

MONITORING REPORT OF CHOL CHAROEN GROUP WASTEWATER TREATMENT WITH BIOGAS SYSTEM I (CHOLBURI)



Document Prepared By South Pole Carbon Asset Management Ltd.

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

Chol Charoen Group Wastewater Treatment with Biogas System I (Cholburi), hereafter 'the project activity', involves the installation and operation of a biogas recovery and utilization system (an open anaerobic effluent treatment system) at Chol Charoen Co. Ltd., a tapioca starch factory in Cholburi, Thailand. The system has been in operation since 7th January 2006 (project start date).

This starch factory has a design daily production capacity of 240 tonnes of dried starch, generating 2,400 m³ of wastewater per operational day. Under the previous system, wastewater released from the plant was treated in 13, cascading, open anaerobic lagoons. With the depth of these ponds being greater than 2 m from the water surface, and the mean temperature of the area being in the region of 29°C, there is a suitable anaerobic environment within the ponds. Anaerobic bacteria in the ponds break down organic compounds in the wastewater, resulting in the release of biogas. The resulting biogas is characterized by the chemical oxygen demand or COD of the wastewater.

The project activity involves modification of the existing open anaerobic lagoon-based process into a closed anaerobic system for treatment of high organic matter wastewater. This is based on Anaerobic Fixed Film Reactor (AFFR) technology, which is a technology derived from joint research between King Mongkut's University of Technology Thonburi (KMUTT) and the National Centre for Genetic Engineering and Biotechnology (BIOTEC). In addition, three open lagoons at the outlet of the AFFRs were redesigned and converted to covered lagoons in order to 1) increase gas-storage capacity and 2) serve as an emergency wastewater treatment system in case the AFFR system malfunctions.

The implementation of AFFR system enables the recovery of biogas that would have been released to the atmosphere and the utilization of the recovered biogas for thermal and electricity generation. Excess biogas (if any) is sent to the enclosed flare system. The hot oil boiler in the existing plant was originally designed to burn fuel oil for heat generation. Under the project activity, the burner is retrofitted with a combination fuel burner, which allows the boiler to be co-fired using both fuel oil and the biogas collected from the reactors. The power produced by the captured biogas augments the electricity requirement of the plant and may, in the future, be fed to the national grid, under the pending power purchase agreement with the Provincial Electricity Authority (PEA). With such utilization of biogas, the project activity achieves GHG emission reduction through avoidance of methane being released to the atmosphere, and also through reduction of fossil fuel consumption (with fuel oil and grid electricity being displaced).

As per the VCS's guideline, the project is verified against the VCS standard. Further background information on the project activity can be found in the VCS Project Design Document (PDD), which has been registered and available on the V-C-S under project number 430 as well as the combined Voluntary Validation and Verification:

<https://vcsprojectdatabase1.apx.com/mymodule/ProjectDoc/EditProjectDoc.asp?id1=430>.

This is the first verification for the second crediting period of this project. The total GHG emission reductions generated in this monitoring period are 29,796 tCO₂e.

1.2 Sectoral Scope and Project Type

The project activity involves recovery of biogas from the wastewater released from tapioca starch processing plant. The recovered biogas is used in a boiler to generate heat for the starch drying process and used to generate electricity in order to meet the power requirement of the starch processing plant and supplied to national-owned grid. After satisfying the above demands, surplus biogas is flared for safety purpose. The project has a total electrical generation capacity of less than 15 MWe_l, thermal generation capacity less than 45 MW_{th} and will generate emission reductions less than 60 ktCO₂e per year. The type/category of the project 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: 18

Electricity generation component:

Type III: Renewable energy projects
 Category III.H: Grid connected renewable electricity generation
 Sectoral Scope 1: Energy industries (renewable/non-renewable sources)
 Version: 18

Fuel replacement component:

Type III: Renewable energy projects
 Category III.H: Thermal energy production with or without electricity
 Sectoral Scope 1: Energy industries (renewable/non-renewable sources)
 Version: 20

The project is not a grouped project.

1.3 Project Proponent

Organization name	Chol Charoen Co.,Ltd
Contact person	Narin Kajohnchalernsak
Title	Mr.
Address	1004/200 Rama3 Road , Bangpongpan , Yannawa
Telephone	Bangkok 10120
Email	+66 2 294 5315-6

1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon Asset Management Ltd.
Role in the project	Carbon consultant
Contact person	Santosh Kumar Singh
Title	Mr.
Address	Technoparkstrasse 1 , Zurich , Switzerland 8005
Telephone	+66 2 678 8979
Email	registration@southpole.com

1.5 Project Start Date

Project start date is 07/01/2006, (the date when emission reduction began). This is the date on which retrofitted hot oil boiler become operational with the utilization of biogas.

1.6 Project Crediting Period

The second crediting period start from 01/01/17 to 31/12/26.

1.7 Project Location

The proposed project activity is located at Chol Charoen Co., Ltd., in Banbung district, Cholburi province. It is approximately 250 km away from Bangkok. The project activity location is depicted in **Figure 1** and **Figure 2**.

Street address: 204 Moo 3 Nongchak, Banbung, Cholburi, 20170, Thailand.

Geographic coordinates: 13° 17.736'N latitude 101° 09.108'E longitude



Figure 1 : Project Location



Figure 2 : Project Boundary

1.8 Title and Reference of Methodology

The approved CDM methodologies are 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:	18

Electricity generation component:

Type III:	Renewable energy projects
Category III.H:	Grid connected renewable electricity generation
Sectoral Scope 1:	Energy industries (renewable/non-renewable sources)
Version:	18

Fuel replacement component:

Type III:	Renewable energy projects
Category III.H:	Thermal energy production with or without electricity
Sectoral Scope 1:	Energy industries (renewable/non-renewable sources)
Version:	20

1.9 Other Programs

The project is not registered under any other mechanism and that the project proponent will not claim the carbon credits under any other GHG emission reduction scheme.

1.10 Sustainable Development

The project activity contributes the sustainable development in more than one way.

Technical:

The advanced biogas reactor system, AFFR, is implemented for reusing biogas as fuel for heat and electricity generation. As compared to the baseline scenario, the installed wastewater treatment system consists of a highly efficient process for wastewater treatment based on well-researched technology from two very respectable institutions in Thailand (Biotech and KMUTT University), which brings about the promotion of new technology in Thailand with replication options.

The anaerobic digester requires special training of skilled staff to operate and maintain the plant, creating employment and leading to knowledge transfer to the Eastern region of the country. The use of this technology in wastewater treatment by the project owner will popularize the technological knowhow in the nearby areas and in plants looking for similar technologies in the country. Also, this locally produced equipment (as well as other associated technologies) may be put to use in other parts of Thailand for similar purposes.

Economic:

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

Sectoral:

The use of CDM approved methodology will be applied under the framework of VCS; this is a good example of an effective waste to energy project which in turn improve 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, as well as during operation. During construction, employment was offered for a lot of local unskilled labours contributing to social well being and economic well being. The involvement of local employees in the project activity will help to enhance the skill of the labours 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 the local stakeholders.

The substitution of fuel oil with biogas from the project activity will result in increased availability of these fuels in the local market. 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 will be sufficiently addressed.

Environment:

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. In fact, the biogas reactor system allows the starch factory to recycle the treated effluent in a starch production process; this constitutes sustainability in water supply while ensuring that groundwater shortage should not be a problem for local community. It must be mentioned that the project activity has zero discharge to the river or other natural sources such as soils and groundwater. 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. As can be seen from Figure 2, under Section 1.5, the starch plant and the pond systems are surrounded by agricultural land. Wastewater overflow can lead to a variety of problems that have significant environmental impacts. Excess nutrients in the wastewater will 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 will be significantly reduced. Overall, the project will have 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.

Geographic/site specific:

The project can be uniquely identified with no barriers regarding logistic. In addition, it is not located in sensitive area such as protected area or where there is any fragile or vulnerable habitats close by. Thus, there are no issues preventing the eligibility of the project in this regard.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The monitoring period for this report is from 01/01/17 to 31/12/17, both days are included.

- From the higher quantity of biogas produced, the excess electricity generated from internal consumption is exported to national grid.
- There is no monitored data during the yearly shutdown period of the starch factory. The shutdown schedule is depended on the situation of cassava roots supply.
- The boiler no.2 has been installed at the project site as spare for the boiler no.1 is not included in the project boundary and the emission reduction calculation.
- There is no change or modification in biogas plant occurred in this monitoring period.

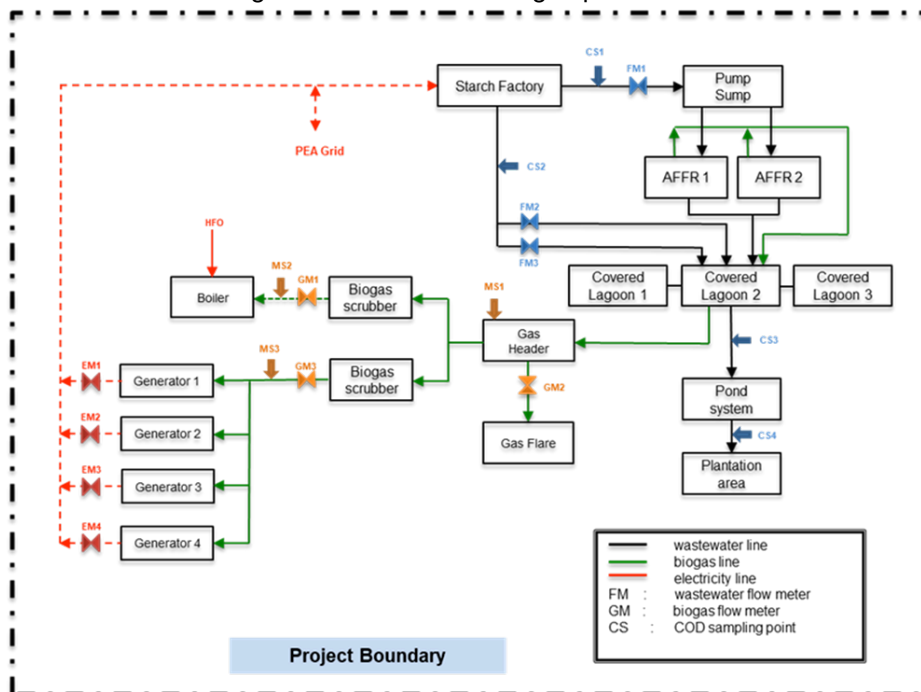


Figure 3: Monitoring diagram of this period

2.2 Deviations

2.2.1 Methodology Deviations

There are methodology deviations stated in the registered PD, to be applied for the whole crediting period.

Methodology and formula that is deviated

Baseline emissions for estimating the fossil fuel replaced. The latest version of methodology AMS I.C., requires monitoring of the fuel that would have been consumed in the absence of the project activity.

Deviated approach or formula

The project proponent uses a conservative approach, based on amount of heat required for starch drying, which in turn is estimated on heat requirements per tonne of starch when only fuel oil was used. The approach compensates the fuel oil usage from total fuel oil requirement (in baseline) and conservatively estimates the fuel oil replaced by methane. Irrespective of quantity of methane burnt.

Justification for deviation

Due to incompleteness of the monitoring equipment, a deviation has been made to the approach specified in methodology AMS I.C. The deviated approach ensures that efficiency lost in system due to dual fired system is conservatively adjusted in baseline emissions. This means that if any efficiency loss happens due to dual fired system and the energy of same is supplied by fuel oil, using the given approach the loss is accounted in biogas usage, thereby estimating lower fuel oil replacement for baseline emission estimation. In addition, the approach does not have any negative impact on additionality of the project.

With reference to the clarification made by the SSC WG, this approach can be considered as not impact negatively on the conservativeness of the applied methodology's criteria and procedures to quantify data leading to GHG emission reductions or removals. The clarification from EB, as referenced above, can be used to substantiate this statement.

2.2.2 Project Description Deviations

There is no PD deviations proposed in this monitoring period.

2.3 Grouped Project

The 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

Place and date of meeting

Stakeholder consultation was held at a meeting room of Chol Charoen Co., Ltd. (in Choburi) on 24 July 2008. Participants were able to examine the location where the proposed project will take place.

Meeting participants

Participants in this meeting are local residents who live within 5 km from the project location. They include local government officers, local shopkeepers, among others.

Language

Documentation and meeting were conducted in Thai (local language)

Meeting procedures

- Purpose of consultation
- Description of the project and its environmental impacts
- Description of VCS
- General feedback

Meeting documents and protocols

Registration was held prior to the meeting. During the meeting, relevant documents for project description, environmental impacts and the effects on sustainable development were delivered to all participants. On completion of the meeting, the following documents were collected and attested with signatures of the stakeholders attended:

- Presence list with name, address and occupation
- Non-technical description of the project
- Documents on environmental impacts of the project

These documents are available in hard copies and can be shown to the Designated Operational Entity (DOE) during validation process.

Summary of the comments received

After the presentations, participants were afforded the opportunity to ask questions regarding the project activity. The overall response to the project was encouraging and positive to local environment and social-economic conditions i.e. the stakeholders appreciate the wastewater treatment in a more efficient way in which irritable odour can be avoided while creating new jobs. In all, no adverse reactions, comments, or clarifications were received during the Stakeholder Consultation process. The project participants did not recognize any need to make changes to the project design or monitoring plan.

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 for methane
Source of data	Global warming potential for CH ₄ valid for the relevant commitment period
Value applied	25
Justification of choice of data or description of measurement methods and procedures applied	As per Annex 1 - clause 5 of VCS standard version 3.7, "Project shall transition to the updated GWP at their project crediting period renewal."
Purpose of Data	Calculation of baseline and project emissions
Comments	-

Data / Parameter	B _{o,ww}
Data unit	kg CH ₄ /kg COD
Description	Methane producing capacity of the wastewater
Source of data	IPCC default value as per methodology AMS III-H version 18
Value applied	0.25
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of baseline and project emissions
Comments	-

Data / Parameter	UF _{BL}
Data unit	-
Description	Model correction factor to account of model uncertainties
Source of data	AMS-III.H version 18
Value applied	0.89
Justification of choice of data or description of measurement methods and procedures applied	Default value from AMS-III.H version 18
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	UF _{PJ}
Data unit	-
Description	Model correction factor to account of model uncertainties
Source of data	AMS-III.H version 18
Value applied	1.12
Justification of choice of data or description of measurement methods and procedures applied	Default value from AMS-III.H version 18
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	MCF _{ww,treatment,BL,i}
Data unit	-
Description	Methane correction factor for the baseline anaerobic wastewater treatment system j
Source of data	Table 2 from AMS-III.H, Version 18, IPCC default values
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	The baseline wastewater treatment system consists of a succession of anaerobic deep lagoons (depth more than 2 metres) therefore the MCF value is chosen as 0.8
Purpose of Data	Calculation of baseline emissions
Comments	IPCC Default values from chapter 6 of volume 5. 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 anaerobic wastewater treatment system k
Source of data	Table 2 from AMS-III.H, Version 18, IPCC default values
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	The project wastewater treatment system without biogas recovery (secondary treatment) consists in a succession of deep lagoons, with depth more than 2 metres, so the value of 0.8 has been chosen.
Purpose of Data	Calculation of project emissions
Comments	IPCC Default values from chapter 6 of volume 5. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

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

Data / Parameter	$\eta_{COD,BL,i}$
Data unit	%
Description	COD removal efficiency of the baseline system i
Source of data	Measurement campaign in the baseline wastewater system for 12 samples
Value applied	87% - Used for ex-ante estimation of baseline emissions.
Justification of choice of data or description of measurement methods and procedures applied	The COD removal efficiency is based, on COD values for baseline system before implementation of project activity. The COD reduction across the baseline treatment system is multiplied by a factor of 0.89 for conservative estimation of baseline emissions. Actual

	reduction across the system is approximately 98.1% ¹ .					
	Sample No.	Parameters	Unit	COD inlet	COD outlet	%COD removal
	1	COD	mg/L	24,773	278	98.8778
	2	COD	mg/L	23,912	472	98.0261
	3	COD	mg/L	21,173	381	98.2005
	4	COD	mg/L	22,917	160	99.3018
	5	COD	mg/L	19,232	162	99.1577
	6	COD	mg/L	18,073	260	98.5614
	7	COD	mg/L	24,168	466	98.0718
	8	COD	mg/L	23,987	397	98.3449
	9	COD	mg/L	20,736	735	96.4554
	10	COD	mg/L	25,827	486	98.1182
	11	COD	mg/L	25,611	704	97.2512
	12	COD	mg/L	26,976	580	97.8499
Purpose of Data	Calculation of baseline emissions					
Comments	-					

Data / Parameter	EF _{grid,CM,y}
Data unit	tCO ₂ e/MWh
Description	Combined margin CO ₂ emission factor for grid connected power generation in year y
Source of data	A Study on Thailand Grid Emission Factor by Thai DNA
Value applied	0.5637 (Fixed ex-ante)
Justification of choice of data or description of measurement methods and procedures applied	The study of the estimation of grid emission factor is carried out by Thai DNA in accordance with the Methodological Tool: Tool to calculate the emission factor for an electricity system. The choice of data has been detailed in the published study by Thai DNA ² .
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	FE
Data unit	%
Description	Flare efficiency
Source of data	Tool to determine project emissions from flaring gases containing methane.
Value applied	0%
Justification of choice of data or description of measurement methods and procedures applied	Default value for enclosed flare as per Tool to determine project emissions from flaring gases containing methane has been applied.

¹ COD measurement records can be used to substantiate this value. Water analysis reports showing the quality of treated wastewater during pre-project scenario has been submitted to the DOE.

² The latest study in 2017 is available at the time of validation for renewable of crediting period. http://ghgreduction.tgo.or.th/t-ver/images/Grid_Emission_Factor_2559_-_Finalised.pdf

Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	DE
Data unit	%
Description	Destruction efficiency of the electricity generator
Source of data	SSC WG
Value applied	100%
Justification of choice of data or description of measurement methods and procedures applied	According to clarification from SSC WG “in the case that the biogas is combusted for a gainful use of the released energy as in an engine or a power plant, a destruction efficiency of 100% can be used for the portion of biogas that is combusted when applying AMS III.H., i.e. use a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use” ³
Purpose of Data	Calculation of baseline emissions
Comments	As per description of deviation 2.

Data / Parameter	EF _{CO₂,i,y}
Data unit	tCO ₂ /TJ
Description	Emission factor of fossil fuel replaced – Residual Fuel oil
Source of data	IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23
Value applied	77.4
Justification of choice of data or description of measurement methods and procedures applied	IPCC default values used for unavailability of national data. In pre project scenario the residual fuel oil has been main source of thermal energy for the processes.
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	$\rho_{CH_4,n}$
Data unit	kg/m ³
Description	Density of methane gas at reference conditions
Source of data	Methodological tool “Project emission from flaring” Version 02.0.0

³ <http://cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKEHF5LB07QICT1P>

Value applied	0.716
Justification of choice of data or description of measurement methods and procedures applied	CDM EB as per EB28 Meeting report (Annex 13).
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	$\eta_{BL, thermal}$
Data unit	-
Description	Efficiency of the boiler using fossil fuel that would have been used in the absence of the project activity
Source of data	Default factor as per AMS.I.C
Value applied	100%
Justification of choice of data or description of measurement methods and procedures applied	Most conservative choice as per AMS I.C
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	$NCV_{i,y}$
Data unit	TJ/tonne
Description	NCV of fuel oil i.e. fossil fuel displaced by biogas
Source of data	IPCC default value
Value applied	0.0404
Justification of choice of data or description of measurement methods and procedures applied	IPCC default value for heavy fuel oil as per 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Table 1.2.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	$Q_{FO, starch}$
Data unit	L/tonne
Description	Liters of fossil fuel required per tonne of dry starch historically
Source of data	Historic data
Value applied	34.3

Justification of choice of data or description of measurement methods and procedures applied	Based on average values compiled from receipts in 2002, 2003, and 2005 2002 = 34.01 litres/tonne 2003 = 34.38 litres/tonne 2005 = 34.39 litres/tonne
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	D _{FO}
Data unit	Kg/litre
Description	Density of fuel oil
Source of data	http://www.engineeringtoolbox.com/fuels-densities-specific-volumes-d_166.html
Value applied	0.93
Justification of choice of data or description of measurement methods and procedures applied	Public available information
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	P _{el}																																																																																				
Data unit	kW																																																																																				
Description	Total electrical capacity of the equipment installed in the project activity																																																																																				
Source of data	Nameplate of the electrical equipment <table><tr><th>Item</th><th>Equipment</th><th>rated power (kW)</th><th>Number</th><th>Total power</th><th>Unit</th></tr><tr><td>1</td><td>Pump</td><td>7.5</td><td>2</td><td>15</td><td>kW</td></tr><tr><td>2</td><td>Pump - covered lagoon</td><td>11</td><td>1</td><td>11</td><td>kW</td></tr><tr><td>3</td><td>Submersible pump</td><td>7.5</td><td>1</td><td>7.5</td><td>kW</td></tr><tr><td>4</td><td>Blower to burner</td><td>22</td><td>1</td><td>22</td><td>kW</td></tr><tr><td>5</td><td>Blower to generator</td><td>22</td><td>1</td><td>22</td><td>kW</td></tr><tr><td></td><td>Blower to generator</td><td>7.5</td><td>2</td><td>15</td><td>kW</td></tr><tr><td>6</td><td>pump-Scrubber for burner</td><td>4</td><td>1</td><td>4</td><td>kW</td></tr><tr><td>7</td><td>pump-Bio scrubber</td><td>4</td><td>4</td><td>16</td><td>kW</td></tr><tr><td></td><td>pump-Bio scrubber</td><td>5.5</td><td>1</td><td>5.5</td><td>kW</td></tr><tr><td>8</td><td>pump-Scrubber for generator</td><td>4</td><td>1</td><td>4</td><td>kW</td></tr><tr><td>9</td><td>Chiller</td><td>0.375</td><td>2</td><td>0.75</td><td>kW</td></tr><tr><td>10</td><td>feed pump</td><td>5.5</td><td>3</td><td>16.5</td><td>kW</td></tr><tr><td colspan="4"></td><td>139.25</td><td>kW</td></tr></table>	Item	Equipment	rated power (kW)	Number	Total power	Unit	1	Pump	7.5	2	15	kW	2	Pump - covered lagoon	11	1	11	kW	3	Submersible pump	7.5	1	7.5	kW	4	Blower to burner	22	1	22	kW	5	Blower to generator	22	1	22	kW		Blower to generator	7.5	2	15	kW	6	pump-Scrubber for burner	4	1	4	kW	7	pump-Bio scrubber	4	4	16	kW		pump-Bio scrubber	5.5	1	5.5	kW	8	pump-Scrubber for generator	4	1	4	kW	9	Chiller	0.375	2	0.75	kW	10	feed pump	5.5	3	16.5	kW					139.25	kW
Item	Equipment	rated power (kW)	Number	Total power	Unit																																																																																
1	Pump	7.5	2	15	kW																																																																																
2	Pump - covered lagoon	11	1	11	kW																																																																																
3	Submersible pump	7.5	1	7.5	kW																																																																																
4	Blower to burner	22	1	22	kW																																																																																
5	Blower to generator	22	1	22	kW																																																																																
	Blower to generator	7.5	2	15	kW																																																																																
6	pump-Scrubber for burner	4	1	4	kW																																																																																
7	pump-Bio scrubber	4	4	16	kW																																																																																
	pump-Bio scrubber	5.5	1	5.5	kW																																																																																
8	pump-Scrubber for generator	4	1	4	kW																																																																																
9	Chiller	0.375	2	0.75	kW																																																																																
10	feed pump	5.5	3	16.5	kW																																																																																
				139.25	kW																																																																																
Value applied	139.25 kW																																																																																				
Justification of choice of data or description of measurement methods and procedures applied	Extract from nameplate of the electrical equipment.																																																																																				
Purpose of Data	Calculation of project emissions																																																																																				
Comments	The rated power consumption of the equipment is updated according to the nameplate of the existing equipment.																																																																																				

3.2 Data and Parameters Monitored

Data / Parameter	$Q_{ww,i,y}$				
Data unit	m^3				
Description	Volume of wastewater treated in the year y				
Source of data	Measured continuously using volumetric flow meter FM1 , FM2 and FM3				
Description of measurement methods and procedures to be applied	Measured continuously by flow meters installed before entering AFFR system.				
Frequency of monitoring/recording	Parameter monitored continuously but aggregated monthly and annually for calculations.				
Value monitored	<table border="1"> <tr> <th>Monitoring period</th><th>Value monitored (m^3)</th></tr> <tr> <td>01/01/2017 to 31/12/2017</td><td>835,971</td></tr> </table>	Monitoring period	Value monitored (m^3)	01/01/2017 to 31/12/2017	835,971
Monitoring period	Value monitored (m^3)				
01/01/2017 to 31/12/2017	835,971				
Monitoring equipment	Wastewater flow meter: Magnetic flow type , as per information provided in Table 6.				
QA/QC procedures to be applied	Flow meters will undergo maintenance / calibration subject to appropriate industry standards, at least once every 3 years.				
Purpose of data	Calculation of baseline and project emissions				
Calculation method	-				
Comments	-				

Data / Parameter	$COD_{ww,untreated,y}$				
Data unit	t COD/ m^3				
Description	The chemical oxygen demand of the wastewater before the treatment system affected by the project activity.				
Source of data	Measured as per colorimetric method CS1 , CS2				
Description of measurement methods and procedures to be applied	The COD content will be analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The results will be logged in the plant operation report on a daily basis.				
Frequency of monitoring/recording	Samples and measurements shall ensure a 90/10 confidence level				
Value monitored	<table border="1"> <tr> <th>Monitoring period</th><th>Value monitored (tCOD/ m^3)</th></tr> <tr> <td>01/01/2017 to 31/12/2017</td><td>0.020</td></tr> </table>	Monitoring period	Value monitored (tCOD/ m^3)	01/01/2017 to 31/12/2017	0.020
Monitoring period	Value monitored (tCOD/ m^3)				
01/01/2017 to 31/12/2017	0.020				

Monitoring equipment	Spectrophotometer for Colorimetric analysis, USEPA approved for wastewater analysis (standard method 5220 D) , , as per information provided in Table 6.
QA/QC procedures to be applied	Sampling and analysis will be carried out adhering to internationally recognized procedures. The spectrophotometer is calibrated at least once every 3 years.
Purpose of data	Calculation of baseline and project emissions
Calculation method	-
Comments	-

Data / Parameter	COD _{ww,treated,y}	
Data unit	t COD/m ³	
Description	The chemical oxygen demand of the wastewater after the treatment system affected by the project activity.	
Source of data	Measured as per colorimetric method , CS3	
Description of measurement methods and procedures to be applied	The COD content will be analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The results will be logged in the plant operation report on a daily basis.	
Frequency of monitoring/recording	Samples and measurements shall ensure a 90/10 confidence level	
Value monitored	Monitoring period	Value monitored (tCOD/ m ³)
	01/01/2017 to 31/12/2017	0.0016
Monitoring equipment	Spectrophotometer for Colorimetric analysis, USEPA approved for wastewater analysis (standard method 5220 D) , as per information provided in Table 6.	
QA/QC procedures to be applied	Sampling and analysis will be carried out adhering to internationally recognized procedures. The spectrophotometer is calibrated at least once every 3 years.	
Purpose of data	Calculation of baseline and project emissions	
Calculation method	-	
Comments	-	

Data / Parameter	$S_{\text{final,PJ,y}}$				
Data unit	t				
Description	Amount of dry matter in the sludge				
Source of data	Measured – same weighbridge at starch plant for tapioca procuring				
Description of measurement methods and procedures to be applied	Measure the total quantity of sludge on a wet basis. The volume (m^3) and density or direct weighing may be used to determine the sludge amount (wet basis). Representative samples are taken to determine the moisture content to calculate the total sludge amount on dry basis. If the methane emissions from anaerobic decay of the final sludge are to be neglected because the sludge is controlled combusted, disposed of in a landfill with methane recovery, or used for soil application, then the end-use of the final sludge will be monitored during the crediting period.				
Frequency of monitoring/recording	Monitoring of 100 per cent of the sludge amount through continuous or batch measurements and moisture content through representative sampling to ensure the 90/10 confidence/precision level				
Value monitored	<table border="1"> <tr> <th>Monitoring period</th><th>Value monitored (t)</th></tr> <tr> <td>01/01/2017 to 31/12/2017</td><td>0</td></tr> </table>	Monitoring period	Value monitored (t)	01/01/2017 to 31/12/2017	0
Monitoring period	Value monitored (t)				
01/01/2017 to 31/12/2017	0				
Monitoring equipment	Truck scale at starch plant				
QA/QC procedures to be applied	Plant manager's signature is required on the record.				
Purpose of data	Calculation of project emissions				
Calculation method	-				
Comments	-				

Data / Parameter	$BG_{\text{burnt,combusted,y}}$
Data unit	Nm^3
Description	Amount of biogas combusted for gainful use in the year y
Source of data	Measured using gas flow meter (GM1, GM3) Calculated from a summation of total biogas utilized in boiler and generation sets.
Description of measurement methods and procedures to be applied	Thermal-mass type flow meters shall automatically measure temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm^3)
Frequency of monitoring/recording	Monitored continuously but aggregated monthly and annually for calculations.

Value monitored	Monitoring period	Value monitored (m ³)
	01/01/2017 to 31/12/2017	2,113,248
Monitoring equipment	Biogas flow meter: Thermal mass type, as per information provided in Table 6.	
QA/QC procedures to be applied	Flow meters will undergo maintenance/ calibration subject to appropriate industry standards, at least once every 3 years.	
Purpose of data	Calculation of baseline emissions	
Calculation method	-	
Comments	-	

Data / Parameter	$BG_{\text{burnt,TOFlare,y}} / V_{\text{RG,m}}$	
Data unit	Nm ³	
Description	Amount of biogas sent to flare system in the year y	
Source of data	Measured using gas flow meter , GM2	
Description of measurement methods and procedures to be applied	Thermal-mass type flow meters shall automatically measure temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm ³)	
Frequency of monitoring/recording	Monitored continuously but aggregated monthly and annually for calculations.	
Value monitored	Monitoring period	Value monitored (m ³)
	01/01/2017 to 31/12/2017	0
Monitoring equipment	Biogas flow meter: Thermal mass type , as per information provided in Table 6.	
QA/QC procedures to be applied	Flow meters will undergo maintenance / calibration subject to appropriate industry standards, at least once every 3 years.	
Purpose of data	Calculation of project emissions	
Calculation method	-	
Comments	-	

Data / Parameter	W_{CH_4}	
Data unit	%	
Description	Methane content in biogas in the year y	
Source of data	Measured using gas analyser (MS1, MS2, MS3)	
Description of measurement methods and procedures to be applied	The fraction of methane in the gas should be measured with a continuous analyser or, alternatively, with periodical measurements at a 90/10 confidence/precision level. The methane content measurement shall be carried out	

	close to a location in the system where a biogas flow measurement takes place.	
Frequency of monitoring/recording	Either with continuous analyzer or alternatively with periodical measurement at 90% confidence level.	
Value monitored	Monitoring period	Value monitored (%)
	01/01/2017 to 31/12/2017	59.8
Monitoring equipment	Methane gas analyzer, as per information provided in Table 6.	
QA/QC procedures to be applied	Gas analyzer will undergo maintenance/calibration subject to appropriate industry standards, at least once every 3 years.	
Purpose of data	Calculation of baseline and project emissions	
Calculation method	-	
Comments	-	

Data / Parameter	$\eta_{\text{flare-m}}$	
Data unit	%	
Description	The flare efficiency	
Source of data	Tool "Project emissions from flaring" version 02.0.0	
Description of measurement methods and procedures to be applied	In the case of enclosed flares, the $\eta_{\text{flare,m}}$ is 0% without the complete flare monitoring system.	
Frequency of monitoring/recording	Continuously monitored	
Value monitored	Monitoring period	Value monitored (%)
	01/01/2017 to 31/12/2017	0
	*conservative default value for enclosed flare	
Monitoring equipment	-	
QA/QC procedures to be applied	-	
Purpose of data	Calculation of project emissions	
Calculation method	-	
Comments	-	

Data / Parameter	$EC_{P,J,y}$
Data unit	MWh
Description	Electricity consumption by wastewater treatment system and biogas plant in year y
Source of data	Maximum rated consumption
Description of measurement methods and procedures to be applied	-

Frequency of monitoring/recording	-	
Value monitored	Monitoring period	Value monitored (MWh)
	01/01/2017 to 31/12/2017	1,125
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 ($TDL_{j,y}$) and the calculation is based on an assumption that the electrical appliances will be running at full capacity on the operating days for the entire year, the QA/QC aspect has already been assured.	
Purpose of data	Calculation of project emissions	
Calculation method	-	
Comments	-	

Data / Parameter	$TDL_{j,y}$	
Data unit	%	
Description	Average technical transmission and distribution losses for providing electricity to the project activity (electricity import)	
Source of data	Recent data available for the host country	
Description of measurement methods and procedures to be applied	As per the guidance given in the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", most recent data available within the host country will be used during monitoring and verification.	
Frequency of monitoring/recording	Annually In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.	
Value monitored	Monitoring period	Value monitored (%)
	01/01/2017 to 31/12/2017	6.073
	(based on most recent data in 2014 published by International Energy Agency ⁴)	
Monitoring equipment	-	
QA/QC procedures to be applied	Not applicable	

⁴ <http://data.worldbank.org/indicator/EG.ELC.LOSS.ZS>

Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	EG _{PJ,y}	
Data unit	MWh	
Description	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y	
Source of data	Electricity meter built into the generator sets ⁵	
Description of measurement methods and procedures to be applied	The power monitoring equipment are installed for continuous measuring of electricity produced from each generator.	
Frequency of monitoring/recording	Continuous monitoring and at least monthly recording	
Value monitored	Monitoring period	Value monitored (MWh)
	01/01/2017 to 31/12/2017	3,173
	*The monitored value is adjusted with 1% of maximum error.	
Monitoring equipment	Power monitoring devices installed at the generators , as per information provided in Table 6.	
QA/QC procedures to be applied	The meter should be verified as per the manufacturer's recommendation.	
Purpose of data	Calculation of baseline emissions	
Calculation method	-	
Comments	-	

Data / Parameter	EG _{thermal,y}	
Data unit	TJ	
Description	Net quantity of thermal energy supplied by the project activity during the year y	
Source of data	Plant records	
Description of measurement methods and procedures to be applied	As per the methodology deviated approach provided in section 2.6	
Frequency of monitoring/recording	Continuous monitoring, aggregated annually	
Value monitored	Monitoring period	Value monitored (TJ)
	01/01/2017 to 31/12/2017	79.07
Monitoring equipment	Fuel oil flow meter , as per information provided in Table	

⁵ The electricity supplied from 4th generator is not included in this calculation since it is the additional equipment after project implementation which is not indicated in registered PD

	6.
QA/QC procedures to be applied	The temperature and flow rate meters shall be subject to periodic calibration according to the equipment's specifications and applicable industrial standards. In the absence of monitoring data or gaps in monitoring procedures, $EG_{thermal, y}$ can be estimated in a conservative manner by an energy balance calculation based on the energy inputs to the boiler system (biogas flow, HFO consumption), assuming a conservative value of 100% for the efficiency of the boiler. The amount of starch dried in a certain period can be used for crosschecking purposes. This approach is chosen for this monitoring period.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	Metering the energy produced by a sample of the systems where the simplified baseline is based on the energy produced multiplied by an emission coefficient

Data / Parameter	$FC_{l,j,y}$	
Data unit	Litres	
Description	Quantity of fossil fuel used in boiler in year y.	
Source of data	A flow meter is available at boiler to monitor the fuel oil usage at the project site.	
Description of measurement methods and procedures to be applied	Fuel oil meter is available at the hot oil boiler. 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. The archive shall be done on a daily basis.	
Frequency of monitoring/recording	Continuously monitoring with recording on daily basis	
Value monitored	Monitoring period	Value monitored (Litres)
	01/01/2017 to 31/12/2017	51,631
Monitoring equipment	Flow meter for fuel oil , as per information provided in Table 6.	
QA/QC procedures to be applied	Periodic calibrations (once in three years) for flow meter are ensured via an external agency.	
Purpose of data	Calculation of project emissions	
Calculation method	-	
Comments	-	

Data / Parameter	Q _{starch,y}		
Data unit	Tonnes		
Description	Quantity of dry starch produced		
Source of data	Based on operational log sheet at the plant		
Description of measurement methods and procedures to be applied	A proper record of all starch produced shall be maintained at the project site. This parameter is component of regular monitoring for starch industry as this the main product and to the revenues the core business are realized from this product.		
Frequency of monitoring/recording	The monitored data will be summarized annually.		
Value monitored	Monitoring period	Value monitored (Tonnes)	
	01/01/2017 to 31/12/2017	62,859	
Monitoring equipment	Truck scale at starch factory		
QA/QC procedures to be applied	Production data can cross-checked with sales record if necessary. The calibration and the accuracy of truck scale is controlled and verified by Central Bureau of Weights and Measures. The calibration certificate is valid for 2 years.		
Purpose of data	Calculation of baseline emissions		
Calculation method	-		
Comments	-		

3.3 Monitoring Plan

The monitoring plan is described in section 3.4 of the registered PD. The documented procedure for VCS monitoring program has been established and implemented. This document describes about the scope of VCS project, responsibility of concerned person, job description and scope, and emergency preparedness & response.

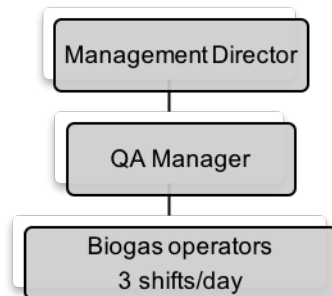
The daily operation data recording and laboratory analysis is carried out by plant operator. The report will be checked and approved by QA manager. The QA manager controls all equipment calibrations.

The QA manager will collect all information and submit to the consultant for emission calculation.

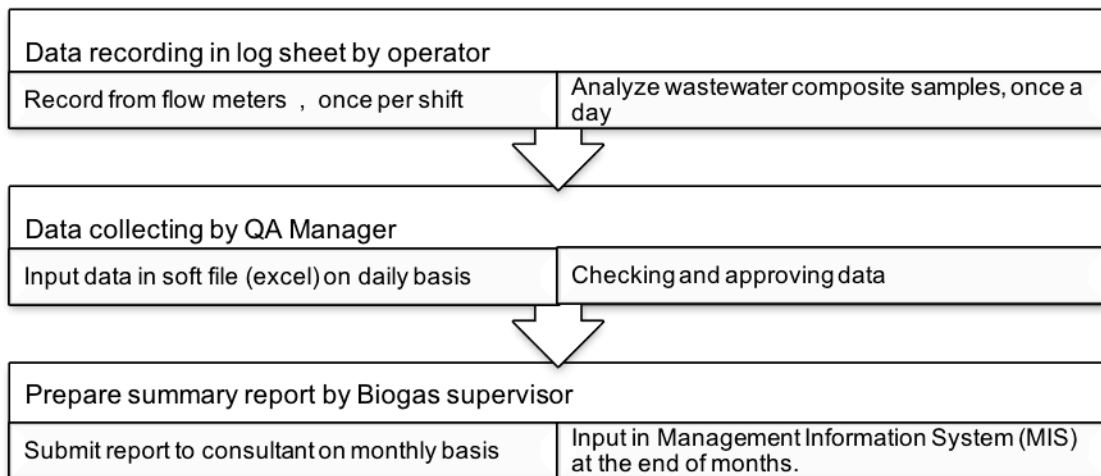
All monitoring data is available in an excel spreadsheet. This spreadsheet consists of:

1. A summary worksheet containing the results of the monitoring for every day of the monitoring period on a yearly basis;
2. The monitored parameters during the monitoring period

Organization structure



Data Collection and management system



Data storage and backup

- The original log sheets are collected and stored at starch operation office by QA Manager.
- The excel spreadsheet is stored in QA manager's computer and backup into external or portable hard disk at least once a month.
- The data stored in MIS report is backup via Chol Charoen's server.
- The excel spreadsheet submitted to consultant is stored and backup via consultant's internal server on monthly basis.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

Baseline emissions calculation as per AMS III.H

Baseline emissions for the systems affected by the project activity can be calculated as per Equation (1) below.

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

Where:

BE_y	=	Baseline emissions in year y (t CO ₂ e)
$BE_{power,y}$	=	Baseline emissions from electricity or fuel consumption in year y (t CO ₂ e)
$BE_{ww,treatment,y}$	=	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (t CO ₂ e)
$BE_{s,treatment,y}$	=	Baseline emissions of the sludge treatment systems affected by the project activity in year y (t CO ₂ e)
$BE_{ww,discharge,y}$	=	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y (t CO ₂ e). The value of this term is zero for the case 1(b)
$BE_{s,final,y}$	=	Baseline methane emissions from anaerobic decay of the final sludge produced in year y (t CO ₂ e). If the sludge is controlled combusted, disposed in a landfill with biogas recovery, or used for soil application in the baseline scenario, this term shall be neglected

a) **Emissions on account of electricity or fossil fuel used ($BE_{power,y}$)**

The only electricity consumption devices used in the baseline wastewater treatment systems are pumps for pumping the wastewater from the palm oil mill into the open anaerobic lagoons. There is no consumption of fossil fuels for the operation of the baseline system.

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

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

b) **Methane emissions from baseline wastewater treatment systems ($BE_{ww,treatment,y}$):**

Methane emissions from the baseline wastewater treatment systems affected by the project ($BE_{ww,treatment,y}$) are determined using the COD removal efficiency of the baseline plant:

Where:

$Q_{ww,i,y}$	= Volume of wastewater treated in baseline wastewater treatment system i in year y (m^3). For ex ante estimation, forecasted wastewater generation volume or the designed capacity of the wastewater treatment facility can be used. However, the ex post emissions reduction calculation shall be based on the actual monitored volume of treated wastewater
$COD_{inflow,i,y}$	= Chemical oxygen demand of the wastewater inflow to the baseline treatment system i in year y (t/m^3). Average value may be used through sampling with the confidence/precision level 90/10
$\eta_{COD,BL,i}$	= COD removal efficiency of the baseline treatment system i , determined as per the paragraphs 38, 39 or 40 of the methodology
$MCF_{ww,treatment,BL,i}$	= Methane correction factor for baseline wastewater treatment systems i as per Table 1
i	= Index for baseline wastewater treatment system
$B_{o,ww}$	= Methane producing capacity of the wastewater (IPCC value of 0.25 kg CH_4/kg COD) ⁶
UF_{BL}	= Model correction factor to account for model uncertainties (0.89) ⁷
GWP_{CH_4}	= Global Warming Potential for methane

If the baseline treatment system is different from the treatment system in the project scenario, the monitored values of the COD inflow during crediting period will be used to calculate the baseline emissions ex post.

The Methane Correction Factor (MCF) shall be determined based on the following table.

Table 1 : IPCC default values⁸ for Methane Correction Factor (MCF)

Type of wastewater treatment and discharge pathway or system	MCF value
Discharge of wastewater to sea, river or lake	0.1
Land application	0.1
Aerobic treatment, well managed	0.0
Aerobic treatment, poorly managed or overloaded	0.3
Anaerobic digester for sludge without methane recovery	0.8
Anaerobic reactor without methane recovery	0.8

⁶ Project activities may use the default value of 0.6 kg CH_4/kg BOD, if the parameter $BOD_{5,20}$ is used to determine the organic content of the wastewater. In this case, baseline and project emissions calculations shall use BOD instead of COD in the equations, and the monitoring of the project activity shall be based in direct measurements of $BOD_{5,20}$, i.e. the estimation of BOD values based on COD measurements is not allowed.

⁷ Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

⁸ Default values from chapter 6 of volume 5. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Type of wastewater treatment and discharge pathway or system	MCF value
Anaerobic shallow lagoon (depth less than 2 metres)	0.2
Anaerobic deep lagoon (depth more than 2 metres)	0.8
Septic system	0.5
Land application ⁹	0.1

c) **Methane emissions from baseline sludge treatment systems ($BE_{s,treatment,y}$)**

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

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

d) **Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake ($BE_{ww,discharge,y}$)**

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

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

e) **Baseline methane emissions from anaerobic decay of the final sludge produced ($BE_{s,final,y}$)**

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

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

Baseline emissions calculation as per AMS I.D

Baseline emissions include only CO₂ emissions from electricity generation in power plants that are displaced due to the project activity. The methodology assumes that all project electricity generation above baseline levels would have been generated by existing grid-connected power plants and the addition of new grid-connected power plants. The baseline emissions are to be calculated as follows:

Where:

$$BE_y = EG_{PJ,y} \times EF_{grid,y} \quad \text{Equation (2)}$$

$$BE_y = \text{Baseline emissions in year } y \text{ (t CO}_2\text{)}$$

⁹ Please refer SSC_664, "Clarification on methane correction factors for treated water used for irrigation under AMS-III.H ver. 16".

$EG_{PJ,y}$ = Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the project activity in year y (MWh)

$EF_{grid,y}$ = Combined margin CO_2 emission factor for grid connected power generation in year y calculated using the latest version of the “Tool to calculate the emission factor for an electricity system” (t CO_2 /MWh)

Greenfield power plants

If the project activity is the installation of a greenfield power plant, then:

$$EG_{PJ,y} = EG_{PJ, facility,y} \quad \text{Equation (3)}$$

Where:

$EG_{PJ, facility,y}$ = Quantity of net electricity generation supplied by the project plant/unit to the grid in year y (MWh)

The emission factor shall be calculated in a transparent and conservative manner as follows:

- A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the “Tool to calculate the emission factor for an electricity system”; or
- The weighted average emissions (in t CO_2 /MWh) of the current generation mix. The data of the year in which project generation occurs must be used.

Determination of

The option a) : a combined margin (CM) which consisting of the combination of operating margin (OM) and build margin (BM) , is chosen in this case.

The combined margin emission factor for Grid system in Thailand is calculated and reported by Thailand Greenhouse Gas Management Organization or TGO¹⁰. The data used for national grid emission calculation is provided by Energy Regulatory Commission or ERC. The $EF_{grid,CM,y}$ from latest available version of the grid emissions study will be used. This approach is in line with the condition identified in clause 19: option A1 of the reference tool, ($EF_{EL,j,y} = EF_{grid,CM,y}$).

The result of grid emission factor for general project reported by the “*Thailand Grid Emission Factor for GHG Reduction Project/Activity*”, published by TGO on 28/09/2017 is shown in table below;

Tool	Weight	Emission Factor	Unit
Operating Margin: OM	0.5	0.5719	tCO ₂ /MWh
Build Margin: BM	0.5	0.5609	
Combined Margin: CM – General Project		0.5664	

¹⁰ http://ghgreduction.tgo.or.th/t-ver/images/Grid_Emission_Factor_2559_-_Finalised.pdf

Refer to clause 84 (b) of 'Tool to calculate the emission factor for an electricity system', version 05.0, All other projects: $w_{OM} = 0.5$ and $w_{BM} = 0.5$ for the first crediting period, and $w_{OM} = 0.25$ and $w_{BM} = 0.75$ for the second and third crediting period.

$$EF_{grid,CM,y} = EF_{grid,OM,y} * w_{OM} + EF_{grid,BM,y} * w_{BM} \quad \text{Equation (4)}$$

Where :

$EF_{grid,BM,y}$	Build margin CO2 emission factor in year y (t CO ₂ /MWh)
$EF_{grid,OM,y}$	Operating margin CO2 emission factor in year y (t CO ₂ /MWh)
w_{OM}	Weighting of operating margin emissions factor (per cent)
w_{BM}	Weighting of operating margin emissions factor (per cent)

The $EF_{grid,CM,y}$ is re-calculated by using equation (16) , the value to be used is 0.5637.

Baseline emissions calculation as per AMS I.C

For thermal energy produced using fossil fuels and/or grid electricity the baseline emissions are calculated as follows:

$$BE_{thermal,CO2,y} = \left(\frac{EG_{thermal,y}}{\eta_{BL,thermal}} \right) \times EF_{FF,CO2} \quad \text{Equation (5)}$$

Where:

$BE_{thermal,CO2,y}$	=	Baseline emissions from thermal energy displaced by the project activity during the year y (t CO ₂)
$EG_{thermal,y}$	=	Net quantity of thermal energy supplied by the project activity during the year y (TJ)
$EF_{FF,CO2}$	=	CO ₂ emission factor of the fossil fuel that would have been used in the baseline plant obtained from reliable local or national data if available, alternatively, IPCC default emission factors can be used (t CO ₂ /TJ)
$\eta_{BL,thermal}$	=	Efficiency of the plant using fossil fuel that would have been used in the absence of the project activity determined as per paragraph 39 or 40

As per the proposed methodology deviation explained in section 2.6 above, the baseline emissions for ex-ante estimations are based on historical specific consumption of fossil fuel oil

per tonne of starch. The future expected starch production is used to estimate the baseline emissions for ex ante purpose. In case of ex-post calculations, the amount of energy delivered by the dual fuel fired boiler is used to estimate the baseline emissions.

Table 2: Summary of Baseline Emissions (BE) calculation

AMS.III.H		2017
COD _{load ww,untreated,y}	tonne	17,074
COD _{removed,i,y}	tonne	14,854.67
BE _{ww,treatment,y}	tCO ₂	66,103
BE _{s,treatment,y}	tCO ₂	0
BE _{power,y}	tCO ₂	0
BE _{ww,discharge,y}	tCO ₂	0
BE _{s,final,y}	tCO ₂	0
BE_y	tCO₂	66,103

AMS.I.C		2017
Q _{starch,y}	kg	62,859
FC _{i,i,y}	litres	51,631
EG _{thermal,y}	TJ/year	79.07
BE_{thermal,CO2,y}	tCO₂	6,120

AMS.I.D		2017
EG _{PJ,y}	MWh	3,173
EF _{grid,CM,y}	tCO ₂ /MWh	0.5637
BE_y	tCO₂	1,789

MD _y		2017
BG _{burnt,combusted,y}	Nm ³	2,113,248
BG _{burnt,TOFlare,y}	Nm ³	0
MD_y	tCO₂	22,561

4.2 Project Emissions

Project emissions calculation as per AMS III.H

The project emissions are calculated from

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

Equation (6)

Where:

PE_y	Project activity emissions in the year y (t CO ₂ e)
$PE_{power,y}$	Emissions from electricity or fuel consumption in the year y (t CO ₂ e).
$PE_{ww,treatment,y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year y (t CO 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 (t CO ₂ e).
$PE_{ww,discharge,y}$	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 (t CO ₂ e).
$PE_{fugitive,y}$	Methane emissions from biogas release in capture systems in year y (t CO ₂ e)
$PE_{flaring,y}$	Methane emissions due to incomplete flaring in year y (t CO ₂ e).
$PE_{biomass,y}$	Methane emissions from biomass stored under anaerobic conditions. (t CO ₂ e)

a) CO₂ emissions from electricity and fuel used by the project facilities ($PE_{power,y}$)

These emissions shall be calculated as per paragraph 28 of the methodology, by following the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

$$PE_{power,y} = \sum_j EC_{PJ,j,y} \times EF_{EF,j,y} \times (1 + TDL_{j,y})$$

Equation (7)

Where :

$PE_{power,y}$	Project emissions from electricity consumption in year y (t CO ₂ / yr)
$EC_{PJ,j,y}$	Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/yr)
$EF_{EF,j,y}$	Emission factor for electricity generation for source j in year y (t CO ₂ /MWh)
$TDL_{j,y}$	Average technical transmission and distribution losses for providing electricity to source j in year y

In the absence of electric meter for the electricity consumption of project activity, maximum rated consumption shall be used to calculate the emissions from $PE_{power,y}$ as follows:

$$PE_{power,y} = \sum P_{el} * (100\% + TDL_{j,y}) * 8,760 \text{ hours} * EF_y / 1,000 \quad \text{Equation (8)}$$

Where:

P_{el} Total electrical capacity of the equipment installed in the project activity (kW)

Determination of $EF_{EF,j,y}$

The scenario A: Electricity consumption from the grid is chosen in this case.

The combined margin emission factor of 0.5637 for Grid system is used as per the description provided in the previous section for the baseline emissions calculation for AMS I.D.

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

These emissions shall be calculated as per equation (2) in the baseline emission calculation, using an uncertainty factor of 1.12 and data applicable to the project situation ($MCF_{ww,treatment,PJ,k}$) and with the following changed definition of parameters:

$MCF_{ww,treatment,PJ,k}$ Methane correction factor for project wastewater treatment system k (MCF values as per Table 1 above)

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

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

d) Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater ($PE_{ww,discharge,y}$)

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

e) Methane emissions from the decay of the final sludge generated by the project activity treatment systems ($PE_{s,final,y}$)

A relatively small amount of final sludge will be removed from the digester. The project proponent will apply final sludge for field application as fertilizer and the final disposal of the sludge shall be monitored during the crediting period. Therefore as suggested by the AMS III.H, the emission from anaerobic decay from the final sludge produced can be omitted.

f) Methane fugitive emissions due to inefficiencies in capture systems ($PE_{fugitive,y}$)

Project activity emissions from methane release in capture systems are determined as follows:

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

Where:

$PE_{fugitive,ww,y}$ = Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year y (t CO₂e)

$PE_{fugitive,s,y}$ = Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y (t CO₂e)

$$PE_{fugitive,ww,y} = (1 - CFE_{ww}) \times MEP_{ww,treatment,y} \times GWP_{CH_4} \quad \text{Equation (10)}$$

Where:

CFE_{ww} = Capture efficiency of the biogas recovery equipment in the wastewater treatment systems (a default value of 0.9 shall be used)

$MEP_{ww,treatment,y}$ = Methane emission potential of wastewater treatment systems equipped with biogas recovery system in year y (t)

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

Where:

$COD_{removed,PJ,k,y}$ = The chemical oxygen demand removed¹¹ by the treatment system k of the project activity equipped with biogas recovery in the year y (t/m³)

$MCF_{ww,treatment,PJ,k}$ = Methane correction factor for the project wastewater treatment system k equipped with biogas recovery equipment (MCF values as per Table 1 above)

UF_{PJ} = Model correction factor to account for model uncertainties (1.12)

Since there is no anaerobic sludge treatment in the project activity. Therefore the $PE_{fugitive,s,y}$ is considered as zero and excluded from the project emission calculation.

Thus, the fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems are given as:

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

¹¹ Difference between the inflow COD and the outflow COD.

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

If the project activity includes flaring of biogas, then project emissions from flaring of biogas ($PE_{flare,y}$) shall be estimated using the “Tool to determine project emissions from flaring gases containing methane” version 02.0.0 . The following applies:

- For small scale projects, project participants may adopt a default value for the fraction of methane in the biogas ($f_{CH_4,default}$) in applying the tool; and
- The tool provides default factors for the flare efficiency, which can be used for large or small scale projects as described in the tool.

The calculation procedure in this tool determines the project emissions from flaring the residual gas ($PE_{flare,y}$) based on the flare efficiency ($\eta_{flare,m}$) and the mass flow of methane to the flare ($F_{CH_4,RG,m}$). The flare efficiency is determined for each minute m of year y based either on monitored data or default values.

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

Step 1: Determination of the methane mass flow in the residual gas

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

Parameter	Details
$F_{CH_4,m}$	Mass flow of methane in the residual gaseous stream in the minute m (kg)

The following requirements apply:

- The gaseous stream tool shall be applied to the residual gas;
- The flow of the gaseous stream shall be measured continuously;
- CH_4 is the greenhouse gas i for which the mass flow should be determined;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 and 17 in the tool); and
- The time interval t for which mass flow should be calculated is every minute m .

$F_{CH_4,m}$, 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 ($F_{CH_4,RG,m}$). $F_{CH_4,m}$ shall be determined on a dry basis.

Step 2: Determination of flare efficiency

Enclosed flare

In the case of enclosed flares, the flare efficiency for minute m ($\eta_{flare,m}$) is determined as per the selected Option A: *Apply a default value for flare efficiency*.

For enclosed flares that are defined as low height flares, the flare efficiency in the minute m ($\eta_{flare,m}$) shall be adjusted, as a conservative approach, by subtracting 0.1 from the efficiency as determined in Options A or B.

Option A: Default value

The flare efficiency for the minute m ($\eta_{flare,m}$) is 90% when the following two conditions are met to demonstrate that the flare is operating:

- (1) The temperature of the flare ($T_{EG,m}$) and the flow rate of the residual gas to the flare ($F_{RG,m}$) is within the manufacturer's specification for the flare ($SPEC_{flare}$) in minute m ; and
- (2) The flame is detected in minute m ($Flame_m$).

Otherwise $\eta_{flare,m}$ is 0% , which is applied for this project for conservativeness.

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 residual gas ($F_{CH_4,RG,m}$) and the flare efficiency ($\eta_{flare,m}$), as follows:

$$PE_{flare,y} = GWP_{CH_4} * \sum_{m=1}^{525600} F_{CH_4,RG,m} * (1 - \eta_{flare,m}) * 10^{-3} \quad \text{Equation (12)}$$

Where:

Parameter	Details
$PE_{flare,y}$	Project emission from flaring of the residual gas stream in year y (tCO ₂ e)
GWP_{CH_4}	Global warming potential of methane valid for the commitment period (tCO ₂ e/tCH ₄)
$F_{CH_4,RG,m}$	Mass flow of methane in the residual gas in the minute m (kg)
$\eta_{flare,m}$	Flare efficiency in minute m

Parameters and data that are not monitored include the constants used in equations, as listed in table below.

Table 3 : Constants used in equations

Parameter	SI Unit	Description	Value
MM_{CH_4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO_2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O_2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H_2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N_2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_C	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_H	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_O	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_N	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_{ref}	Pa	Atmospheric pressure at reference conditions	101 325
R_u	Pa.m ³ /kmol.K	Universal ideal gas constant	0.008314472
T_{ref}	K	Temperature at reference conditions	273.15
$V_{O_2,air}$	Dimensionless	O ₂ volumetric fraction of air	0.21
GWP_{CH_4}	tCO ₂ /tCH ₄	Global warming potential of methane valid for the commitment period	21 (for the first commitment period)
MV_n	m ³ /kmol	Volume of one mole of any ideal gas at reference conditions	22.414
$\rho_{CH_4,n}$	kg/m ³	Density of methane gas at reference conditions	0.716
$NA_{i,j}$	Dimensionless	Number of atoms of element j in component i , depending on molecular structure	
VM_{ref}	m ³ / kmol	Volume of one mole of any ideal gas at reference temperature and pressure	22.4

- h) Methane emissions from biomass stored under anaerobic conditions which would not have occurred in the baseline situation ($PE_{biomass,y}$).*

Biomass storage is not envisaged in the project activity. Therefore methane emissions from biomass stored under anaerobic conditions which does not take place in the baseline situation are not taken into consideration.

Table 4 : Summary of project emissions calculation

AMS.III.H		2017
$EC_{PJ,i,y}$	MWh	1,125
$PE_{Power,y}$	tCO ₂	673
$COD_{ww,removed,lagoon,y}$	tonne	1,184.97
$PE_{ww,treatment,y}$	tCO ₂	6,636
$PE_{s,treatment}$	tCO ₂	0
$PE_{ww,discharge,y}$	tCO ₂	0
$PE_{s,final,y}$	tCO ₂	0
$PE_{fugitive,y}$	tCO ₂	8,798.88
$MEP_{ww,treatment,y}$	-	3,520
$PE_{biomass,y}$	tCO ₂	0
$BG_{burnt,TOFlare,y}$	Nm ³	-
$PE_{flare,y}$	tCO ₂	-
PE_y	tCO₂	16,107

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. All the equipment used in the project activity for power and heat generation is either already existing or brought for purpose of project activity and there is no shifting of old equipment takes place. Therefore, there is no leakage as per AMS.I.C and AMS.I.D.

4.4 Net GHG Emission Reductions and Removals

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

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

Equation (13)

Where:

Parameter	Details
$ER_{y, \text{expost}}$	Emission reductions achieved by the project activity based on monitored values for year y (tCO ₂ e)
$BE_{y, \text{expost}}$	Baseline emissions calculated as per Equation 1
$PE_{y, \text{expost}}$	Project emissions calculated as per Equation 6
MD_y	Methane captured and destroyed/gainfully used by the project activity in the year y

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)
2017	30,469	673	0	29,796
Total	30,469	673	0	29,796

APPENDIX 1: ADDITIONAL INFORMATION

Table 5 : Summary of monitored parameters

Monitored parameter	Unit	PD Value	2017
$Q_{ww,i,y}$	m^3/y	543,157	835,971
$Q_{ww,AFFR,y}$	m^3/y		237,514
$Q_{ww,CL,y}$	m^3/y		598,457
$COD_{ww,untreated,y}$	tCOD/m ³	0.023	0.020
$COD_{ww,untreated,AFFR,y}$	mg/l		28,390
$COD_{ww,untreated,CL,y}$	mg/l		16,984
$COD_{ww,treated,y}$	mg/l	0.0046	1,442
$COD_{load\ ww,untreated,y}$	tonnes/y		17,074
$COD_{load\ y,out,PJ,y}$	tonnes/y		1,362
	tonnes/m ³		0.0016
$COD_{ww,removed,PJ}$	tonnes/y		15,712
$COD_{removed,PJ,k,y}$	tonnes/m ³		0.0188
W_{CH_4}	%	55	59.8%
$BG_{burnt,combusted,y}$	Nm ³ /y	5,075,720	2,113,248
$Q_{biogas,boiler,y}$	Nm ³ /y		982,870
$Q_{biogas,gas\ engine,y}$	Nm ³ /y		1,130,378
$BG_{burnt,TOFlare,y}$	Nm ³ /y	0	0
$H_{flare-m}$	%	0	0
$EC_{PJ,y}$	MWh/y	1158	1,125
$TDL_{i,y}$	%	6.073	6.073
$EG_{PJ,y}$	MWh/y	4,827.56	3,173
$EG_{thermal,y}$	TJ	69.92	79
$Q_{starch,y}$	kg/y	54,316	62,859
$FC_{i,j,y}$	Litres/y	530,513	51,631
$S_{final,PJ,y}$	Tonnes/y	0	0
Operating days	days		306

Table 6 : Information of monitoring equipment

Meter	Location	Brand	Model	S/N	Accuracy	Calibration record			
						Before 2014	2015	2016	2017
FM1	AFFR	Euromag	MUT 1000EL	YAL1623	0.2%		22-Jun-15	18-Jun-16	10-Jun-17
FM2	CL2	Euromag	MUT 1000EL	YAL1624	0.2%		22-Jun-15	18-Jun-16	12-Jun-17
FM3	CL2	Euromag	MUT 1000EL	YAL1625	0.2%		22-Jun-15	18-Jun-16	12-Jun-17
GM1	Boiler	Veris dete	Verabar	V9107-03.1	1.0%		18-Jun-15	16-Jun-16	
GM2	Flare	Veris dete	Verabar	V21059-01.1	1.0%		18-Jun-15	16-Jun-16	
GM3	Gen set	FOX	FT2A-09I	20880	1%		18-Jun-15	16-Jun-16	19-Jun-17
EM1	Gen1	Carlo Gav	WM3-96	61580000N0050	1%	23-May-12			
EM2	Gen2	Huatong	PDM-803AC-M4	HT08051884	0.5%				
EM3	Gen3	Huatong	PDM-803AC-M5	HT09050004	0.5%				
MS	Portable	Gas Data		12368			4-Mar-15		
CS		HACH	DR900	HAC160600001037				29-Feb-16	
OM	Boiler	Aquametr	Contoil VZ	20320	1%		29-Jun-15	20-Jun-16	23-Jun-17