitoring equipment	There are two monitoring equipment in this monitoring period. <table border="1"> <tr><td>Meter name</td><td>FM3</td></tr> <tr><td>Serial Number</td><td>S5G802553 736</td></tr> <tr><td>Brand</td><td>Yokogawa</td></tr> <tr><td>Model</td><td>APX1500</td></tr> <tr><td>Accuracy</td><td>0.35%</td></tr> <tr><td>Calibration Frequency</td><td>1 / 3 years</td></tr> <tr><td>Calibration Date</td><td>26/12/2017</td></tr> <tr><td>Validity</td><td>25/12/2020</td></tr> </table> The old meter has been replaced on 12/06/2018. <table border="1"> <tr><td>Meter name</td><td>FM3</td></tr> <tr><td>Serial Number</td><td>3K672018091156</td></tr> <tr><td>Brand</td><td>ABB</td></tr> <tr><td>Model</td><td>FEP300</td></tr> <tr><td>Accuracy</td><td>0.40%</td></tr> <tr><td>Calibration Frequency</td><td>1 / 3 years</td></tr> <tr><td>Calibration Date</td><td>08/03/2018</td></tr> <tr><td>Validity</td><td>07/03/2021</td></tr> </table>	Meter name	FM3	Serial Number	S5G802553 736	Brand	Yokogawa	Model	APX1500	Accuracy	0.35%	Calibration Frequency	1 / 3 years	Calibration Date	26/12/2017	Validity	25/12/2020	Meter name	FM3	Serial Number	3K672018091156	Brand	ABB	Model	FEP300	Accuracy	0.40%	Calibration Frequency	1 / 3 years	Calibration Date	08/03/2018	Validity	07/03/2021
Meter name	FM3																																
Serial Number	S5G802553 736																																
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Calibration Date	08/03/2018																																
Validity	07/03/2021																																

QA/QC procedures to be applied	Periodic calibrations (Once in three years) for wastewater flow meter are ensured via an external agency.
Purpose of the data	Calculation of baseline and project emissions
Calculation method	-
Comments	-

Data / Parameter	COD _{y,ww,untreated,starch}										
Data unit	mg/l										
Description	COD of wastewater from starch plant : CS1										
Source of data	Measured – Titrimetric analysis										
Description of measurement methods and procedures to be applied	Monitoring: Closed reflux titrimetric method in the onsite laboratory of the treatment plant. Sample was taken from the outlet of wastewater from starch plant before entering CL1. Data type: Records in both hard and soft files.										
Frequency of monitoring/recording	Frequency: Daily basis Recording : Daily records										
Value monitored:	<table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value (mg/l)</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>01/01/2018 to 31/12/2018</td><td>17,182</td><td>20,612</td></tr></table>			Monitoring period	Value (mg/l)		Lower	Higher	01/01/2018 to 31/12/2018	17,182	20,612
Monitoring period	Value (mg/l)										
	Lower	Higher									
01/01/2018 to 31/12/2018	17,182	20,612									
Monitoring equipment	n/a										
QA/QC procedures to be applied	In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner (as per deviation 2 of section 2.2) or ignored out of emission reduction estimation. The closed reflux titrimetric method is well documented ² and well accepted by international standards ; method 5220 C approved by United States Environmental Protection Agency – USEPA										
Purpose of the data	Calculation of baseline and project emissions										
Calculation method	-										
Comments	-										

Data / Parameter	COD _{y,ww,untreated,sweetener}		
Data unit	mg/l		
Description	COD of wastewater from sweetener plant : CS2		
Source of data	Measured – Titrimetric analysis		

² The Examination of water and wastewater", 1st Ed 2005 and Wastewater analysis manual from Environmental Engineering Association , Thailand , 3rd Ed. 1997

Description of measurement methods and procedures to be applied	Monitoring: Closed reflux titrimetric method in the onsite laboratory of the treatment plant. Sample was taken from the outlet of wastewater from sweetener plant before entering CL2. Data type: Records in both hard and soft files.										
Frequency of monitoring/recording	Frequency: Daily basis Recording : Daily records										
Value monitored:	<table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value (mg/l)</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>01/01/2018 to 31/12/2018</td><td>15,395</td><td>19,309</td></tr></table>			Monitoring period	Value (mg/l)		Lower	Higher	01/01/2018 to 31/12/2018	15,395	19,309
Monitoring period	Value (mg/l)										
	Lower	Higher									
01/01/2018 to 31/12/2018	15,395	19,309									
Monitoring equipment	n/a										
QA/QC procedures to be applied	Please see COD _{y,ww,untreated,starch}										
Purpose of the data	Please see COD _{y,ww,untreated,starch}										
Calculation method	-										
Comments	Please see COD _{y,ww,untreated,starch}										

Data / Parameter	COD _{y,ww,untreated,Ethanol}										
Data unit	mg/l										
Description	COD of wastewater from ethanol plant : CS3										
Source of data	Measured – Titrimetric analysis										
Description of measurement methods and procedures to be applied	Monitoring: Closed reflux titrimetric method in the onsite laboratory of the treatment plant. Sample was be taken from the outlet of wastewater from ethanol plant before entering CL3. Data type: Records in both hard and soft files.										
Frequency of monitoring/recording	Frequency: Daily basis Recording : Daily records										
Value monitored:	<table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value (mg/l)</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>01/01/2018 to 31/12/2018</td><td>49,308</td><td>54,283</td></tr></table>			Monitoring period	Value (mg/l)		Lower	Higher	01/01/2018 to 31/12/2018	49,308	54,283
Monitoring period	Value (mg/l)										
	Lower	Higher									
01/01/2018 to 31/12/2018	49,308	54,283									
Monitoring equipment	n/a										
QA/QC procedures to be applied	Please see COD _{y,ww,untreated,starch}										
Purpose of the data	Please see COD _{y,ww,untreated,starch}										
Calculation method	-										
Comments	Please see COD _{y,ww,untreated,starch}										

Data / Parameter	COD _{y,ww,treated,CL2}		
Data unit	mg/l		
Description	COD of wastewater exiting the covered lagoon 2 treatment process : CS4		
Source of data	Measured – Titrimetric analysis		
Description of measurement methods and procedures to be applied	Monitoring: Closed reflux titrimetric method in the onsite laboratory of the treatment plant. Sample was be taken from the outlet of CL2 before entering the open lagoons. Data type: Records in both hard and soft files.		
Frequency of monitoring/recording	Frequency: Daily basis Recording: Daily records		
Value monitored:	Monitoring period	Value (mg/l)	
		Lower	Higher
	01/01/2018 to 31/12/2018	9,099	11,044
Monitoring equipment	n/a		
QA/QC procedures to be applied	Please see COD _{y,ww,untreated,starch}		
Purpose of the data	Please see COD _{y,ww,untreated,starch}		
Calculation method	-		
Comments	Please see COD _{y,ww,untreated,starch}		

Data / Parameter	COD _{y,ww,treated,CL3}		
Data unit	mg/l		
Description	COD of wastewater exiting the covered lagoon 3 treatment process : CS5		
Source of data	Measured – Titrimetric analysis		
Description of measurement methods and procedures to be applied	The monitoring of this parameter is in line with deviation 1 in section 2.2.2 above. Monitoring: Closed reflux titrimetric method in the onsite laboratory of the treatment plant. Sample was be taken from the outlet of CL3. Data type: Records in both hard and soft files.		
Frequency of monitoring/recording	Frequency: Daily basis Recording: Daily records		
Value monitored:	Monitoring period	Value (mg/l)	
		Lower	Higher
	01/01/2018 to 31/12/2018	3,780	6,190

Monitoring equipment	n/a
QA/QC procedures to be applied	Please see COD _{y,ww,untreated,starch}
Purpose of the data	Please see COD _{y,ww,untreated,starch}
Calculation method	-
Comments	Please see COD _{y,ww,untreated,starch}

Data / Parameter	W _{CH4}																
Data unit	%																
Description	Methane content in biogas																
Source of data	Measured by online gas analyzer																
Description of measurement methods and procedures to be applied	Monitoring: Online methane analyzer Data type: Records in both hard and soft files																
Frequency of monitoring/recording	Frequency: Continuous measurement Recording: Daily records.																
Value monitored:	<table border="1"> <thead> <tr> <th>Monitoring period</th><th>Value (%)</th></tr> </thead> <tbody> <tr> <td>01/01/2018 to 31/12/2018</td><td>53%</td></tr> </tbody> </table>	Monitoring period	Value (%)	01/01/2018 to 31/12/2018	53%												
Monitoring period	Value (%)																
01/01/2018 to 31/12/2018	53%																
Monitoring equipment	<table border="1"> <tr> <td>Meter name</td><td>MS02</td></tr> <tr> <td>Serial Number</td><td>96159</td></tr> <tr> <td>Brand</td><td>UNION</td></tr> <tr> <td>Model</td><td>INCA 4002 T099-01</td></tr> <tr> <td>Accuracy</td><td>1%</td></tr> <tr> <td>Calibration Frequency</td><td>1 / 3 years</td></tr> <tr> <td>Calibration Date</td><td>14/03/2017</td></tr> <tr> <td>Validity</td><td>13/03/2020</td></tr> </table>	Meter name	MS02	Serial Number	96159	Brand	UNION	Model	INCA 4002 T099-01	Accuracy	1%	Calibration Frequency	1 / 3 years	Calibration Date	14/03/2017	Validity	13/03/2020
Meter name	MS02																
Serial Number	96159																
Brand	UNION																
Model	INCA 4002 T099-01																
Accuracy	1%																
Calibration Frequency	1 / 3 years																
Calibration Date	14/03/2017																
Validity	13/03/2020																
QA/QC procedures to be applied	Periodic calibrations (generally once in three years) for methane analyser are ensured via an external agency according to national or international standard.																
Purpose of the data	Calculation of project emissions																
Calculation method	-																
Comments	-																

Data / Parameter	BG _{combusted,y}
Data unit	Nm ³
Description	Amount of biogas combusted for gainful use in the year y
Source of data	Measured - Biogas flow meters : GM1,GM2

Description of measurement methods and procedures to be applied	Measurements of volume of biogas sent to boilers are done continuously using gas flow meters. The gas flow meters are installed and values recorded regularly by skilled employees. In recording this parameter, plant's operators shall first manually archive the monitored data onto log sheets then transfer to the computer for electronic storage.																																								
Frequency of monitoring/recording	The data achievement is done on a daily basis.																																								
Value monitored:	<table border="1"> <tr> <th>Monitoring period</th><th>Value (Nm³)</th></tr> <tr> <td>01/01/2018 to 31/12/2018</td><td>8,355,426</td></tr> </table>	Monitoring period	Value (Nm ³)	01/01/2018 to 31/12/2018	8,355,426																																				
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01/01/2018 to 31/12/2018	8,355,426																																								
Monitoring equipment	<table border="1"> <tr> <td>Meter name</td><td>GM1_(starch-boilers)</td></tr> <tr> <td>Serial Number</td><td>503208</td></tr> <tr> <td>Brand</td><td>FCI</td></tr> <tr> <td>Model</td><td>ST51</td></tr> <tr> <td>Accuracy</td><td>2%</td></tr> <tr> <td>Calibration Frequency</td><td>1 / 3 years</td></tr> <tr> <td>Calibration Date</td><td>20/12/2017</td></tr> <tr> <td>Validity</td><td>19/12/2020</td></tr> </table> There are two GM2 meters in this monitoring period, please see the detail of the meters below. <table border="1"> <tr> <td>Meter name</td><td>GM2_(turbine generator)</td></tr> <tr> <td>Serial Number</td><td>630166</td></tr> <tr> <td>Brand</td><td>FCI</td></tr> <tr> <td>Model</td><td>ST51</td></tr> <tr> <td>Accuracy</td><td>2%</td></tr> <tr> <td>Calibration Frequency</td><td>1 / 3 years</td></tr> <tr> <td>Calibration Date</td><td>20/12/2017</td></tr> <tr> <td>Validity</td><td>19/12/2020</td></tr> <tr> <td>Installation period</td><td>The meter was detached on 08/10/2018.</td></tr> </table> The new GM2 meter with the same model has been replaced the old one on 08/10/2018 to present. <table border="1"> <tr> <td>Meter name</td><td>GM2_(turbine generator)</td></tr> <tr> <td>Serial Number</td><td>630165</td></tr> <tr> <td>Brand</td><td>FCI</td></tr> </table>	Meter name	GM1 _(starch-boilers)	Serial Number	503208	Brand	FCI	Model	ST51	Accuracy	2%	Calibration Frequency	1 / 3 years	Calibration Date	20/12/2017	Validity	19/12/2020	Meter name	GM2 _(turbine generator)	Serial Number	630166	Brand	FCI	Model	ST51	Accuracy	2%	Calibration Frequency	1 / 3 years	Calibration Date	20/12/2017	Validity	19/12/2020	Installation period	The meter was detached on 08/10/2018.	Meter name	GM2 _(turbine generator)	Serial Number	630165	Brand	FCI
Meter name	GM1 _(starch-boilers)																																								
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Brand	FCI																																								

	Model	ST51
	Accuracy	2%
	Calibration Frequency	1 / 3 years
	Calibration Date	12/11/2018
	Validity	11/11/2021
	Installation period	The meter was installed on 08/10/2018 to present.
QA/QC procedures to be applied	The gas flow meter shall be subjected to periodic calibration once in three years according to the equipment's specifications and applicable industrial standards.	
Purpose of the data	Calculation of baseline emissions	
Calculation method	-	
Comments	The calibration gap of GM2 is found during this monitoring period. The equipment accuracy class of 2.0% has been applied to the monitored data during 08/10/2018 to 12/11/2018. Please see ER calculation file for more information.	

Data / Parameter	EC _y				
Data unit	MWh				
Description	Electricity consumption by wastewater treatment system and biogas plant in year y				
Source of data	Maximum rated consumption is calculated by multiplying total electrical capacity with 8,760 hours and 10% additional factor to be conservative.				
Description of measurement methods and procedures to be applied	Calculation based on maximum rated consumption is conducted in a conservative manner (as per paragraph 35 in AMS III. H., version 13).				
Frequency of monitoring/recording	-				
Value monitored:	<table border="1"> <tr> <th>Monitoring period</th><th>Value (MWh)</th></tr> <tr> <td>01/01/2018 to 31/12/2018</td><td>2,361</td></tr> </table>	Monitoring period	Value (MWh)	01/01/2018 to 31/12/2018	2,361
Monitoring period	Value (MWh)				
01/01/2018 to 31/12/2018	2,361				
Monitoring equipment	-				
QA/QC procedures to be applied	In the absence of electric meter for the electricity consumption of project activity, maximum rated consumption shall be used to calculate the emissions from PE _{power, y} . Since this approach has taken into account the distribution losses of 10% and the calculation is based on an assumption that the electrical appliances are running at full capacity for 8,760 hours per year, the QA/QC aspect has already been assured.				
Purpose of the data	Calculation of project emissions				

Calculation method	-
Comments	-

3.3 Monitoring Plan

1. Monitoring management

The project hires people to operate the biogas generation and utilization plants. The required monitoring equipment are installed by the technology provider who are in consultation with the equipment suppliers and under the supervision of the managing director as well as the Environmental Officer and Consulting. Flow meters are to be calibrated generally on once in three years basis using recognized procedures and sampling is carried out by onsite staffs according to appropriate industrial standards.

Data acquisition from the gas and wastewater flow meters are executed through log- book system and record by on-site operators, while COD of wastewater at sampling point is daily monitored and reported by on-site environmental laboratory.

The collected data must be approved and supervised by the Environmental Officer who is in charge of data processing.

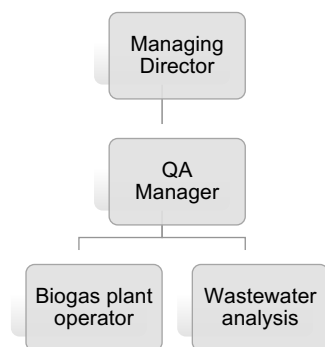


Figure 4 : Organization Chart

2. Quality Assurance and Quality Control

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

3. On-site procedures

Plant performance is recorded daily in log sheets and later stored in electronic format for periodic download onsite or remote transfer for further processing. In terms of procedures for calibration of equipment, the Environmental Officer would contact the third party to carry out calibration according to international standards. Note that the Environmental Officer is responsible for executing timely calibration as per the specification from the equipment supplier or at least once in three years.

4. Data storage and filing – Electric Workbook

All relevant data is stored electronically in computer. A daily record is kept. All parameters monitored under the monitoring plan are kept for a period of two years following the end of the crediting period or the last issuance of VERs for the project activity, whichever occurs later.

5. Emergency preparedness

The project activity does not result in any unidentified activity that can result in substantial emissions from the project activity.

However, the leakages, if any, in the piping or digester shall come under notice of plant operator either during regular monitoring of data parameters, else at the time of data logging, due to mismatch between expected biogas generation from wastewater quantities processed or other way around.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

Baseline emissions for AMS III.H

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

Where:

Parameter	Details	Quantification
BE_y	Baseline emission in year y (tCO ₂ e)	01/01/2018 to 31/12/2018 = 152,127
$BE_{power,y}$	Baseline emission from electricity or fuel consumption in year y (tCO ₂ e)	01/01/2018 to 31/12/2018 = 0
$BE_{ww,treatment,y}$	Baseline emission of the wastewater systems affected by the project activity in year y (tCO ₂ e)	01/01/2018 to 31/12/2018 = 152,127
$BE_{s,treatment,y}$	Baseline emissions of the sludge treatment systems affected by the project activity in year y (tCO ₂ e)	01/01/2018 to 31/12/2018 = 0
$BE_{ww,discharge,y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y (tCO ₂ e).	01/01/2018 to 31/12/2018 = 0
$BE_{s,final,y}$	Baseline methane emissions from anaerobic decay of the final sludge produced in year y (tCO ₂ e). If the sludge is controlled combusted, disposed in a landfill with biogas recovery, or used for soil application in the baseline scenarios, this term shall be neglected.	01/01/2018 to 31/12/2018 = 0

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

$$BE_{ww,treatment,y} = \sum Q_{ww,i,y} * COD_{removed,i,y} * MCF_{ww,treatment,BL,I} * B_{o,ww} * UF_{BL} * GWP_{CH4}$$

Where:

Parameter	Details	Quantification
$BE_{ww,treatment,y}$	Baseline emission of the wastewater systems affected by the project activity in year y (tCO ₂ e)	01/01/2018 to 31/12/2018 = 152,127
$Q_{ww,i,y}$	Volume of wastewater treated in baseline wastewater treatment system i in year y. (m ³)	01/01/2018 to 31/12/2018 = 1,664,815
$COD_{removed,i,y}$	Chemical oxygen demand removed by baseline treatment system i in year y (tonnes/m3), measured as the difference between inflow COD and the outflow COD in system i	COD _{removed,i,y,starch} 01/01/2018 to 31/12/2018 = 0.02 COD _{removed,i,y,sweetener} 01/01/2018 to 31/12/2018 = 0.02

Parameter	Details	Quantification
		COD _{removed, i, y, ethanol} 01/01/2018 to 31/12/2018 = 0.05
MCF _{ww, treatment, BL, i}	Methane correction factor for baseline wastewater treatment systems i (MCF values as per table III.H.1)	0.8
i	Index for baseline wastewater treatment system	1
B _{o, ww}	Methane producing capacity of the wastewater (IPCC lower value of 0.21 kg CH ₄ /kg COD)	0.21
UF _{BL}	Model correction factor to account for model uncertainties	0.94
GWP _{CH₄}	Global warming potential for methane	25

According to the paragraph 31 AMS-III.H version 13.0 emission reduction achieved by the project activity is limited to the ex-post calculated baseline emissions minus project emission using the actual monitored data for the project activity. The emission reductions achieved in any year are the lowest value of the following:

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

As per paragraph 32 in AMS III.H. version 13.0, in case of flaring/combustion, MD_y was measured using the conditions of the flaring process:

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

Where:

Parameter	Details
BG _{burnt, y}	Biogas volume in year y (m ³)
W _{CH₄}	Methane content in the biogas in the year y (mass fraction)
D _{CH₄}	Density of methane at the temperature and pressure of the biogas in the year y (tonnes/m ³)
FE	Flare efficiency in year y (fraction)

As per the registered VCS PD, the alternative MD_y value is deviated from the approved methodology and can be calculated as follows:

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

Where:

Parameter	Details	Quantification
MD _y	Methane captured and destroyed/gainfully used by the project activity in the year y (tCO _{2e})	01/01/2018 to 31/12/2018 = 79,595

Parameter	Details	Quantification
$W_{CH_4, y}$	Methane content in the biogas in the year y (mass fraction)	01/01/2018 to 31/12/2018 = 53.22%
D_{CH_4}	Density of methane at the temperature and pressure of the biogas in the year y (kg/m ³)	0.716
GWP_{CH_4}	Methane producing capacity of the wastewater	25
$BG_{Flare, y}$	Biogas sent to flared in year y (Nm ³)	01/01/2018 to 31/12/2018 = 0
$BG_{combusted, y}$	Biogas volume in year (consumption for gainful use) (Nm ³)	01/01/2018 to 31/12/2018 = 8,355,426
DE	Destruction efficiency of biogas combusted for a gainful propose	100%

4.2 Project Emissions

Project activity emissions from the systems affected by the project activity are:

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

(Equation 4)

Where :

PE_y	Project activity emission in year y (tCO ₂ e)
$PE_{power, y}$	Emission from electricity or fuel consumption in year y (tCO ₂ e)
$PE_{ww, treatment, y}$	Methane emission from the wastewater systems affected by the project activity and not equipped with biogas recovery , in year y (tCO ₂ e)
$PE_{s, treatment, y}$	Methane emissions from sludge treatment systems affected by the project activity and not equipped with biogas recovery , in year y (tCO ₂ e)
$PE_{y, ww, discharge}$	Methane emissions from degradable organic carbon in treated wastewater in year y (tCO ₂ e).
$PE_{s, final, y}$	Methane emissions from anaerobic decay of the final sludge produced in year y (tCO ₂ e).
$PE_{fugitive, y}$	Methane emissions from biogas release in capture systems in year y (tCO ₂ e).
$PE_{flaring, y}$	Methane emissions due to incomplete flaring in year y (tCO ₂ e).
$PE_{biomass, y}$	Methane emissions from biomass stored under anaerobic conditions in year y (tCO ₂ e).

Parameter	Details	Quantification
PE_y	Project activity emissions in year y (tCO ₂ e)	01/01/2018 to 31/12/2018 = 97,654
$PE_{power, y}$	Emissions from electricity or fuel consumption in year y (tCO ₂ e).	01/01/2018 to 31/12/2018 = 1,194
$PE_{ww, treatment, y}$	Methane emissions from the wastewater treatment systems affected by the project activity and not equipped with biogas recovery in year y (tCO ₂ e)	01/01/2018 to 31/12/2018 = 77,405
$PE_{s, treatment, y}$	Methane emissions from sludge treatment systems affected by the project	01/01/2018 to 31/12/2018 = 0

Parameter	Details	Quantification
	activity and not equipped with biogas recover, in year y (tCO _{2e})	
PE _{y,ww,discharge}	Methane emissions from degradable organic carbon in treated wastewater in year y (tCO _{2e}).	01/01/2018 to 31/12/2018 = 0
PE _{s,final,y}	Methane emissions from anaerobic decay of the final sludge produced in year y (tCO _{2e}).	01/01/2018 to 31/12/2018 = 0
PE _{fugitive, y}	Methane emission from biogas release in capture system in year y (tCO _{2e})	01/01/2018 to 31/12/2018 = 14,882
PE _{flaring, y}	Methane emission due to incomplete flaring in year y (tCO _{2e}).	01/01/2018 to 31/12/2018 = 0
PE _{biomass,y}	Methane emissions from biomass stored under anaerobic conditions in year y (tCO _{2e}).	01/01/2018 to 31/12/2018 = 0

Project Emissions from electricity or fuel consumption in year y (tCO_{2e}); PE_{power, y}

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

Emissions from electricity consumption by the project activity facilities are calculated according to the paragraphs 26 and 19 of AMS III.H. as determined per the procedures described in AMS-I.D. The energy consumption shall include all equipment/devices in the baseline wastewater and sludge treatment facility. The following formula is used:

$$PE_{power,y} = EF_y * EC_y$$

Where:

Parameter	Details
EC _y	Electricity consumption by the project activity (MWh)
EF _y	Thailand National Grid emission factor (tCO _{2e} /MWh)

In the absence of electric meter for the electricity consumption of project activity, maximum rated consumption shall be used to calculate the emissions from PE_{power} as per prescribed method in paragraph 35 of AMS III.H., as follows:

$$PE_{Power,y} = \frac{\sum P_{el} * 110\% * 8,760 * EF_y}{1000}$$

Where:

Parameter	Details
P _{el}	Total electrical capacity of the equipments installed in the project activity (kW) – 245.1 kW as per list of auxiliary equipment submitted during project validation was used for this monitoring period.
EF _y	Thailand National Grid emission factor (tCO _{2e} /MWh)

Taking into account the distribution losses, 10% has been added to the total electricity consumption. As well, the calculated electricity consumption is based on an assumption that the electrical appliances will be running at full capacity for the entire year.

Parameter	Unit	2018
EC _y	MWh	2,361

EF _y	tCO ₂ e/MWh	0.5057
PE _{power, y}	tCO ₂ e	1,194.16

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

Methane emissions from wastewater treatment systems affected by the project activity are calculated as per the paragraph 20, AMS III.H. The following equation is used.

$$PE_{ww,treatment,y} = Q_{ww,y} * COD_{removed,PJ,lagoon,y} * MCF_{ww,treatment,PJ,lagoon} * B_{o,ww} * UF_{PJ} * GWP_{CH4}$$

It is assumed that all COD from the effluent of the second covered lagoon (CL2) is degraded. This is conservative regarding the project emissions.

Where:

Parameter	Details
Q _{ww,k,y}	Volume of wastewater treated in project wastewater treatment system <i>k</i> in year <i>y</i> (m ³)
COD _{removed, PJ, lagoon,y}	Chemical oxygen demand removed by project secondary wastewater treatment system in year <i>y</i> (tonnes/m ³), calculated as COD _{inflow,lagoon(CS4)} minus COD _{outflow,lagoon(CS5)}
B _{o,ww}	Methane producing capacity of the wastewater (IPCC default value of 0.21 kg CH ₄ /kg COD)
MCF _{ww, treatment, PJ, lagoon}	Methane correction factor for project wastewater treatment system without biogas recovery
UF _{PJ}	Model correction factor to account for model uncertainties (1.06)
GWP _{CH4}	Global Warming Potential for methane (value of 25 is used)
k	Wastewater treatment systems affected by the project activity, and not equipped with biogas recovery; k= lagoon

Parameter	Unit	2018
Q _{ww, l, y} * COD _{y,removed,pj,k}	tonnes	17,387
MCF _{ww, treatment, PJ, k}	-	0.8
B _{o, ww}	kg CH ₄ /kg COD	0.21
UF _{PJ}	-	1.06
GWP _{CH4}	-	25
PE _{ww,treatment,y}	tCO ₂ e	77,405.95

Project emission from biogas release in capture system in year y (tCO₂e); PE_{fugitive, y}

Project activity emissions from methane release in capture systems are determined as per paragraph 26 of AMS III.H., as given below.

$$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y}$$

Where:

Parameter	Details
$PE_{y, \text{fugitive ww}}$	Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment in the year y (tCO _{2e})
$PE_{y, \text{fugitive, s}}$	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y (tCO _{2e})

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

These emissions are calculated as follows

$$PE_{\text{fugitive, ww}, y} = (1 - CFE_{\text{ww}}) * MEP_{\text{ww, treatment}, y} * GWP_{CH4}$$

Where:

Parameter	Details
CEF_{ww}	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems (a default value of 0.9 shall be used)
$MEP_{y, \text{ww, treatment}}$	Methane emission potential of wastewater treatment systems equipped with biogas recovery system in year y (tonnes)

Note that:

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

Parameter	Details
$COD_{\text{removed, PJ, k}, y}$	The chemical oxygen demand removed ³ by the treatment system k of the project activity equipped with biogas recovery in the year y (tonnes/m ³) calculated as: For $k = CL_2$: $COD_{\text{removed, PJ, CL}_2, y} = COD_{\text{load, ww, untreated, y, starch/ sweetener / ethanol}} - COD_{\text{loadout, PJ, CL}_2, y}$
$MCF_{\text{ww, treatment, PJ, UASB}}$	Methane correction factor for the project wastewater treatment system equipped with biogas recovery equipment (UASB) (MCF values as per table III.H.1)
UF_{PJ}	Model correction factor to account for model uncertainties (1.06)
k	Anaerobic wastewater treatment system equipped with biogas recovery. $k = CL_1, UASB, \& CL_2$

³ Difference of inflow COD and the outflow COD

Parameter	Unit	2018
$Q_{ww, l, y} * COD_{y, removed, pj, k}$	tonnes	32,799.88
$CEF_{ww, y}$		0.90
$MEP_{ww, treatment, y}$	tonnes	5,841.00
GWP_{CH4}	-	25.00
$PE_{fugitive, ww, y}$	tCO ₂ e	14,602.51

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

Sludge will be used only for land application, therefore no sludge treatment envisaged in the project activity. Therefore emission from sludge treatment is omitted.

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

No biogas will be flared, since the capacity of the 6 steam boilers and of the hot oil boiler is higher than the maximum generation capacity of the wastewater treatment plant. This has also been accepted during validation and previous verification.

4.3 Leakage

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

4.4 Net GHG Emission Reductions and Removals

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

Where:

$ER_{y, ex\ post}$	Emission reductions achieved by the project activity based on monitored values for year y (tCO ₂ e)
$BE_{y, ex\ post}$	Baseline emission calculated as per paragraph ex-post monitored values
$PE_{y, ex\ post}$	Project emission calculated as per paragraph ex-post monitored values
MD_y	Methane captured and destroyed/gainfully used by the project activity in year y

Justification for the increasing of emission reductions in this monitoring period

The increasing emission reduction in this monitoring period, comparing to the estimated value of 36,973 tCO₂e annually, is mainly from the higher quantity of wastewater entering the system. During on site verification, project owner has claimed that cassava roots themselves have higher water content in them. Another reason is from 75% conservative value had been applied to the ex-ante calculation during validation.

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)
01/01/2018 to 31/12/2018	152,127	93,203	0	58,924
Total	152,127	93,203	0	58,924

APPENDIX 1: ADDITIONAL INFORMATION

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