

PROJECT DOCUMENT OF WASTEWATER TREATMENT WITH BIOGAS PRODUCTION (UASB) AND HEAT UTILIZATION AT GENERAL STARCH CO.,LTD.



Document Prepared By South Pole Carbon Asset Management Ltd.

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1. PROJECT DETAILS

1.1 Summary Description of the Project

The project activity involves installation of an anaerobic wastewater treatment facility, based on Upflow Anaerobic Sludge Blanket (UASB) technology, at a starch manufacturing plant that has been in operation since 1995.

The first phase of the project (UASB 1) was implemented at General Starch Co., Ltd. in 2003 with start up of operations in January 2004 and the second phase of the project (UASB 2) in 2005 with start up of operations in January of 2006.

The starch plant has a total production capacity of 600 tonnes of native starch per day, generating an average of 5,000 m³ of wastewater every production day. As a normal practice, the wastewater in the plant is treated through cascading lagoons with a retention time of more than a year. The minimum depth of these ponds is about 10 meters for the first two lagoons and more than 3 m from the water surface for the remaining lagoons. The average atmospheric temperature in the region is 28 degree Celsius and the waste water has a temperature of between 25 and 35 degree Celsius at all times.

These conditions result in anaerobic environment within the ponds, resulting in methane generation from the organic content (characterized by chemical oxygen demand or COD) of the wastewater which is released into the atmosphere.

The use of UASB to treat the wastewater generated in the plant will enable the capture of methane produced in the process as well as to meet the effluent standards. This will help reduce the emission of GHG.

The project utilizes the captured methane as fuel in existing heat generating devices in the plant replacing heavy fuel oil, and the surplus methane, if any, is flared in an open flare.

Sustainable Development Benefits of the Project

1. Economic dimension

The construction, operation and maintenance of the biogas plant generate local employment. Eight permanent positions will be created (2 qualified positions and 6 support staff). The displacement of fuel oil with biogas means (a) less dependence on imported fossil energy, resulting in energy security and foreign exchange savings. The local manpower and other resources are used more efficiently in this project.

2. Environmental dimension

The proposed project activity captures the methane which otherwise would have been let into the atmosphere, and uses it for energy purpose, thereby achieving better local air quality. The risk of groundwater contamination is overcome by reducing the COD of wastewater in a concrete digester before it is released to the tail-end ponds. Also, the treated water is recycled for use in the plant, and is not released into any surface water body, thus promoting a better local environment. The implementation of the project does not divert land under agriculture or natural growth, as well as that linked to cultural heritage. Therefore, it is not expected to affect any biodiversity sensitive areas, or other ecologically or culturally important sites in the region. The sludge from the wastewater treatment system has a potential to be applied as a fertilizer for agriculture.

3. Social dimension

The involvement of local employees in the project activity will help to enhance the skills of the labor 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 due to 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 insignificantly low. There are no other occupational health issues identified. The safety aspects of operating the biogas plant will be sufficiently addressed. Stainless steel piping is used for transporting the generated gas, which avoids all possibilities of corrosion, leakage and fire hazard.

4. Technology dimension

The project involves the use of some imported components and hence the transfer of technology from outside the country. The UASB technology is already available in a few local industries and hence the local technology transfer is enhanced. The use of this technology in wastewater treatment by the project owner will popularise the technology know how in the nearby areas and in the plants looking for similar technologies in the country. Also, the locally produced equipment may be put to use in other parts of Thailand for similar purposes.

1.2 Sectoral Scope and Project Type

The project sectoral scope, as defined by the UNFCCC, is: 13 – Waste handling and disposal.

1.3 Project Proponent

Organization name	Papop Renewable Co.,Ltd
Contact person	Mr. Likit Nimtrakul
Title	Director
Address	43 Soi. Prasertmanukij 5 , Prasertmanukij Road Jorakaebua , Ladphrao Bangkok , Thailand 10230
Telephone	+ 66 2 570 5580
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1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon Asset Management Ltd.
Role in the project	Emission reduction project developer / consultant
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Title	Managing Partner
Address	2/22 Iyara building , 6 th floor Chan Road Soi 2 , Thungwatdorn Sathorn , Bangkok Thailand 10120
Telephone	+ 66 2 678 8977 , 9
Email	p.buergi@thesouthpolegroup.com

1.5 Project Start Date

The commissioning date of the first UASB reactor was 1st Jan 2004.

1.6 Project Crediting Period

The project initially had renewable crediting period for 7 years from 1st January 2004 to 31st December 2010 (as per the registered VCS PD). As per the VCS standard version 3.22 '*The Project Crediting Period for the VCS version 1 shall be the same as for the VCS 2007.1 commencing at the specific Project Crediting Period Start Date*'. This means that the crediting period for a VCS version 1 project is 10 years, twice renewable, starting at the beginning of the original project crediting. By this statement the first crediting period is updated to be from 1st January 2004 to 31st December 2013 for this project activity.

This document is revised to cover the second crediting period i.e. from 1st January 2014 to 31st December 2023.

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	
Large project	☒

Year	Estimated GHG emission reductions or removals (tCO ₂ e)
Year 2014	92,908
Year 2015	92,908
Year 2016	92,908
Year 2017	92,908
Year 2018	92,908
Year 2019	92,908
Year 2020	92,908
Year 2021	92,908
Year 2022	92,908
Year 2023	92,908
Total estimated ERs	650,356
Total number of crediting years	10
Average annual ERs	92,908

1.8 Description of the Project Activity

The project activity deals with the recovery of methane from the wastewater generated in the tapioca processing plant. The recovered methane is used to replace heavy fuel oil in the starch drying process. The excess methane may also be flared for safety purpose, in case it is not used for heating.

UASB technology is used in the project for methane generation from wastewater high in organic content by anaerobic digestion. This is a two-stage technology, involving an Acidification System and a UASB Reactor. The organic matter is the wastewater, which is represented by its COD and BOD.

In the first stage, starch in wastewater is converted into Volatile Fatty Acids through the Acidification System that uses acidogenic bacteria. The pH of wastewater drops significantly due to the acidification process. In the second stage, effluent from the Acidification System is processed through the UASB reactor after neutralizing it with lime. The UASB reactor can briefly be described as a system in which wastewater passes first through an expanded sludge bed containing a high concentration of biomass. The sludge in the reactor may exist in granular or flocculent form. Most of the organic matter removal takes place in the sludge bed. The remaining portion of the substrate passes through a less dense biomass, called the sludge blanket. Above the sludge blanket, the reactor has a three-phase Gas-Liquid-Solid

(GLS) separator, which separates the solid particles from the liquid and gas, allowing liquid and gas to leave the system.

The organic matter in the wastewater is digested by methanogenic bacteria in the UASB reactor. This results in the production of methane, which is separated in GLS separator and collected for further use, or for flaring.

The new systems (covered lagoon 3,4) are additional units from the previous version of the registered PD. The new wastewater and biogas flow meters are installed at each unit in order to separate the wastewater and biogas volume from the project activity. This additional volume will be excluded from emission reduction calculation. The explanation will be provided in Appendix 1.

The original wastewater treatment facility, the open lagoon system, is able to treat the wastewater and meet the current environmental standards, with 120 mg or less COD per litre of wastewater released into the water bodies. However, the treated wastewater is not discharged into a water body but evaporates.

1.9 Project Location

The proposed project site is located on Ratchasima-Chokchai Road , Amphur Kornburi in Nakorn Ratchasima Province in the northeast of Thailand. Nakorn Ratchasima, about 250 km away from Bangkok, is one of the five biggest cities in Thailand. Most of the tapioca starch plants in Thailand are located in this province. The closest Railway station is Jira Station, and the closest airport is Nakorn Ratchasima Airport.

Physical Address No.99 , Chokchai – Kornburi Road , Amphur Kornburi ,Nakornratsima

GPS coordinate N 14.58375, E 102.186728



Figure 1 : Project location

1.10 Conditions Prior to Project Initiation

Prior to project implementation, the wastewater treatment facility was an open lagoon system with gravitational flow (cascading flow through 34 individual lagoons). The quality of the treated water was in compliance with the effluent standards regulated by the authority. The treated wastewater is reused within starch factory and plantation of green areas within factory boundary.

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

The project activity meets all local laws and regulations of Thailand. The current law in Thailand allows the use of open lagoon systems and other wastewater treatment technologies that meet the effluent standards for the discharge of treated wastewater into the environment. There is no other regulatory requirement for the implementation of a specific wastewater treatment technology such as anaerobic digester or aerobic treatment system to cassava processing plants for effluent treatment.

1.12 Ownership and Other Programs

1.12.1 Right of Use

The ownership of each project proponents can be verified through following documents ;

- BOT (Built-Own-Transfer) contract agreement
- Operation license
- Service agreement or Emission Reductions Purchasing Agreement

1.12.2 Emissions Trading Programs and Other Binding Limits

The net GHG emission reductions or removals generated by the project will not be used for compliance with an emissions trading program or to meet binding limits on GHG emissions.

1.12.3 Other Forms of Environmental Credit

The project neither has nor intends to generate any other form of GHG-related environmental credit for GHG emission reductions or removals claimed under the VCS Program.

1.12.4 Participation under Other GHG Programs

The project has been registered under VCS program with Project ID. 82.

1.12.5 Projects Rejected by Other GHG Programs

The project has not been rejected by any other GHG programs.

1.13 Additional Information Relevant to the Project

Eligibility Criteria

As this project is not a grouped project activity , the eligibility criteria is not applicable.

Leakage Management

Not applicable.

Commercially Sensitive Information

Not applicable.

Further Information

Not applicable.

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

The project applies the approved consolidated baseline and monitoring methodology ACM0014 : Large-scale Consolidated Methodology , Treatment of wastewater (Version 06.0).

Tools referenced in this methodology are ;

- Tool for the demonstration and assessment of additionality , version 07.0.0 ;
- Tool to calculate baseline , project and/or leakage emissions from electricity consumption , version 02 ;
- Tool to calculate the emission factor for an electricity system , version 04.0 ;
- Tool to determine the baseline efficiency of thermal or electricity generation system , version 01 ;
- Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period , version 03.0.1 ;
- Project and leakage emissions from anaerobic digesters , version 01.0.0 .

2.2 Applicability of Methodology

The project meets all the relevant applicability conditions of the methodologies, as described in the Table 1.

Table 1 : Scenarios Applicable to the Methodology

Scenario	Description of the baseline situation	Description of the project activity
1	The wastewater is directed to open lagoons that have clearly anaerobic conditions. In cases where solid materials are separated before directing the wastewater to the open lagoons, the solid materials have a different treatment than the wastewater	The wastewater is either treated in a new anaerobic digester or dewatered and directed to land application. In cases where solid materials are separated from the wastewater (both in the project and baseline scenarios), they will be treated separately and not treated with the new anaerobic digester employed for treatment of liquid effluents. The biogas extracted from the anaerobic digester and, if applicable, biogas ¹ generated from the treatment of solid materials, is flared and/or used to generate electricity and/or heat. The residual from the anaerobic digester, after treatment, is directed to open lagoons or is treated under clearly aerobic conditions (e.g. dewatering and land application)
2	The wastewater is treated in a wastewater treatment plant. Sludge is generated from primary and/or secondary settlers. The sludge is directed to sludge pit(s) that have clearly anaerobic conditions.	The wastewater is treated in the same wastewater treatment plant as in the baseline situation. The sludge from primary and/or secondary settler is treated in one or both of the following ways: The sludge is treated in a new anaerobic digester. The biogas extracted from the anaerobic digester is flared and/or used to generate electricity and/or heat. The residual from the anaerobic digester after treatment is directed to open lagoons or is treated under clearly aerobic conditions (e.g. dewatering and land application); The sludge is treated under clearly aerobic conditions (e.g. dewatering and land application).
3	The wastewater is not treated, or is directly released to water bodies or is directed to land application without dewatering - scenarios W2, W6 and/or W8. This scenario applies only to domestic wastewater, and	Domestic wastewater is treated as described in scenarios 1 or 2 above.

1

Emission reductions are not claimed for both methane avoidance and biogas generation from the solid materials.

Scenario	Description of the baseline situation	Description of the project activity
	only if at least 50 per cent of the domestic wastewater in the project boundary is not treated or is directed to land application without dewatering prior to the implementation of the project activity, confirmed for example through a survey or national information.	

Scenario 1 is applicable to the project activity. In baseline scenario the wastewater discharged from starch plant is directed to an existing cascade open lagoon system under anaerobic condition. As part of the project activity, the new anaerobic digesters were installed. Flaring of excess biogas will only occur in times when the starch production process is not in operation. The treated wastewater will be reused internally in starch factory ; washing of cassava roots and plantation.

Scenario 2 is not applicable since there is no primary settler installed in the baseline scenario. While the rotating screen for solid materials separation has been installed at the entrance of acidification ponds after the implementation of project activity. The separated solid materials will be dried on the sand drying bed and will be used as fertilizer for palm oil plantation within the factory.

The project activity fulfils the applicability criteria of the applied methodology as shown in Table 2.

Table 2 : Applicability Criteria

Type	Applicability criteria	Project status
For all scenarios	(a) The average depth of the open lagoons or sludge pits in the baseline scenario is at least 1 m.	Depth of the baseline anaerobic open lagoons is approximately 10 m. and always greater than 1 m. Therefore, the project is satisfied for this applicability condition.
	(b) The residence time of the organic matter in the open lagoon or sludge pit system should be at least 30 days.	As per the baseline lagoon design, the retention time of the cascade lagoon system is more than a year. Therefore, the project is satisfied for this applicability condition.
	(c) Inclusion of solid materials in the project activity is only applicable where: (i) Such solid materials are generated by the industrial facility producing the wastewater; and (ii) The solid materials would be generated both in the project and in the baseline scenario	The solid materials are not separated before directing the open lagoon system in baseline situation. The solid materials are separated by the rotating screen installed for the UASB system in the project scenarios. Therefore, this criterion is not applicable.
	(d) The sludge produced during the implementation of the project activity is not stored onsite before land application to avoid any possible methane emissions from anaerobic degradation.	The excess sludge from UASB reactors will be pumped out via sludge drainage system at the bottom of the reactors. The drainage pipe will be connected to the truck/tanker and transferred from project site without storage. In order to avoid the methane generation by limiting the methanogenic activity during transportation, the tap water (clean water) will be filled into the tank for COD dilution purpose. The excess sludge (granular) from UASBs is owned and copyright by technology provider which will be only used as seeding material for start up the new UASBs. Therefore, the project is satisfied for this applicability condition.

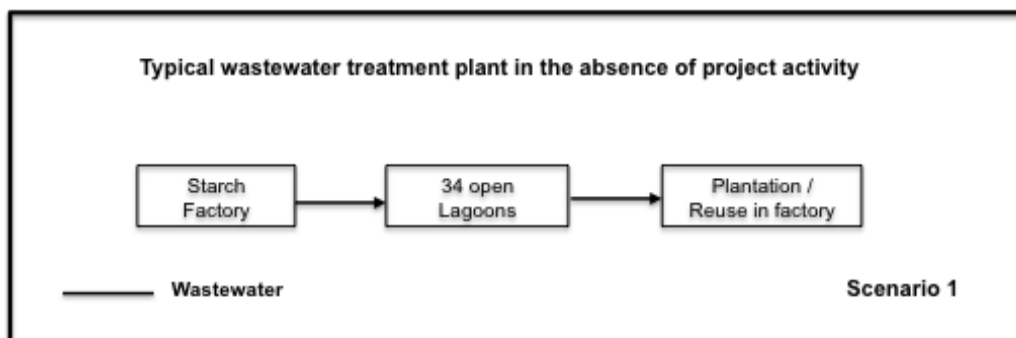


Figure 2 : The situation before the start of implementation of project activity

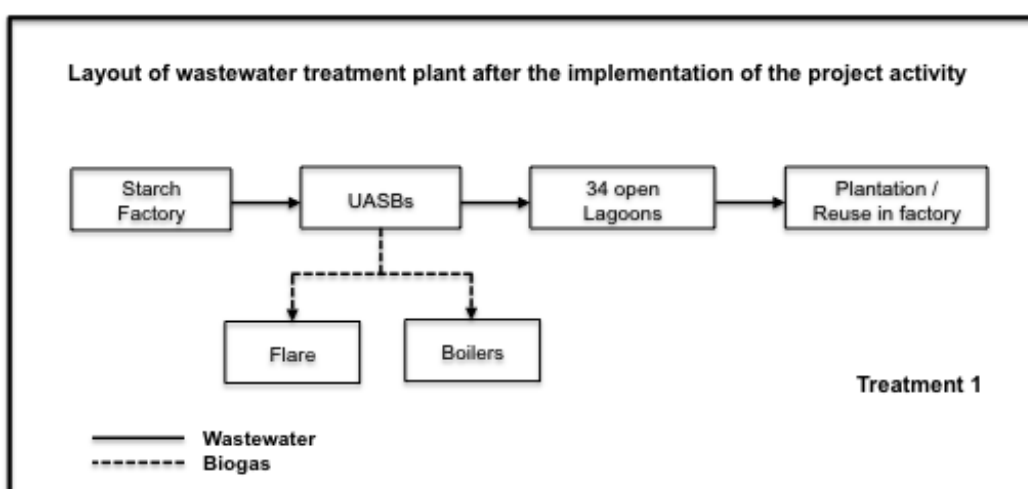


Figure 3 : The situation after the start of implementation of project activity

2.3 Project Boundary

The spatial extent of the project boundary includes:

- The site where the wastewater is treated in both the baseline and the project scenario;
- Any on-site facilities to generate heat that is used by the wastewater treatment systems;
- If applicable, the anaerobic digester, the heat generation equipment and/or the flare installed under the project activity;

The emission sources included in the project boundary are described in Table 3 below.

Table 3 : Emission sources included and excluded from the project boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Wastewater treatment processes or sludge disposal	CO ₂	No	CO ₂ emissions from the decomposition of organic waste are not accounted for
		CH ₄	Yes	Main source of emissions
		N ₂ O	No	Excluded for simplification
	Electricity consumption / generation	CO ₂	Yes	Electricity may be consumed for the operation of the wastewater or sludge treatment system in the baseline scenario
		CH ₄	No	Excluded for simplification
		N ₂ O	No	Excluded for simplification
	Thermal energy consumption	CO ₂	Yes	On-site thermal energy generation could be displaced by the project activity
		CH ₄	No	Excluded for simplification
		N ₂ O	No	Excluded for simplification
Project	Wastewater treatment process or sludge disposal	CO ₂	No	CO ₂ emissions from the decomposition of organic waste are not accounted for
		CH ₄	Yes	Main source of emissions
		N ₂ O	Yes	In case of projects that involve land application of sludge
	On-site Electricity use	CO ₂	Yes	May be an important emission source
		CH ₄	No	Excluded for simplification
		N ₂ O	No	Excluded for simplification
	On-site fossil fuel consumption	CO ₂	Yes	May be an important emission source
		CH ₄	No	Excluded for simplification
		N ₂ O	No	Excluded for simplification

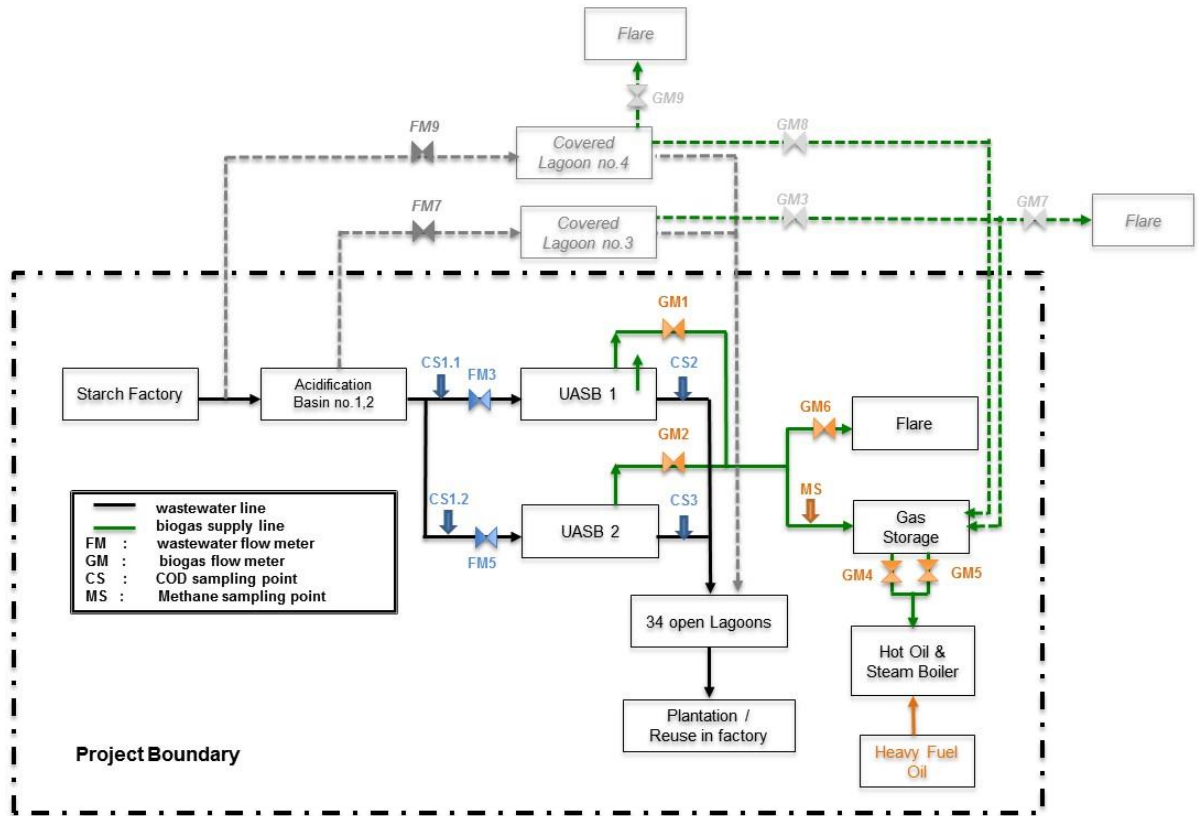


Figure 4 : Diagram of Project Boundary



Figure 5 : General Starch Boundary

2.4 Baseline Scenario

The most plausible baseline scenario is identified in the following steps:

- STEP 1: Identification of alternative scenarios
- STEP 2: Eliminate alternatives that are not complying with applicable laws and regulations
- STEP 3: Eliminate alternatives that face prohibitive barriers
- STEP 4: Compare economic attractiveness of remaining alternatives

STEP 1: Identification of alternative scenarios

For all project configurations, plausible alternative scenarios for the treatment of wastewater (W) should be determined. These may include, but are not limited to, the following:

- W1: The use of open lagoons for the treatment of the wastewater;
- W2: Direct release of wastewater to a nearby water body;
- W3: Aerobic wastewater treatment facilities (e.g. activated sludge or filter bed type treatment);
- W4: Anaerobic digester with methane recovery and flaring;
- W5: Anaerobic digester with methane recovery and utilization for electricity or heat generation;
- W6: Wastewater is directed to land application without dewatering;
- W7: Wastewater is dewatered and directed to land application/used as fuel in energy applications.

As the project activity is not related to scenario 2, the plausible alternative scenarios for the treatment of sludge (S1-S6) are not considered.

The project does not concern the electricity generation. The biogas will replace an existing renewable source of energy and is thereby not considered for electricity end use. Thus, the plausible alternative scenarios for the electricity generation (E1-E3) is not considered.

As the project activity involves heat generation with biogas from a new anaerobic digester, the plausible alternative scenarios for the generation of heat should be determined. These may include, but are not limited to, the following:

- H1: Co-generation of heat using fossil fuels in a captive cogeneration power plant;
- H2: Heat generation using fossil fuels in a boiler;
- H3: Heat generation using renewable sources.

There is no sludge treatment in the baseline and project activity. The sludge generated in lagoons in baseline and project scenario is naturally decay within lagoons and will not be removed from lagoons. A very small amount of excess sludge will be generated in the project activity, UASB system. The excess sludge removed from UASB system will be used as seeding for starting up the new anaerobic reactor in other plants. Thereby, the plausible alternative scenarios for the treatment of solid materials (SM1-SM4) are not considered.

STEP 2: Eliminate alternatives that are not complying with applicable laws and regulations.

As required by the applied methodology, sub-step 1b from the latest version of “*Tool for the demonstration and assessment of additionality*” version 07.0.0, is applied to eliminate alternatives that are not in compliance with all applicable legal and regulatory requirements.

Regulations in Thailand prohibit the direct discharge of untreated wastewater into water bodies such as rivers and lakes, primarily through the Enhancement and Conservation of National Environmental Quality Act of 1992. Therefore, alternative W2 is not in compliance with local laws and regulations and is not further considered.

According to the operation permit of General Starch Ltd., issued by the Department of Industrial Works, (DIW) : Conditions for factory operation permission ;

“ 1.4 Do not allow to discharge effluent outside the factory

1.5 To dispose the sludge from wastewater treatment by using the appropriate method which not create the hazard to public”

Therefore, alternative W2 (Direct release of wastewater to a nearby water body) and W6 (wastewater is directed to land application) are eliminated. Similarly alternative W7 involves dewatering and redirection to land application would not be in accordance with guidelines, as it would involve discharge of un-treated wastewater for land use. Thereby alternative W7 is ruled out.

Alternatives W1, W3, W4 and W5 are in compliance with host country regulations and remain as possible alternatives.

As in the absence of project activity , the fuel oil is used as the main heat energy source for starch drying process. There is no regulatory in Thailand concerned the use of heavy fuel oil for heat generation , alternative H2 is the only possible alternative.

For heat generation alternatives , all the three alternatives (H1 to H3) are complying with applicable laws and regulations.

STEP 3: Eliminate alternatives that face prohibitive barriers

As required by the ACM0014 version 06.0 , Step 3 (Barrier Analysis) from the “*Tool for the demonstration and assessment of additionality*” (version 07.0.0) is applied to eliminate alternatives that face prohibitive barriers. The following barriers are considered in the analysis:

- a) Investment barriers
- b) Technological barriers such as complex operation
- c) Barriers due to prevailing practice
- d) Other barriers – non-availability of fuel, grid electricity etc.

a) Investment barriers

Alternative W1 creates acceptable operational costs to achieve compliance with domestic effluent regulation. The anaerobic open lagoon technology is well-established technology. Open anaerobic lagoons require very low investment and have lower operation and maintenance costs², as compared to alternative systems such as anaerobic reactors and aerobic systems. Given the significantly lower investment cost, it is clear that Alternative W1 does not face significant financial barriers and represents a plausible baseline scenario.

Alternative W3 entails high investment and very high O&M costs³ in comparison to alternatives W1 and W5. The major reason for high O&M costs for treating wastewater with high organic content in aerobic systems is the very high electricity demand for forced aeration and high costs associated to sludge disposal as compared to anaerobic treatment systems. Due to high investment and O&M costs and the lack of commercial returns from energy production, it is clear that Alternative W3 would face similar or even stronger access-to-

²Wastewater Stabilization Ponds (WSP) For Wastewater Treatment - Table 1 - <http://www.eolss.net/sample-chapters/c07/e6-144-12.pdf>

³ Wastewater Stabilization Ponds (WSP) For Wastewater Treatment - Table 1 - <http://www.eolss.net/sample-chapters/c07/e6-144-12.pdf>

finance barriers as the project activity (see Section B.5 for more details). Therefore, the alternative can be excluded from further analysis.

Alternative W4, anaerobic digester with methane recovery and flaring, also entails high investment and O&M costs and no returns as the produced biogas is destroyed without use. There will be no expected revenue generation from the project activity and therefore, this alternative is not considered a practical option because it would face even greater access-to-finance barriers as the project activity. Therefore, the alternative is excluded from further analysis.

Alternative W5, anaerobic digester with methane recovery and utilization, also involves substantial capital investment but also has economic returns for biogas usage for energy generation. Therefore, the alternative is further analysed in the next step.

In addition, the available literature also presents the industry situation in Thailand. It analyses the kind of barriers, which already exists to the implementation of different kind of project technologies. The relevant implementation barriers that must be overcome to establish sustainable energy technologies in Thailand are shown in **Table 4**. The table is referred to here to establish that implementation of sustainable energy technologies in Thailand, there are some relevant barriers i.e. lack of knowledge to operate and manage new technologies and limited availability of spare parts and maintenance expertise. Thus being non-profitability and facing with many technical barriers, it is excluded from the plausible alternative scenarios.

Table 4 : The relevant implementation barriers to established sustainable energy technologies in Thailand

Implementation barriers	High ranked technologies				
	Biomass generator	Biogas generator	Energy efficiency	CHP	Steam boiler upgrading
1.Limited present affordability	✓	✓	✓	✓	✓
2.Existing domestic legal/institution framework	✓	✓			
3.Availability of cheaper but less sustainable alternative technologies	✓	✓		✓	
4.Investment climate, financial misuse/limited transparency, lack of investment	✓	✓	✓		✓
5.Lack of knowledge to operate and manage new technologies	✓	✓	✓	✓	✓
6.Limited availability of spare parts and maintenance expertise	✓	✓	✓	✓	✓
7.Negative impact on community social structures	✓	✓			
8.Lack of effective publicity for investors and the public	✓	✓	✓		✓
9.Lack of energy subsidies	✓	✓	✓	✓	✓

Source: “Potential of sustainable energy technologies under CDM in Thailand: Opportunities and barriers” – Table 6 page 11/12⁴

b) Technological barriers such as complex operation

H1: Co-generation of heat using fossil fuels in a captive power plant;

The starch plant currently combusts fuel oil for heat generation in existing boilers. The heat that is generated is sufficient to meet the full demand of the starch factory. The removal of the existing boilers and replacement with a cogeneration system would require amount of modifications and additional training of the operators. In addition, the introduction

⁴ S. Adhikari, N. Mithulananthan, A. Dutta, A. J. Mathias, 2008. Potential of sustainable energy technologies under CDM in Thailand: Opportunities and barriers, cited at http://www.researchgate.net/profile/Mithulananthan_Nadarajah2/publication/222434468_Potential_of_sustainable_energy_technologies_under_CDM_in_Thailand_Opportunities_and_barriers/links/0046352624a6571cc8000000.pdf

of new equipment, and operating requirements, would introduce additional risk to the stability and reliability of the heat supply at the starch factory. As the starch factory relies on thermal energy supply to starch production process, this additional risk is not warranted without substantial gains such as a financial return, or increases in efficiency. Therefore, this alternative can be eliminated.

H2: Heat generation using fossil fuels in a boiler

The starch factory currently combusts fuel oil for heat generation in existing steam and hot oil boilers. The heat that is generated is sufficient to meet the full demand of the starch drying process. In addition, the existing boiler system has been reliably operating since the factory started the production process. The operators are experienced in operating the system. Therefore, no technical barrier is faced to the continuation of the existing situation.

H3: Heat generation using renewable resources:

The possible option for renewable source of heat generation in starch factory is biomass. The first type of biomass which should be considered is the cassava pulp or cake since it is by-product from starch plant. The starch plant currently combusts fuel oil for heat generation in existing boilers. The heat that is generated is sufficient to meet the full demand of the starch factory. The removal of the existing boilers and replacement with a biomass system would require amount of modifications and additional training of the operators. In addition, the introduction of new equipment, and operating requirements, would introduce additional risk to the stability and reliability of the heat supply at the starch factory. As the starch factory relies on thermal energy supply to starch production process, this additional risk is not warranted without substantial gains such as a financial return, or increases in efficiency. Therefore, this alternative can be eliminated.

Overall conclusion for the plausible baseline scenarios for step 3

The analysis of each alternative above shows that the only combinations which are realistic and plausible baseline scenario for the project is the combination of W1 “The use of open lagoons for the treatment of the wastewater”, and H2 “Heat generation using fossil fuels in a boiler” while W5 “Anaerobic digester with methane recovery and utilization for electricity or heat generation” is the alternative for project activity without VCS.

STEP 4: Compare economic attractiveness of remaining alternatives

According to the ACM0014 version 06.0 , this step is necessary when more than one combination or alternative for the project activity remains at Step 3. For the proposed project activity, only one alternative remains in Step 3 and thus this step can be neglected.

The scenarios analysis demonstrate that the baseline scenario corresponds to Scenario 1 and scenarios W1 for the treatment of wastewater and H2 for the heat generation are most likely, therefore ACM0014 is applicable for the proposed project activity.

2.5 Additionality

The alternative W1 : continuation of the using of open anaerobic lagoons for the treatment of the wastewater throughout the crediting period represents the most plausible baseline scenario for this project: existing lagoons are sufficient to meet wastewater treatment needs of the facility, no additional capacity expansion is planned and there is no incentive to change to a more costly technology nor does the facility need to comply with stricter discharge limits. The only rationale for the investment is the availability of additional incentives from the production of power and carbon credits as well as reduction of energy costs.

Project additionality is confirmed using criteria A. in the VCS Version 1 verification protocol and standard , referred to the previous registered PD.

There is clear evidence that each of the following three requirements of the Additionality Test have been met by the project:

Additionality Criteria	Evidence	Documentation
- The project is not common practice. - Provision of underlying service or product with the project technology does not exceed 51% in the defined market area. - Business-as-usual technology options are clearly defined and their position on the market proven by official Statistics.	The treatment of wastewater from tapioca starch production in Thailand is mandated to ensure that the effluent that is discharged into the environment meets national effluent standards for COD. Historically, all 50 starch producers used open lagoon systems (the only business as usual technology option) to comply with this standard. The project was one of the first in Thailand introducing UASB technology. An increasing number of starch producers invest in either UASB reactors or covered lagoons. All of the projects that have been implemented previously or are currently underway that are similar to the proposed project activity in Thailand have submitted CDM applications, intend to do so or plan to produce VER and are therefore not to be considered in the current practice scenario (according to CDM EB Additionality Tool Step 4a).	Market overview: waste water treatment in Thai tapioca starch factories.
2. The project is not required by regulation - Local or National Legislation does not require the production of the underlying service or product with the chosen technology. - Additionally, the Project should not have been undertaken to meet a formal or voluntary target imposed by government regulation or under agreement	Regulation mandates the concentration of a number of pollutants in the effluent that is discharged into the environment and does not mandate the technology. Also, the project was not undertaken to meet any agreed target but on the initiative of the plant owner. No other environmental asset or financial instrument is created by the project.	

with a government agency (e.g. the auto manufacturers and the EU, where companies agree to meet reduction targets voluntarily through their industry association). - Carbon credits should not be the by-product from the creation of an ancillary environmental asset and/or financial instrument (e.g. renewable energy credits). - The emission reductions from the Project must not have been used against any voluntary corporate emission reduction targets. - Project is not a downstream energy efficiency project in a jurisdiction with a mandatory GHG emissions cap on upstream electricity generators.	The project operator does not have a voluntary corporate emission reduction target. Project is not a downstream energy efficiency project in a jurisdiction with a mandatory GHG emissions cap.	
3. The project is not the least cost option for providing the underlying product or service. Companies shall provide calculations that illustrate that the project is not the Least Cost Option.	The use of the existing open lagoon system is the least cost option to comply with effluent standard regulation when compared to the project investment and its cost of operation.	Financial analysis comparison

2.6 Methodology Deviations

Not applicable.

3 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

3.1 Baseline Emissions

Baseline emissions are estimated as follows:

$$BE_y = BE_{CH_4,y} + BE_{EL,y} + BE_{HG,y} \quad (1)$$

Where:

Parameter	Details
BE_y	Baseline emissions in year y (tCO ₂ e / yr)
$BE_{CH_4,y}$	Methane emissions from anaerobic treatment of the wastewater in open lagoons in the absence of the project activity in year y (tCO ₂ e / yr)
$BE_{EL,y}$	CO ₂ emissions associated with electricity generation that is displaced by the project activity and / or electricity consumption in the absence of the project activity in year y (tCO ₂ e / yr)
$BE_{HG,y}$	CO ₂ emissions associated with fossil fuel consumption for heating equipment that is displaced by the project in year y (tCO ₂ e / yr)

The project will only claim emission reductions from the methane avoidance due to the installation of a new, closed, anaerobic, wastewater-treatment system. Heat generated from the project activity will replace the heat generated from heavy fuel oil that would be occurred in the absence of project activity.

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

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

$$BE_{CH_4,y} = \min \{ Q_{CH_4,y} ; BE_{CH_4,MCF,y} \} \quad (2)$$

Methane produced

Projects proponent shall use Step 1 “Determination of the quantity of methane produced in the digester ($Q_{CH_4,y}$)” of the latest version of the tool “Project and leakage emissions from anaerobic digesters” version 01.0.0 to determine the amount of methane produced after the implementation of the project activity ($Q_{CH_4,y}$).

Step 1: Determination of the quantity of methane produced in the digester ($Q_{CH_4,y}$)

For large scale projects only Option 1 shall be used.

Option 1: Procedure using monitored data

$Q_{CH_4,y}$ shall be measured using the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” version 03.0.0.

The mass flow of a greenhouse gas i in a gaseous stream ($F_{i,t}$) is determined through measurement of the flow and volumetric fraction of the gaseous stream. The Table 5 shows

the different ways to make these measurements and the corresponding calculation option for $F_{i,t}$.

Table 5 : Measurement options

Option	Flow of gaseous stream	Volumetric fraction
A	Volume flow – dry basis	dry or wet basis
B	Volume flow – wet basis	dry basis
C	Volume flow – wet basis	wet basis
D	Mass flow - dry basis	dry or wet basis
E	Mass flow - wet basis	dry basis
F	Mass flow - wet basis	wet basis

For this project activity , the installed flow meter measured the volume of biogas in Nm^3 . There is no system to remove the humidity in biogas. And the methane content in biogas is measured in wet basis. Hence option C is applicable for this case.

Option C

The mass flow of greenhouse gas i ($F_{i,t}$) is determined as follows:

$$F_{i,t,db} = V_{t,wb,n} * v_{i,t,wb} * \rho_{i,n} \quad (9)$$

with

$$\rho_{i,n} = \frac{P_n * MM_i}{R_u * T_n} \quad (10)$$

Where:

Parameter	Details
$F_{i,t,db}$	Mass flow of greenhouse gas i in the gaseous stream in time interval t (kg gas/h)
$V_{t,wb,n}$	Volumetric flow of the gaseous stream in time interval t on a wet basis at normal conditions (m^3 wet gas/h)
$v_{i,t,wb}$	Volumetric fraction of greenhouse gas i in the gaseous stream in time interval t on a wet basis (m^3 gas i/m^3 wet gas)
$\rho_{i,n}$	Density of greenhouse gas i in the gaseous stream at normal conditions (kg gas i/m^3 wet gas i)
P_n	Absolute pressure at normal conditions (Pa)
T_n	Temperature at normal conditions (K)
MM_i	Molecular mass of greenhouse gas i (kg/kmol)
R_u	Universal ideal gases constant ($\text{Pa} \cdot \text{m}^3/\text{kmol} \cdot \text{K}$)

The following equation should be used to convert the volumetric flow of the gaseous stream from actual conditions to normal conditions of temperature and pressure:

$$V_{t,wb,n} = V_{t,wb} * [(T_n/T_t) * (P_t/P_n)] \quad (11)$$

Where:

Parameter	Details
$V_{t,wb,n}$	Volumetric flow of the gaseous stream in a time interval t on a wet basis at normal conditions (m^3 wet gas/h)
$V_{t,wb}$	Volumetric flow of the gaseous stream in time interval t on a wet basis (m^3 wet gas/h)
P_t	Pressure of the gaseous stream in time interval t (Pa)

T_t	Temperature of the gaseous stream in time interval t (K)
P_n	Absolute pressure at normal conditions (Pa)
T_n	Temperature at normal conditions (K)

Methane conversion factor

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

$$BE_{CH_4,MCF,y} = GWP_{CH_4} * MCF_{BL,y} * B_o * COD_{BL,y} \quad (3)$$

Where:

Parameter	Details
$BE_{CH_4,MCF,y}$	Methane emissions from anaerobic treatment of the wastewater in open lagoons (Scenario 1) or the anaerobic treatment of sludge in sludge pits (Scenario 2) in the absence of the project activity in year y (tCO ₂ e/yr)
GWP_{CH_4}	Global Warming Potential of methane valid for the commitment period (tCO ₂ e/tCH ₄)
$MCF_{BL,y}$	Average baseline methane conversion factor (fraction) in year y , representing the fraction of ($COD_{PJ,y} \times B_o$) that would be degraded to CH ₄ in the absence of the project activity
B_o	Maximum methane producing capacity, expressing the maximum amount of CH ₄ that can be produced from a given quantity of chemical oxygen demand (tCH ₄ /tCOD)
$COD_{BL,y}$	Quantity of chemical oxygen demand that would be treated in open lagoons (Scenario 1) in the absence of the project activity in year y (tCOD/yr)

Determination of $COD_{BL,y}$

The baseline chemical oxygen demand ($COD_{BL,y}$) is equal to the chemical oxygen demand that is treated under the project activity ($COD_{PJ,y}$), unless there would have been effluent from the lagoons (Scenario 1) in the baseline, in this case the COD_{PJ} should be adjusted by an adjustment factor which relates the COD supplied to the lagoon or sludge pit with the COD in the effluent.

$$COD_{BL,y} = \rho \left[1 - \frac{COD_{out,x}}{COD_{in,x}} \right] * COD_{PJ,y} \quad (4)$$

Where:

Parameter	Details
$COD_{BL,y}$	Quantity of chemical oxygen demand that would be treated in open lagoons (Scenario 1) in the absence of the project activity in year y (tCOD/yr)
ρ	Discount factor for historical information
$COD_{out,x}$	COD of the effluent in the period x (t COD)
$COD_{in,x}$	COD directed to the open lagoons (Scenario 1) or in sludge pits (Scenario 2) in the period x (t COD)
x	Representative historical reference period
$COD_{PJ,y}$	Quantity of chemical oxygen demand that is treated in the anaerobic digester

	or under clearly aerobic conditions in the project activity in year y (t COD/yr)
--	--

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

$$COD_{PJ,y} = \sum_{m=1}^{12} F_{PJ,dig,m} * COD_{dig,m} \quad (5)$$

Where:

Parameter	Details
$COD_{PJ,y}$	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in year y (t COD/yr)
$F_{PJ,dig,m}$	Quantity of wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (m ³ /month)
$COD_{dig,m}$	Chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (t COD / m ³)
m	Months of year y of the crediting period

Determination of $MCF_{BL,y}$

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

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

Where:

Parameter	Details
$MCF_{BL,y}$	Average baseline methane conversion factor (fraction) in year y , representing the fraction of ($COD_{PJ,y} \times B_0$) that would be degraded to CH ₄ in the absence of the project activity
f_d	Factor expressing the influence of the depth of the lagoon or sludge pit on methane generation
$f_{T,y}$	Factor expressing the influence of the temperature on the methane generation in year y
0.89	Conservativeness factor

Determination of f_d

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

$$f_d = \begin{cases} 0 ; & \text{if } D < 1m \\ 0.5 ; & \text{if } 1m \leq D < 2m \\ 0.7 ; & \text{if } D \geq 2m \end{cases} \quad (7)$$

Where:

Parameter	Details
f_d	Factor expressing the influence of the depth of the lagoon or sludge pit on methane generation
D	Average depth of the lagoons or sludge pits (m)

Determination of $f_{T,y}$

An increase in temperature in the lagoon has several benefits to generate more methane, including an increasing solubility of the organic compounds, enhanced biological and chemical reaction rates. The factor $f_{T,y}$ is calculated using a monthly stock change model which aims at assessing how much COD degrades in each month.

For each month m , the quantity of wastewater directed to the lagoon or sludge directed to a pit, the quantity of organic compounds that decay and the quantity of any effluent water from the lagoon is balanced, giving the quantity of COD that is available for degradation in the next month: the amount of organic matter available for degradation to methane ($COD_{available,m}$) is assumed to be equal to the amount of organic matter directed to the open lagoon or sludge pit, less any effluent, plus the COD that may have remained in the lagoon or sludge pit from previous months, as follows:

$$COD_{available,m} = COD_{BL,m} + (1 - f_{T,m-1}) * COD_{available,m-1} \quad \text{with} \quad (8)$$

$$COD_{BL,m} = \left(1 - \frac{COD_{out,x}}{COD_{in,x}}\right) * COD_{PJ,m} \quad \text{and} \quad (9)$$

$$COD_{PJ,m} = F_{PJ,dig,m} * COD_{dig,m} \quad (10)$$

Where:

Parameter	Details
$COD_{available,m}$	Quantity of chemical oxygen demand available for degradation in the open lagoon in month m (t COD/month)
$COD_{BL,m}$	Quantity of chemical oxygen demand that would be treated in open lagoons (Scenario 1) in the absence of the project activity in month m (t COD/month)
$COD_{PJ,m}$	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (t COD/month)
$F_{PJ,dig,m}$	Quantity of wastewater that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (m ³ /month)
$COD_{dig,m}$	Chemical oxygen demand in the wastewater that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (t COD/m ³)
$f_{T,m-1}$	Factor expressing the influence of the temperature on the methane generation in month m
m	Months of year y of the crediting period
$COD_{in,x}$	COD of the effluent in the period x (t COD)
$COD_{out,x}$	COD directed to the open lagoons (Scenario 1) or in sludge pits (Scenario 2) in the period x (t COD)
x	Representative historical reference period

In case of emptying the lagoon, the accumulation of organic matter restarts with the next inflow and the COD available from the previous month should be set to zero. The monthly

factor to account for the influence of the temperature on methane generation is calculated based on the following “van’t Hoff – Arrhenius” approach:

$$f_{T,m} = \begin{cases} 0 ; & \text{if } T_{2,m} < 278 \text{ K} \\ e^{\frac{E \cdot (T_{2,m} - T_1)}{R \cdot T_1 \cdot T_{2,m}}} ; & \text{if } 278 \text{ K} \leq T_{2,m} \leq 302.5 \text{ K} \\ 0.95 ; & \text{if } T_{2,m} > 302.5 \text{ K} \end{cases} \quad (11)$$

Where:

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

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

$$f_{T,y} = \frac{\sum_{m=1}^{12} f_{T,m} \cdot COD_{available,m}}{\sum_{m=1}^{12} COD_{BL,m}} \quad (12)$$

Where:

Parameter	Details
$f_{T,y}$	Factor expressing the influence of the temperature on the methane generation in year y
$f_{T,m}$	Factor expressing the influence of the temperature on the methane generation in month m
$COD_{available,m}$	Quantity of chemical oxygen demand available for degradation in the open lagoon or sludge pit in month m (t COD/month)
$COD_{BL,m}$	Quantity of chemical oxygen demand that would be treated in open lagoons (Scenario 1) or in sludge pits (Scenario 2) in the absence of the project activity in month m (t COD/month)
m	Months of year y of the crediting period

Baseline under a suppressed demand scenario

Suppressed demand scenario may only be applied if the procedure to determine the baseline scenario identifies W2, W6 and/or W8 as the scenario for the treatment of at least 50 per cent of the domestic wastewater in the project boundary. This scenario is not applicable for this project activity.

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

In this step, baseline emissions from consumption of electricity associated with the treatment of wastewater (Scenario 1) are estimated. Since the project activity does not generate the

electricity from biogas , the baseline emission from generation and/or consumption of electricity is considered as 0.

Step 3: Baseline emissions from the generation of heat

This step is applicable if the biogas captured from the new anaerobic digester is utilized in the project scenario for heat generation. In this case , for the application of the baseline Scenarios H2, fossil fuels from the generation of heat in boilers are displaced and baseline emissions are calculated as follows:

$$BE_{HG,y} = \frac{HG_{PJ,y} * EF_{CO2,FF,boiler}}{\eta_{BL,boiler}} \quad (14)$$

Where:

Parameter	Details
$BE_{HG,y}$	CO ₂ emissions associated with fossil fuel combustion for heating equipment that is displaced by the project in year y (tCO ₂ /yr)
$HG_{PJ,y}$	Net quantity of heat generated in year y with biogas from the new anaerobic digester (GJ)
$EF_{CO2,FF,boiler}$	CO ₂ emission factor of the fossil fuel type used in the boiler for heat generation in the absence of the project activity (tCO ₂ /GJ)
$\eta_{BL,boiler}$	Efficiency of the boiler that would be used for heat generation in the absence of the project activity

Determination of $EF_{CO2,FF,boiler}$

The heavy fuel oil was used in the industrial facility that generates the wastewater for heating purposes before the implementation of the project activity.

Determination of $\eta_{BL,boiler}$

The heating combustion efficiency is 90% , default value for the new oil fired boiler as the tool “tool to determine the baseline efficiency of thermal or electricity generation system”, version 01.

Determination of $HG_{PJ,y}$

In order to calculate the quantity of fuel that is displaced by biogas, the two fuels are substituted on the basis of equivalent delivered energy. The following energy densities are used:

- The NCV of CH₄ is 39820⁵ kJ/Nm³ or 39.82 MJ/Nm³ and 39.77 MJ/litre for fuel oil (Thailand Energy Statistic Report from DEDE⁶)
 - Combustion efficiency on HFO as well as biogas is considered to be 90 %.
 - Therefore : $HG_{PJ,y} \text{ (GJ)} = F_{biogas,boiler,y} \text{ (Nm}^3\text{)} * NCV_{CH4} \text{ (MJ/Nm}^3\text{)} * W_{CH4,biogas,y} * 90\% / 1,000$

⁵ http://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html

⁶ http://www.dede.go.th/download/state_58/sit_57_58/Thailand%20Energy%20Efficiency%20Situation%202014.pdf

3.2 Project Emissions

Since the project activity introduces an anaerobic digester for the treatment of wastewater. The tool “*Project and leakage emissions from anaerobic digesters version 01.0.0*” is applied to calculate project and leakage emissions.

The following sources of project emissions are accounted for in this tool:

- (a) CO₂ emissions from consumption of electricity associated with the operation of the anaerobic digester;
- (b) CO₂ emissions from consumption of fossil fuels associated with the operation of the anaerobic digester;
- (c) CH₄ emissions from the digester (emissions during maintenance of the digester, physical leaks through the roof and side walls, and release through safety valves due to excess pressure in the digester); and
- (d) CH₄ emissions from flaring of biogas.

The project emissions associated with the anaerobic digester ($PE_{AD,y}$) are determined as follows:

$$PE_{AD,y} = PE_{EC,y} + PE_{Fc,y} + PE_{CH_4,y} + PE_{flare,y} \quad (1)$$

Where:

Parameter	Details
$PE_{AD,y}$	Project emissions associated with the anaerobic digester in year y (t CO ₂ e)
$PE_{EC,y}$	Project emissions from electricity consumption associated with the anaerobic digester in year y (t CO ₂ e)
$PE_{Fc,y}$	Project emissions from fossil fuel consumption associated with the anaerobic digester in year y (t CO ₂ e)
$PE_{CH_4,y}$	Project emissions of methane from the anaerobic digester in year y (t CO ₂ e)
$PE_{flare,y}$	Project emissions from flaring of biogas in year y (t CO ₂ e)

These parameters are determined through the steps outlined below.

Step 1: Determination of the quantity of methane produced in the digester ($Q_{CH_4,y}$)

The project activity is large scale project. The Option 1 is used to determine the quantity of methane produced in the digester in year y ($Q_{CH_4,y}$).

Option 1: Procedure using monitored data

$Q_{CH_4,y}$ shall be measured using the *Tool to determine the mass flow of a greenhouse gas in a gaseous stream*.

Follow the same calculating step for Option C in baseline emission calculation step1.

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

The project activity consumes the electricity supplied from grid. The Option 2 is used for

$PE_{EC,y}$ calculation.

Option 2 : Procedure using a default value

Project emissions from electricity consumption associated with the anaerobic digester are calculated as follows:

$$PE_{EC,y} = Q_{CH_4} * F_{EC,default} * EF_{EL,default} \quad (3)$$

Where :

Parameter	Details
$PE_{EC,y}$	Project emissions from electricity consumption in year y (t CO ₂ e)
Q_{CH_4}	Quantity of methane produced in the anaerobic digester in year y (t CH ₄)
$F_{EC,default}$	Default factor for the electricity consumption associated with the anaerobic digester per ton of methane generated (MWh / t CH ₄)
$EF_{EL,default}$	Default emission factor for the electricity consumed in year y (t CO ₂ / MWh)

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

Where the anaerobic digester facility uses fossil fuels, project participants shall calculate $PE_{FC,y}$ using the “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”. The project emission source j referred to in the tool is fossil fuel consumption associated with the anaerobic digestion facility (not including fossil fuels consumed for transportation of feed material and digester or any other on-site transportation). The $PE_{FC,y}$ is 0 for this project activity.

Step 4: Determination of project emissions of methane from the anaerobic digester ($PE_{CH_4,y}$)

Project emissions of methane from the anaerobic digester include emissions during maintenance of the digester, physical leaks through the roof and side walls, and release through safety valves due to excess pressure in the digester. These emissions are calculated using a default emission factor ($EF_{CH_4,default}$), as follows:

$$PE_{CH_4,y} = Q_{CH_4,y} * EF_{CH_4,default} * GWP_{CH_4} \quad (4)$$

Where :

Parameter	Details
$PE_{CH_4,y}$	Project emissions of methane from the anaerobic digester in year y (t CO ₂ e)
$Q_{CH_4,y}$	Quantity of methane produced in the anaerobic digester in year y (t CH ₄)
$EF_{CH_4,default}$	Default emission factor for the fraction of CH ₄ produced that leaks from the anaerobic digester (fraction)
GWP_{CH_4}	Global warming potential for CH ₄ (t CO ₂ / t CH ₄)

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

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

The flare efficiency depends on the efficiency of combustion in the flare and the time that the flare is operating. For open flares a default value must be applied.

Open flare

In the case of open flares, the flare efficiency in the minute m ($\eta_{flare,m}$) is 50% when the flame is detected in the minute m (Flame_m), otherwise $\eta_{flare,m}$ is 0%.

Step 3: Calculation of project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions for each minute m in year y , based on the methane mass flow in the residual gas ($F_{CH_4,RG,m}$) and the flare efficiency ($\eta_{flare,m}$), as follows:

$$PE_{flare,y} = GWP_{CH_4} * \sum_{m=1}^{525600} F_{CH_4,RG,m} * (1 - \eta_{flare,m}) * 10^{-3} \quad (15)$$

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 6 below.

Table 6 : 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

3.3 Leakage

The project activity introduces an anaerobic digester for the treatment of wastewater , the latest approved version of the tool “*Project and leakage emissions from anaerobic digesters*” is applied to calculate leakage emissions.

However , according to ACM0014 version 06.0.0 “*Additionally leakage emissions are also calculated for Scenario 1 type projects that include the treatment of solid materials in the digester in the project activity*”. Hence , there is no leakage occurred from this project activity.

3.4 Net GHG Emission Reductions and Removals

Emission reductions for any given year of the crediting period are obtained by subtracting project emissions from baseline emissions:

$$ER_y = BE_y - PE_y - LE_y \quad (24)$$

Where:

Parameter	Details
ER_y	Emissions reductions of the project activity in year y (tCO ₂ e/year)
BE_y	Baseline emissions in year y (tCO ₂ e/year)
PE_y	Project emissions in year y (tCO ₂ e/year)
LE_y	Leakage emissions in year y (tCO ₂ e/year)

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
Year 2014	123,330	30,422	0	92,908
Year 2015	123,330	30,422	0	92,908
Year 2016	123,330	30,422	0	92,908
Year 2017	123,330	30,422	0	92,908
Year 2018	123,330	30,422	0	92,908
Year 2019	123,330	30,422	0	92,908
Year 2020	123,330	30,422	0	92,908
Year 2021	123,330	30,422	0	92,908
Year 2022	123,330	30,422	0	92,908
Year 2023	123,330	30,422	0	92,908
Total	863,310	212,954	0	650,356

4 MONITORING

4.1 Data and Parameters Available at Validation

a) From ACM0014 version 06.0.0

Data / Parameter	$COD_{out,x}$ $COD_{in,x}$
Data unit	t COD
Description	COD of the effluent in the period x COD directed to the open lagoons (Scenario 1) in the period x
Source of data	Previous registered PD – Annex 3 : Baseline Information
Value applied:	$COD_{out,x}$ 2,674.52 $COD_{in,x}$ 22,066.99
Justification of choice of data or description of measurement methods and procedures applied	$COD_{out,x}$: Calculated from $COD_{in,x}$ with the removal ratio for lagoon from CDM project no.1040 – Korat Waste To Energy at 87.88%. $COD_{in,x}$: From operating data of 2006
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	X
Data unit	Time
Description	Representative historical reference period
Source of data	Previous registered PD – Annex 3 : Baseline Information
Value applied:	1 year
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	ρ
Data unit	-
Description	Discount factor for historical information
Source of data	For existing plants: - If one year of historical data is available $\rho=1$; - If a measurement campaign of at least 10 days is available $\rho=0.89$.
Value applied:	0.89

Justification of choice of data or description of measurement methods and procedures applied	The value of 0.89 for the case where there is no one year historical data is to account for the uncertainty range (of 30% to 50%) associated with this approach as compared to one-year historical data.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	B ₀
Data unit	tCH ₄ /tCOD
Description	Maximum methane producing capacity, expressing the maximum amount of CH ₄ that can be produced from a given quantity of chemical oxygen demand (COD).
Source of data	2006 IPCC Guidelines
Value applied:	0.25
Justification of choice of data or description of measurement methods and procedures applied	No measurement procedures.
Purpose of Data	Calculation of baseline emissions
Comments	Taking into account the uncertainty of this estimate , a value of 0.25 tCH ₄ /tCOD is chosen as a conservative assumption for B ₀ .

Data / Parameter	D
Data unit	m
Description	Average depth of the lagoons
Source of data	Lagoon system layout
Value applied:	5.32
Justification of choice of data or description of measurement methods and procedures applied	Determine the average depths of the whole lagoon under normal operating condition.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	EC _{BL}
Data unit	MWh/yr
Description	Annual quantity of electricity that would be consumed in the absence of the project activity for the treatment of the wastewater (Scenario 1).
Source of data	In case of existing plants: Average yearly electricity consumption of the most recent three years prior to the implementation of the project activity.
Value applied:	0

Justification of choice of data or description of measurement methods and procedures applied	The open lagoon system is designed for gravity flow. There is no electricity consumed equipment installed in the absence of project activity.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	EF _{CO2,FF,boiler}
Data unit	tCO ₂ /GJ
Description	CO ₂ emission factor of the fossil fuel type used in the boiler for heat generation in the absence of the project activity.
Source of data	IPCC 2006
Value applied:	0.0774
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline emissions
Comments	If the measurement results differ significantly from previous measurements or other relevant data sources, conduct additional measurements. Double-checked against IPCC defaults (for consistency) if data is local or regional.

Data / Parameter	GWP _{CH4}
Data unit	tCO ₂ e/tCH ₄
Description	Global warming potential for CH ₄
Source of data	IPCC
Value applied:	21
Justification of choice of data or description of measurement methods and procedures applied	Global warming potential for CH ₄ valid for the relevant commitment period
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	Shall be updated according to any future COP/MOP decisions.

- b) From "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" version 02.0.0

Data / Parameter	R_u
Data unit	Pa.m ³ /kmol.K
Description	Universal ideal gases constant
Source of data	Tool to determine the mass flow of greenhouse gas in as gaseous team version 02
Value applied:	8,314
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	-

Data / Parameter	MM _i		
Data unit	kg/kmol		
Description	molecular mass of greenhouse gas i		
Source of data	Tool to determine the mass flow of greenhouse gas in as gaseous team version 02		
Value applied:			
	Compound	Structure	Molecular mass (kg / kmol)
	Carbon dioxide	CO ₂	44.1
	Methane	CH ₄	16.04
	Nitrous oxide	N ₂ O	44.02
	Sulfur hexafluoride	SF ₆	146.06
	Perfluoromethane	CF ₄	88.00
	Perfluoroethane	C ₂ F ₆	138.01
	Perfluoropropane	C ₃ F ₈	188.02
	Perfluorobutane	C ₄ F ₁₀	238.03
	Perfluorocyclobutane	c-C ₄ F ₈	200.03
	Perfluoropentane	C ₅ F ₁₂	288.03
Perfluorohexane	C ₆ F ₁₄	338.04	
Justification of choice of data or description of measurement methods and procedures applied	-		
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage		

Comments	-
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Data / Parameter	P _n
Data unit	Pa
Description	Total pressure at normal condition
Source of data	Tool to determine the mass flow of greenhouse gas in as gaseous team version 02
Value applied:	101,325
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	-

Data / Parameter	T _n
Data unit	K
Description	Temperature at normal condition
Source of data	Tool to determine the mass flow of greenhouse gas in as gaseous team version 01
Value applied:	273.15
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	-

c) From "Project and leakage emissions from anaerobic digesters" version 01.0.0

Data / Parameter	ρ_{CH_4}
Data unit	t CH ₄ / Nm ³ CH ₄
Description	Density of methane at normal condition
Source of data	Methodology tool
Value applied:	0.00067
Justification of choice of data or description of measurement methods and procedures applied	Technical literature
Purpose of Data	Calculation of project emissions and leakage
Comments	Normal conditions are defined as 20°C and 1 atm pressure

Data / Parameter	$EF_{CH_4, default}$
Data unit	t CH ₄ leaked / t CH ₄ produced
Description	Default emission factor for the fraction of CH ₄ produced that leaks from the anaerobic digester
Source of data	IPCC (2006), Flesch et al. (2011) and Kurup (2003)
Value applied:	0.05: UASB type digesters, floating gas holders with no external water seal;
Justification of choice of data or description of measurement methods and procedures applied	Use the default value corresponding to the type of digester used in the project activity.
Purpose of Data	Calculation of leakage
Comments	Applicable to the step "Determination of project emissions of methane from the anaerobic digester"

Data / Parameter	$F_{EC, default}$
Data unit	MWh / t CH ₄ produced
Description	Default factor for the electricity consumption associated with the anaerobic digester per ton of CH ₄ generated
Source of data	Methodology tool
Value applied:	0.01 - UASB / filter bed reactor for wastewater / fluidized bed reactor
Justification of choice of data or description of measurement methods and procedures applied	The values were derived based on a review of registered CDM projects, other projects using digesters and reference books (Metcalf & Eddy, 2003; and for solid waste Sri Bala et al., 2009).
Purpose of Data	Calculation of leakage

Comments	Applicable to the step “Determination of project emissions of methane from the anaerobic digester”
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Data / Parameter	$EF_{EL,default}$
Data unit	t CO ₂ / MWh
Description	Default emission factor for the electricity consumed in year y
Source of data	Tool to calculate baseline, project and/or leakage emissions from electricity consumption
Value applied:	1.3
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of project emissions
Comments	-

4.2 Data and Parameters Monitored

Data / Parameter	$F_{PJ,dig,m}$
Data unit	m ³ /month
Description	Quantity of wastewater that is treated in the anaerobic digester in the project activity in month <i>m</i>
Source of data	Measured
Description of measurement methods and procedures to be applied	Measured continuously by flow meters installed at the inlet of UASB no.1 and 2.
Frequency of monitoring/recording	Parameter monitored continuously but aggregated monthly and annually for calculations.
Value applied:	UASB no.1 : 41,289 UASB no.2 : 68,700
Monitoring equipment	Wastewater flow meter (FM3 , FM5) : Magnetic flow type
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	In case of Scenario 1, if the solid materials are also treated in the baseline and project scenario, the $F_{PJ,dig,m}$ does not account the amount of solid materials treated or separated from the wastewater stream in the anaerobic digester, if applicable.

Data / Parameter	COD _{dig,m}
Data unit	t COD / m ³
Description	Chemical oxygen demand in the wastewater that is treated in the anaerobic digester in the project activity in month <i>m</i>
Source of data	Measurements
Description of measurement methods and procedures to be applied	Measure the COD according to national or international standards. If COD is measured more than once per month, the average value of the measurements should be used.
Frequency of monitoring/recording	Regularly, calculate average monthly and annual values
Value applied:	0.016
Monitoring equipment	Spectrophotometer for Colorimetric analysis , USEPA approved for wastewater analysis (standard method 5220 D).
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	In case of Scenario 1, if the solid materials are also treated in the baseline and project scenario, the F _{PJ,dig,m} does not account the amount of solid materials treated or separated from the wastewater stream in the anaerobic digester, if applicable.

Data / Parameter	T _{2,m}
Data unit	K
Description	Average temperature at the project site in month <i>m</i>
Source of data	Measurement in the project site, or national or regional weather statistics
Description of measurement methods and procedures to be applied	Refer to National published report ; the monthly average temperature of Nakornratchasima province. http://www.e-report.energy.go.th/weather.html
Frequency of monitoring/recording	Continuously, aggregated in monthly average values
Value applied:	298.05
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions

Calculation method	-
Comments	The applied data is the average temperature in 2014 from http://service.nso.go.th/nso/web/statseries/statseries27.html

Data / Parameter	EG _{PJ,y}
Data unit	MWh/year
Description	Net quantity of electricity generated in year y with biogas from the new anaerobic
Source of data	Measurements
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	-
Value applied:	0
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	The project activity does not concern the generation of electricity.

Data / Parameter	HG _{PJ,y}
Data unit	GJ/year
Description	Net quantity of heat generated in year y with biogas from the new anaerobic digester
Source of data	Measurement of the volume of biogas captured and used for heat generation multiplied by methane content of biogas , NCV of methane , and the efficiency of the boiler during the project (i.e. with biogas).
Description of measurement methods and procedures to be applied	The biogas flow meters are installed at the outlet of gas storage , before entering blower station (GM4,GM5).
Frequency of monitoring/recording	Parameter monitored continuously but aggregated annually for calculations.
Value applied:	194,838.59
Monitoring equipment	The biogas flow meter : thermal mass type with temperature and pressure measuring for display in Nm ³ .

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	$S_{LA,m}$ $DWW_{LA,m}$
Data unit	t/month
Description	Amount of sludge applied to land in month m
Source of data	Measured
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	Parameter monitored continuously but aggregated monthly for calculations.
Value applied:	0 – no sludge applied to land
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	-
Data / Parameter	$F_{biogas,y}$ or $Q_{biogas,y}$
Data unit	Nm ³ /yr
Description	Total amount of biogas collected in the outlet of the new digester in year y
Source of data	Measured
Description of measurement methods and procedures to be applied	The biogas flow meters are installed at the outlet of biogas from UASB no.1 and 2 (GM1 and GM2).
Frequency of monitoring/recording	Parameter monitored continuously but aggregated annually for calculations.
Value applied:	10,930,945
Monitoring equipment	The biogas flow meter : thermal mass type with temperature and pressure measuring for display in Nm ³ .
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	Applied to estimate emissions associated with physical leakage from the digester.

Data / Parameter	$W_{CH_4, biogas, y}$
Data unit	kg CH ₄ / m ³
Description	Concentration of methane in the total biogas supply in the outlet of the new digester
Source of data	Measured
Description of measurement methods and procedures to be applied	Using calibrated continuous gas analyzer.
Frequency of monitoring/recording	Either with continuous analyzer or alternatively with periodical measurement at 95% confidence level.
Value applied:	0.65
Monitoring equipment	-
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	$V_{RG, y}$
Data unit	Nm ³ /yr
Description	Volumetric flow of the residual gas on a dry basis at reference conditions
Source of data	Measured
Description of measurement methods and procedures to be applied	The biogas flow meters are installed at the flare (GM6).
Frequency of monitoring/recording	Parameter monitored continuously but aggregated annually for calculations.
Value applied:	2,566,871
Monitoring equipment	The biogas flow meter : thermal mass type with temperature and pressure measuring for display in Nm ³ .
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	

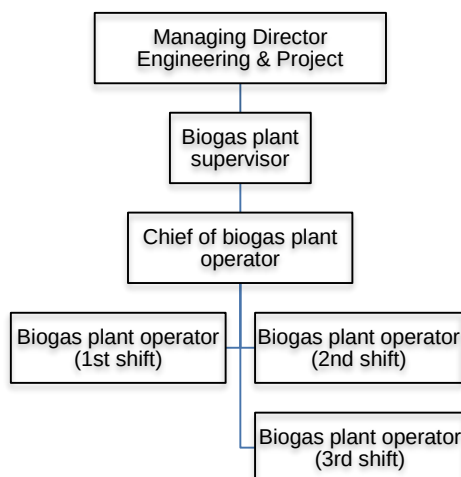
4.3 Monitoring Plan

The operation of the wastewater treatment system is responsible by General Starch Limited (GSL). The wastewater treatment system operational and management systems have been certified under ISO 14001 version 2004 by UKAS , the validity of certification is maintained. This certificate ensures that requirements and procedures for parameter monitoring, data recording and data archiving for environmental management system of biogas section are well managed according to ISO14001 requirements⁷.

The plant operator carries out the daily operation recording and laboratory analysis. The monitored data is collected and recorded in the excel spread sheet by chief of biogas operator. The report will be checked and approved by the plant supervisor. The summary reports are submitted to management on daily basis.

All equipment calibrations are controlled by the biogas plant supervisor. All documents are managed according to the requirements of ISO14001.

Organization structure



⁷ http://www.fs.fed.us/ems/includes/sum_ems_elements.pdf

Data Collection and management system

Biogas plant operator

- Data recording from flow meter into log sheet at least once a day.
- The wastewater analysis is carried out once per shift or three times per day.

Chief of biogas plant operator

- Transfer and check recorded data from log sheet into electronic format on daily basis.
- Summarize data and submit to Biogas plant supervisor on daily basis.

Biogas plant supervisor

- Submit the report to consultant on monthly basis.
- Prepare summary report and submit to concerned department.

Data storage and backup

- The original log sheets are collected and stored at biogas plant office by Chief of biogas operator.
- The data in excel format is stored at two computers at biogas plant. The backup of hard disk is done by IT department on monthly basis.
- The data submitted to consultant is stored and backup via consultant's internal server on monthly basis.

5 ENVIRONMENTAL IMPACT

The project does not lead to any additional emissions. No EIA was required.

6 STAKEHOLDER COMMENTS

Not applicable.

APPENDIX 1: BASELINE INFORMATION

Table 7 : Reference for ex-ante estimation from operation data (2006) - page 16 of the 1st monitoring report (http://www.vcsprojectdatabase.org/#/project_details/82)

MONITORING RESULTS SUMMARY

		Value			
ID no	Parameter	2004	2005	2006	Jan - May 2007
Monitoring parameter according to AM0022v4					
1	WW _{input}	470,437	426,633	1,319,869	638,995
2	WW _{out}	470,437	426,633	1,319,869	638,995
3	MCOD _{in}	6,858,554	6,307,839	22,066,994	10,604,866
4	MCOD _{out}	280,160	257,664	977,358	357,231
5	V _{boiler}	786,720	1,429,749	8,364,074	5,607,566
6	- blank -	NA	NA	NA	NA
7	EL	NA	NA	NA	NA
8	F	452	821	4,804	3,221
9	V ₁	1,364,357	797,637	2,566,871	2,200,468
10	V _{genset}	0	0	0	0
11	C _{CH4}	65%	65%	65%	65%
12	PE _{flare}	6,667	3,898	12,544	10,753
13	M _{ox_agent}	0	0	0	0
14	E _{ta} _{genset}	NA	NA	NA	NA
15	E _{ta} _{boiler}	98.5%	98.5%	98.5%	98.5%
16	WW _{bypass}	12,362,872	13,191,805	-	-
17	LOSS _{pipeline}	0	0	0	0
18	M _{removed}	0	0	0	0
19	NCV _{biogas}	23.205	23.205	23.205	23.205
	V _{biogas produced}	2,151,077	2,227,386	10,930,945	7,808,034
	E _{CH4coll}	21,023	21,769	106,832	55,843