

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



Document Prepared By South Pole Carbon Asset Management Ltd.

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Project Title	Chol Charoen Group Wastewater Treatment with Biogas System I (Cholburi)
Version	03
Date of Issue	21-May-2018
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1 PROJECT DETAILS

1.1 Summary Description 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 07/01/06 (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).

In the absence of the project activity, the wastewater from the tapioca processing plant would have been treated in open anaerobic lagoons. After the implementation of the AFFR reactor, methane generated is recovered and used as an alternative to fossil fuel as well as electricity generation. This achieves emission reduction from avoidance of fugitive methane emissions to the environment by using AFFR reactors, and avoidance of carbon dioxide emissions from replacement of fossil fuel with biogas and replacing of electricity from grid.

The proposed project activity is expected to reduce 37,292 tCO₂e annually or total of 372,920 tCO₂e during 10-years of the second crediting period.

1.2 Sectoral Scope and Project Type

The project activity involves recovery of fugitive methane emissions using Complete Stirred Tank Reactor (CSTR) system together with anaerobic covered lagoon and utilizing the biogas produced to generate electricity.

The project has an electricity generation capacity less than 15 MW and 45 MW_{th}, which will generate emission reductions less than 60 ktCO_{2e} 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 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 energy generation component:

Type I: Renewable energy projects
 Category I.D: Grid connected renewable electricity generation
 Sectoral Scope 01: Energy Industries
 Version 18

Thermal energy generation component:

Type I: Renewable energy projects
 Category I.C: Thermal energy for the user with or without electricity
 Sectoral Scope 01: Energy Industries
 Version 20

This project activity is not a grouped project and not AFOLU project.

1.3 Project Proponent

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

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
Contact person	Santosh Kumar Singh
Title	Mr.
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1.5 Project Start Date

Project start date is 07/01/06 , (the date when emission reduction began). This is the date on which retrofitted hot oil boiler become operational with the utilisation of biogas.

1.6 Project Crediting Period

The second crediting period is ten years, from 01/01/2017 to 31/12/2026.

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	X
Large project	

Year	Estimated GHG emission reductions or removals (tCO ₂ e)
Year 2017	37,292
Year 2018	37,292
Year 2019	37,292
Year 2020	37,292
Year 2021	37,292
Year 2022	37,292
Year 2023	37,292
Year 2024	37,292
Year 2025	37,292
Year 2026	37,292
Total estimated ERs	372,920
Total number of crediting years	10
Average annual ERs	37,292

1.8 Description of the Project Activity

Technology description

This project entails an installation of “AFFR”, Anaerobic Fixed Film Reactor. This is a biological system and is designed as a high rate anaerobic reactor, where the loading rate of wastewater is a function of the quantity of methanogenic bacteria in the system. The basic fixed-film digester design consists of a tank, filled with media on which a consortium of bacteria attach and grow as a slime layer or “biofilm”; hence the name fixed film digester. The media is fully submerged and wastewater flow can either be upwards (up flow reactor) or downwards (down flow reactor). In this project activity, an up flow reactor is being used. As the wastewater passes through the media-filled reactor, the attached and suspended anaerobic biomass converts both soluble and particulate organic matter in the wastewater to biogas, a mixture of mostly methane and carbon dioxide.

Immobilization of the bacteria as a bio film prevents washout of slower growing cells and provides biomass retention independent of the hydraulic retention time (HRT). Since the bacteria are not continuously washed along with the effluent, a substantial microbial biomass develops within the reactor. Because there are more bacteria for a given reactor volume relative to conventional suspended-growth designs, less time is needed to degrade the wastewater, allowing operation at short HRTs. AFFR digesters are ideally suited for treating large volumes of dilute, low-strength wastewaters because large numbers of bacteria can be concentrated inside smaller digesters operating at shorter HRTs than would be needed to achieve the same degree of treatment with conventional suspended-growth anaerobic reactors.

The two AFFR based digesters, together, are designed with volumetric capacity of around 10,000 m³. In addition, synthetic high-density polyurethane (HDPE) lining have been installed to cover 3 existing lagoons in order to convert them into a biogas storage system to ensure the durability of biogas supply as well as being an emergency wastewater treatment system in the case of malfunction to the AFFR system..

Anaerobic treatment

The effluent from starch processing plant flows parallelly into two Anaerobic Fixed Film Reactors through an influent distribution system. In these methane reactors, organic compounds in wastewater are transformed mainly into biogas by anaerobic bacteria system. Under the design COD removal efficiency of raw tapioca wastewater of 80%, the production of biogas is estimated at 12,733 Nm³ per day (with methane percentage being at 55%¹). This represents the expected level of activity.

Biogas handling

The captured biogas will be routed to the boiler with a capacity of 3.78 MW_{thermal} (that has been modified to equip as a combination burner²), then onto gas engine with an installed generation capacity at an approximate of 2.2 MW_e³. The excess biogas (if any) will be sent to high temperature enclosed flare to destroy methane gas as it is produced. It should be noted that the flaring system will only be used in the case of emergency; in fact over the past first crediting period, an enclosed flare system has never been in used.

¹ Average methane content of biogas has a broad range of 55-80%; a lower value of 55% is chosen for the calculation to be conservative. <http://www.oregon.gov/ENERGY/RENEW/Biomass/biogas.shtml>

² A combination burner is installed to allow combustion of both biogas and fuel oil at the same time.

³ The electricity generation capacity is from (2 x 500 + 2 x 600).

Secondary treatment and final wastewater

The effluent will continue to flow from the closed anaerobic treatment section to the open lagoon system. After the whole treatment process, the COD concentration of the wastewater will be very low and thus the wastewater is again recycled to the factory for further utilisation⁴. It must be mentioned that there is no wastewater discharge outside the factory at all. The method of final discharge remains the same before and after the project activity. A relatively small amount of sludge will be removed infrequently and will be treated aerobically by land application⁵.

Table 1 : Description of main equipments in the project activity

Project/Baseline Component	Brief Description
Lagoon System	13 lagoons, commissioned in 1980 along with the operation start date of starch plant.
AFFR	Anaerobic Fixed Film Reactor with 80% design COD reduction efficiency. The hydraulic retention time is approximate 5 days as per design proposal provided by technology supplier. The AFFR started operation in January 2006, first month of biogas usage. Note that the two AFFR based digesters, together, are designed with volumetric capacity ⁶ of around 10,000 m ³ .
Boiler	This boiler is a dual fired boiler with thermal capacity with a capacity of 3.78 MW _{th} .
Gas engines	Altogether, there are electricity generation set consists of 4 generators, with total capacity of 2.2 MW _e (2 sets of 500 kW and 2 set of 600 kW ⁷).
Gas storage device	Two AFFRs and three covered lagoons are used as a gas storage system. The dimensions of these devices have been submitted during validation.
Flare	Flare has a maximum operation capacity of 250 Nm ³ /hr as per the technology description by the supplier. Last day biogas sent to flare was 03/06/06.
Capacity of auxiliary drives	Total capacity of the auxiliary drives amount to 139 kW , as per the latest information available during the last verification of the first crediting period.

⁴ Either for washing cassava roots or use for irrigation purpose of internal farmlands.

⁵ The sludge will be used for fertiliser purpose.

⁶ Design value

⁷ The generator no.1 was stopped and removed on 06/05/17, the existing generator no.4 which has been installed as spare engine for no.1 is permanently on duty. The new generator set has been installed in 2018. The order of generator is re-arranged.

- Generator no. 1 and 2 (previously no.2 and 3) - 500GF-RZ (500 kW): <http://www.generatorsetscn.com/1-3-4-500kw-biomass-generator-set.html> ;
- Generator no.3 (previously no.4) - 600GFZ1-RZ-ESM1 (600 kW) : <http://www.generatorsetscn.com/1-3-5-600kw-biomass-generator-set.html>
- Generator no.4 (new) - 600GFZ1-PWZ-ESM1 (600 kW): <http://www.generatorsetscn.com/1-3-5-600kw-biomass-generator-set.html>

1.9 Project Location

The proposed project activity is located at Chol Charoen Co., Ltd., in Banbung district, Choburi 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, Choburi, 20170, Thailand.

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



Figure 1 : Project Location



Figure 2 : Project Boundary

1.10 Conditions Prior to Project Initiation

Methane avoidance component:

Prior to project initiation, the wastewater from the tapioca processing plant was treated in the cascade of 13 open anaerobic lagoons (with retention time of around 300 days), thus emitting methane into the atmosphere. The open lagoon system, although has partially been modified to incorporate the gas storage system (in the form of covered lagoons), is still in use at the project activity as secondary treatment after the effluent has gone through the biogas reactor system.

Electricity generation component:

Fossil fuels based grid electricity by the Provincial Electricity Authority (PEA), was used for the operation of the starch factory.

Thermal generation component:

Fuel oil was solely used for thermal generation in hot oil boiler. The same boiler, after retrofit, is used also for combustion of methane.

Prior to project implementation, the sludge removal from lagoons is an irregular mechanism as anaerobic process does not lead to excessive sludge formation. The sludge removal from lagoons is a need based mechanism and observed interval of sludge removal is once a year during the past. The sludge removed is used for soil application as a fertilizer in the plant premises. Under the post-project scenario, any sludge removed from lagoons or anaerobic digester system is planned to be used for soil application.

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

The proposed project activity is in compliance with factory of Act, local laws and regulations such as the operation permit from the local government section and the Ministry of Industry, Thailand. The plant has the necessary legal documents including property deed, construction permit and operation permit. Moreover, the project activity needs to be get acceptance from the local stakeholders since any stakeholders' bad comment can be effect to the operation permit approval from Industrial Work Department (DIW).

The project's compliance to the local laws and regulations is confirmed by applicable operation license. For no discharge of wastewater outside the plant operational boundary the wastewater discharge regulations are not application in host country.

Laws and regulations	Control on	Demonstration of the compliance
Regulation on the limitation of discharge wastewater	Limit on COD of 120 mg/l of wastewater from starch factory that can be discharged out of the factory. ⁸	This project did not discharge wastewater to outside of the factory, instead the wastewater is used in the plantation area.

A valid operation permit ensures the compliance to applicable laws and regulations.

⁸ Notification by the Ministry of Industry, No. 2, B.E. 2539 (1996) issued under the Factory Act B.E. 2535 (1992); Re: Standard of Discharging Effluent from Factories. Note that an exception has been made to starch plants that 5-day BOD is not to exceed 60 mg/l and COD is not to exceed 120 mg/L. As well, the maximum permissible COD content of wastewater discharge is 400 mg/l for all types of industry.

1.12 Ownership and Other Programs

1.12.1 Project Ownership

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

- 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 not been and will not be registered under other GHG programs.

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.

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 wellbeing. 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.

Further Information

Not Applicable.

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

Baseline & Monitoring Methodology for the project activity is defined:

- AMS III.H: Methane Recovery in Wastewater Treatment, version 18.0;
- AMS I.C: Thermal energy for user with or without electricity, version 20.0;
- AMS I.D : Grid connected renewal electricity generation, version 18.0.

The above selected methodologies also refer to the latest approved versions of the following approved methodologies and methodological tools:

- a) Project emissions from flaring, version 02.0.0;
- b) Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" , version 03.0;
- c) Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion, version 03.0;
- d) Determining the baseline efficiency of thermal or electric energy generation systems, version 02.0;
- e) Tool to calculate the emission factor for an electricity system, version 06.0.

2.2 Applicability of Methodology

Applicability Criteria from AMS III.H	Project Status
2. This methodology comprises measures that recover biogas from biogenic organic matter in wastewater by means of one, or a combination, of the following options: (a) Substitution of aerobic wastewater or sludge treatment systems with anaerobic systems with biogas recovery and combustion; (b) Introduction of anaerobic sludge treatment system with biogas recovery and combustion to a wastewater treatment plant without sludge treatment; (c) Introduction of biogas recovery and combustion to a sludge treatment system; (d) Introduction of biogas recovery and combustion to an anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an on-site industrial plant; (e) Introduction of anaerobic wastewater treatment with biogas recovery and combustion, with or without anaerobic sludge treatment, to an untreated wastewater stream; (f) Introduction of a sequential stage of wastewater treatment with biogas recovery and combustion, with or without sludge treatment, to an anaerobic wastewater treatment system without biogas recovery (e.g. introduction of treatment in an anaerobic reactor with biogas recovery as a sequential treatment step for the wastewater that is presently being treated in an anaerobic lagoon without methane recovery).	In the absence of the project activity the wastewater would have been treated in existing open lagoons (all with depth greater than 2 meters) under anaerobic condition without biogas recovery. The project activity involves the installation of AFFR and covered lagoon system to treat high COD concentration of wastewater generated and to capture biogas. Therefore, the project activity can fulfil the applicability condition (f).

Applicability Criteria from AMS III.H	Project Status
3. In cases where baseline system is anaerobic lagoon the methodology is applicable if: a) The lagoons are ponds with a depth greater than two meters, without aeration. The value for depth is obtained from engineering design documents, or through direct measurement, or by dividing the surface area by the total volume. If the lagoon filling level varies seasonally, the average of the highest and lowest levels may be taken; b) Ambient temperature above 15°C, at least during part of the year, on a monthly average basis; c) The minimum interval between two consecutive sludge removal events shall be 30 days.	The wastewater would have been treated in an open anaerobic lagoon in the absence of the project. a) The baseline system is anaerobic lagoons with the minimum depth of 2 m.; b) The average atmospheric temperature in the region is greater than 15 degree Celsius⁹; c) There was no any sludge removal before the implementation of project activity. The minimum interval is definitely more than 30 days. Therefore, the project activity is applicable for this criterion.
4. The recovered biogas from the above measures may also be utilised for the following applications instead of combustion/flaring: a) Thermal or mechanical, electrical energy generation directly; b) Thermal or mechanical, electrical energy generation after bottling of upgraded biogas, in this case additional guidance provided in the appendix shall be followed; or c) Thermal or mechanical, electrical energy generation after upgrading and distribution, in this case additional guidance provided in the appendix shall be followed: i. Upgrading and injection of biogas into a natural gas distribution grid with no significant transmission constraints; ii. Upgrading and transportation of biogas via a dedicated piped network to a group of end users; or iii. Upgrading and transportation of biogas (e.g. by trucks) to distribution points for end users; d) Hydrogen production; e) Use as fuel in transportation applications after upgrading.	The captured biogas from the project activity will be utilized for thermal and electricity energy generation directly which falls under condition a).

⁹ Source: METEOROLOGICAL DEPARTMENT, website http://www.tmd.go.th/agromet_report.php

Applicability Criteria from AMS III.H	Project Status
5. If the recovered biogas is used for project activities covered under paragraph 4(a), that component of the project activity can use a corresponding methodology under Type I.	The recovered biogas will be used for heat and power generation as mentioned above and that component of the project activity will use the category under AMS I.C and AMS I.D.
6. For project activities covered under paragraph 4(b), if bottles with upgraded biogas are sold outside the project boundary, the end-use of the biogas shall be ensured via a contract between the bottled biogas vendor and the end-user. No emission reductions may be claimed from the displacement of fuels from the end use of bottled biogas in such situations. If, however, the end use of the bottled biogas is included in the project boundary and is monitored during the crediting period CO ₂ emissions avoided by the displacement of fossil fuel can be claimed under the corresponding Type I methodology, e.g. "AMS-I.C.: Thermal energy production with or without electricity".	This condition is not relevant to the project activity.
7. For project activities covered under paragraph 4(c)(i), emission reductions from the displacement of the use of natural gas are eligible under this methodology, provided the geographical extent of the natural gas distribution grid is within the host country boundaries.	This condition is not relevant to the project activity.
8. For project activities covered under paragraph 4(c)(ii), emission reductions for the displacement of the use of fuels can be claimed following the provision in the corresponding Type I methodology, e.g. AMS-I.C.	This condition is not relevant to the project activity.
9. In particular, for the case of paragraph 4(b) and (c)(iii), the physical leakage during storage and transportation of upgraded biogas, as well as the emissions from fossil fuel consumed by vehicles for transporting biogas shall be considered. Relevant procedures in paragraph 18 of the appendix of "AMS-III.H.: Methane recovery in wastewater treatment" shall be followed in this regard.	This condition is not relevant to the project activity.
10. For project activities covered under paragraph 4(b) and (c), this methodology is applicable if the upgraded methane content of the biogas is in accordance with relevant national regulations (where these exist) or, in the absence of national regulations, a minimum of 96 per cent (by volume).	This condition is not relevant to the project activity.

Applicability Criteria from AMS III.H	Project Status
11. If the recovered is utilized for the production of hydrogen (project activities covered under paragraph 3(d)), that component of the project activity shall use the corresponding methodology “AMS III.O.: Hydrogen production using methane extracted from biogas”.	This condition is not relevant to the project activity.
12. If the recovered biogas is used for project activities covered under paragraph 4(e), that component of the project activity shall use corresponding methodology “AMS-III.AQ.: Introduction of Bio-CNG in transportation applications”.	This condition is not relevant to the project activity.
13. New facilities (Greenfield projects) and project activities involving a change of equipment resulting in a capacity addition of the wastewater or sludge treatment system compared to the designed capacity of the baseline treatment system are only eligible to apply this methodology if they comply with the relevant requirements in the “General guidelines for SSC CDM methodologies”. In addition the requirements for demonstrating the remaining lifetime of the equipment replaced, as described in the general guidelines shall be followed.	The project activity is not a greenfield project. Hence this condition is not relevant to the project activity.
14. The location of the wastewater treatment plant as well as the source generating the wastewater shall be uniquely defined and described in the PDD.	The location of project activity is clearly identified in section 1.9 above.
15. Measures are limited to those that result in aggregate emissions reductions of less than or equal to 60 kt CO ₂ equivalent annually from all Type III components of the project activity.	The emission reductions achieved by this project activity is 37,292 tCO ₂ e per year which is much less than the limit.

Applicability Criteria from AMS I.D	Project Status
2. This methodology comprises renewable energy generation units, such as photovoltaics, hydro, tidal/wave, wind, geothermal and renewable biomass: (a) Supplying electricity to a national or a regional grid; or (b) Supplying electricity to an identified consumer facility via national/regional grid through a contractual arrangement such as wheeling.	The project involves the installation of generators that will use biogas as fuel to produce electricity. The total capacity of the generators is 1.952 MW. Hence, the project activity is satisfied with this applicability criterion.
3. Illustration of respective situations under which each of the methodology (i.e. “AMS-I.D.: Grid	The project activity will use a part of biogas (a renewable fuel) which is

Applicability Criteria from AMS I.D	Project Status
connected renewable electricity generation", "AMS-I.F.: Renewable electricity generation for captive use and mini-grid" and "AMS-I.A.: Electricity generation by the user) applies is included in the appendix.	captured from the methane avoidance component of the project activity to generate electricity by the gas engines. The electricity generated will be firstly served the internal consumption and then exported to the national grid. Hence, it can be concluded that AMS I.D is applicable for this project activity.
4. This methodology is applicable to project activities that (a) Install a Greenfield plan; (b) Involve a capacity addition in (an) existing plant(s); (c) Involve a retrofit of (an) existing plant(s); (d) Involve a rehabilitation of (an) existing plant(s)/unit(s); or (e) Involve a replacement of (an) existing plant(s).	The project activity will install a gas engine set at the project site where there was no renewable energy power plant operating prior to the implementation of the project.
5. Hydro power plants with reservoirs that satisfy at least one of the following conditions are eligible to this methodology: (a) The project activity is implemented in an existing reservoir with no change in the volume of reservoir; (b) The project activity is implemented in an existing reservoir, where the volume of reservoir is increased and the power density of the project activity, as per definitions given in the project emissions section, is greater than 4 W/m ² ; (c) The project activity results in new reservoirs and the power density of the power plant, as per definitions given in the project emissions section, is greater than 4 W/m ² .	This condition is not relevant to the project activity.
6. If the new unit has both renewable and non-renewable components (e.g. a wind/diesel unit), the eligibility limit of 15MW for a small-scale CDM project activity applies only to the renewable component. If the unit added co-fires fossil fuel, the capacity of the entire unit shall not exceed the limit of 15 MW.	The total capacity of the generators for producing electricity is 1.952 MW which does not use the co-fired fossil fuel. Therefore, the project activity is applicable for this criterion.
7. Combined heat and power (co-generation) systems are not eligible under this category.	This condition is not relevant to the project activity
8. In the case of project activities that involve the capacity addition of renewable energy generation units at an existing renewable power generation facility, the added capacity of the units added by the project should be lower than	This condition is not relevant to the project activity

Applicability Criteria from AMS I.D	Project Status
15 MW and should be physically distinct from the existing units.	
9. In the case of retrofit, rehabilitation or replacement, to qualify as a small-scale project, the total output of the retrofitted, rehabilitated or replacement power plant/unit shall not exceed the limit of 15 MW.	This condition is not relevant to the project activity
10. In the case of landfill gas, waste gas, wastewater treatment and agro-industries projects, recovered methane emissions are eligible under a relevant Type III category. If the recovered methane is used for electricity generation for supply to a grid then the baseline for the electricity component shall be in accordance with procedure prescribed under this methodology. If the recovered methane is used for heat generation or cogeneration other applicable Type-I methodologies such as “AMS-I.C.: Thermal energy production with or without electricity” shall be explored.	The approved baseline and monitoring methodologies. AMS-I.D. is used for the electricity generation components of the project activity.
11. In case biomass is sourced from dedicated plantations, the applicability criteria in the tool “Project emissions from cultivation of biomass” shall apply.	This condition is not relevant to the project activity

Applicability Criteria from AMS I.C	Project Status
3. Biomass-based cogeneration and trigeneration systems are included in this category.	The project activity is not the biomass-based cogeneration and trigeneration systems. Hence, this condition is not relevant to the project activity.
4. Emission reductions from a biomass cogeneration or trigeneration system can accrue from one of the following activities: a) Electricity supply to a grid; b) Electricity and/or thermal energy production for on-site consumption or for consumption by other facilities; c) Combination of (a) and (b).	This condition is not relevant to the project activity.
5. Project activities that seek to retrofit or modify an existing facility for renewable energy generation are included in this category.	The project activity concerns the retrofitting of the existing fossil fuelled boiler system.
6. In the case of new facilities (Greenfield projects) and project activities involving capacity additions the relevant requirements related to determination of baseline scenario provided in the "General guidelines for SSC CDM methodologies" for Type-II and Type III Greenfield/capacity expansion project activities also apply.	The project activity is not a greenfield project. Hence, this condition is not relevant to the project activity.
7. The total installed/rated thermal energy generation capacity of the project equipment is equal to or less than 45 MW thermal (see paragraph 9 for the applicable limits for cogeneration and trigeneration project activities).	The thermal capacity of boiler is 3.78 MW _{th} which is lower than the 45 MW _{th} threshold. Hence, the project activity satisfies this condition.
8. For co-fired systems, the total installed thermal energy generation capacity of the project equipment, when using both fossil and renewable fuel, shall not exceed 45 MW thermal (see paragraph 9 for the applicable limits for cogeneration project activities).	The thermal capacity of boiler is 3.78 MW _{th} which is lower than the 45 MW _{th} threshold. Hence, the project activity satisfies this condition.
9. The following capacity limits apply for biomass cogeneration and trigeneration units: a) If the emission reductions of the project activity are on account of thermal and electrical energy production, the total installed thermal and electrical energy generation capacity of the project equipment shall not exceed 45 MW thermal. For the purpose of calculating the capacity limit the conversion factor of 1:3 shall be used for converting electrical energy to thermal energy (i.e. for renewable energy project activities, the installed capacity of 15 MW(e) is	The project activity is not the biomass cogeneration and trigeneration system.

Applicability Criteria from AMS I.C	Project Status
equivalent to 45 MW thermal output of the equipment or the plant); b) If the emission reductions of the project activity are solely on account of thermal energy production (i.e. no emission reductions accrue from the electricity component), the total installed thermal energy production capacity of the project equipment shall not exceed 45 MW thermal; c) If the emission reductions of the project activity are solely on account of electrical energy production (i.e. no emission reductions accrue from the thermal energy component), the total installed electrical energy generation capacity of the project equipment shall not exceed 15 MW.	
10. The capacity limits specified in paragraphs 7 to 9 above apply to both new facilities and retrofit projects. In the case of project activities that involve the addition of renewable energy units at an existing renewable energy facility, the total capacity of the units added by the project shall comply with capacity limits specified in the paragraphs 7 to 9, and shall be physically distinct from the existing units.	The thermal capacity of boiler is 3.78 MW_{th} which is lower than the 45 MW_{th} threshold. Hence, the project activity satisfies this condition.
11. If solid biomass fuel (e.g. briquette) is used, it shall be demonstrated that it has been produced using solely renewable biomass and all project or leakage emissions associated with its production shall be taken into account in the emissions reduction calculation.	The project activity does not consume any solid biomass fuels.
12. Where the project participant is not the producer of the processed solid biomass fuel, the project participant and the producer are bound by a contract that shall enable the project participant to monitor the source of the renewable biomass to account for any emissions associated with solid biomass fuel production. Such a contract shall also ensure that there is no double-counting of emission reductions.	This condition is not relevant to the project activity.
13. If electricity and/or thermal energy produced by the project activity is delivered to a third party i.e. another facility or facilities within the project boundary, a contract between the supplier and consumer(s) of the energy will	The thermal energy generated from project activity will be used internally within starch factory.

Applicability Criteria from AMS I.C	Project Status
have to be entered into that ensures there is no double-counting of emission reductions.	
14. If the project activity recovers and utilizes biogas for producing electricity and/or thermal energy and applies this methodology on a standalone basis i.e. without using a Type III component of a SSC methodology, any incremental emissions occurring due to the implementation of the project activity (e.g. physical leakage of the anaerobic digester, emissions due to inefficiency of the flaring), shall be taken into account either as project or leakage emissions as per relevant procedures in the tool “Emissions from solid waste disposal sites” and/or “Project emissions from flaring”. In the event that the biomass fuel (solid/liquid/gas) is sourced from an existing CDM project, then the emissions associated with the production of the fuel shall be accounted with that project.	The project activity also applies AMS III.H for methane avoidance component.
15. If project equipment contains refrigerants, then the refrigerant used in the project case shall have no ozone depleting potential (ODP).	This condition is not relevant to the project activity.

Applicability Criteria from AMS I.C	Project Status
16. Charcoal based biomass energy generation project activities are eligible to apply the methodology only if the charcoal is produced from renewable biomass sources-provided: a) Charcoal is produced in kilns equipped with methane recovery and destruction facility; or b) If charcoal is produced in kilns not equipped with a methane recovery and destruction facility, methane emissions from the production of charcoal shall be considered. These emissions shall be calculated as per the procedures defined in the approved methodology "AMS-III.K: Avoidance of methane release from charcoal production by shifting from traditional open-ended methods to mechanized charcoaling process". Alternatively, conservative emission factor values from peer reviewed literature or from a registered CDM project activity can be used, provided that it can be demonstrated that the parameters from these are comparable e.g. source of biomass, characteristics of biomass such as moisture, carbon content, type of kiln, operating conditions such as ambient temperature.	This condition is not relevant to the project activity.
17. In cases where the project activity utilizes biomass, sourced from dedicated plantations, applicability conditions prescribed in the tool "Project emissions from cultivation of biomass" shall apply.	This condition is not relevant to the project activity.

2.3 Project Boundary

The project boundary is the physical, geographical site where the wastewater and sludge treatment takes place, in the baseline and project situations. It covers all facilities affected by the project activity including sites where processing, transportation and application or disposal of waste products as well as biogas takes place.

The following emission sources and gases are considered in the emission reduction calculation of this project activity.

Source		Gas	Included?	Justification/Explanation
Baseline	Emission from the existing wastewater treatment system, i.e., open lagoon system	CH ₄	Included	Emission from decomposition of organic matter in anaerobic conditions.
		CO ₂	Excluded	CO ₂ emissions from the decomposition of organic matter are not accounted for because biogenic in nature.
		N ₂ O	Excluded	Excluded for simplification.
	Electricity energy Generation	CH ₄	Excluded	Excluded for simplification. This is conservative
		CO ₂	Included	Emission from electricity generation in the grid displaced by the project activity.
		N ₂ O	Excluded	Excluded for simplification. This is conservative
	Thermal energy Generation (Boiler)	CH ₄	Excluded	Excluded for simplification. This is conservative
		CO ₂	Included	Emission from fuel oil consumption in the baseline scenario.
		N ₂ O	Excluded	Excluded for simplification. This is conservative
Project	Wastewater treatment system	CH ₄	Included	The treatment of wastewater under the project activity are from: - Decomposition of the organic matter in the open anaerobic lagoons - Physical leakage from the bio-digester - Incomplete flaring
		CO ₂	Excluded	CO ₂ emissions from the decomposition of organic matter are not accounted for because biogenic in nature.
		N ₂ O	Excluded	Excluded for simplification. This is conservative.
	On-site electricity use	CH ₄	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		CO ₂	Included	On-site electricity consumed by project activity which is imported from grid will be accounted for.
		N ₂ O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	On-site fossil fuel consumption	CH ₄	Excluded	Excluded for simplification. This is conservative
		CO ₂	Included	Emission from fuel oil consumption in the project scenario.
		N ₂ O	Excluded	Excluded for simplification. This is conservative

The system boundaries for calculation of project and baseline emissions is illustrated in the following figures.



Figure 3 : The baseline system boundary

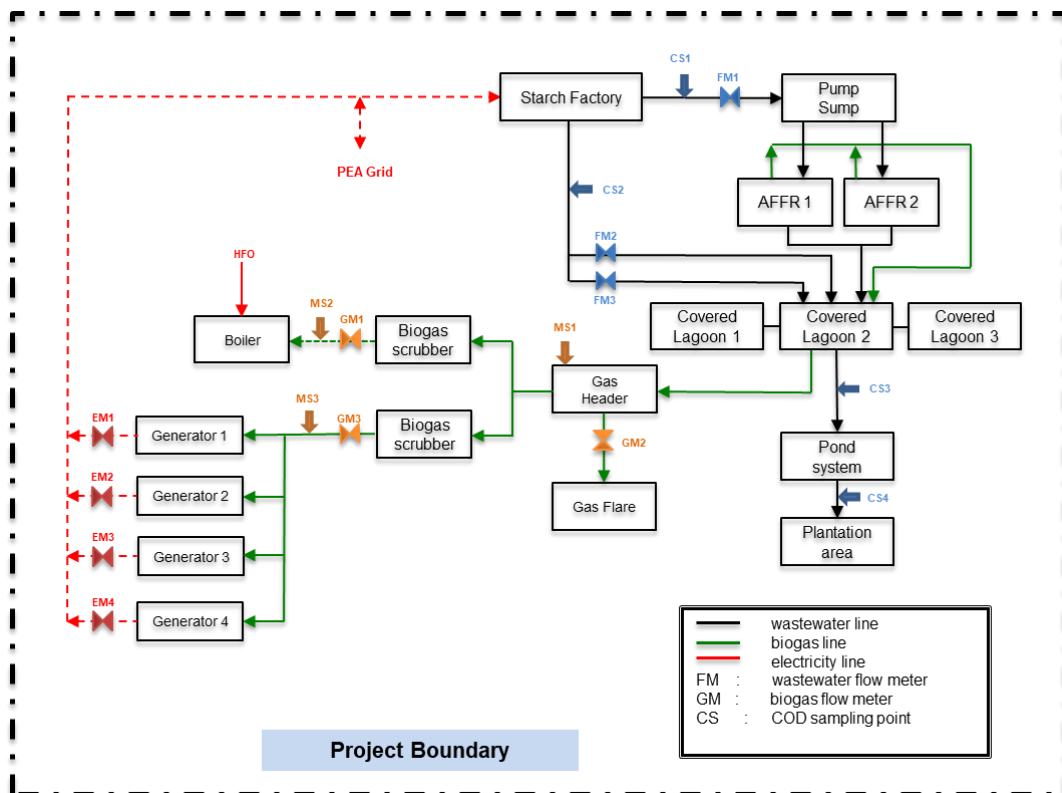


Figure 4 : The project system boundary

2.4 Baseline Scenario

Demonstration the validity of baseline scenario

As per reference from the VCS standard (version 3 v.3.7), section 3.8.5: Renewal of Project Crediting Period, 2) *The validity of the original baseline scenario shall be demonstrated, or where invalid a new baseline scenario shall be determined, when renewing the project crediting period, as follows:*

Assessment as per VCS standard	Justification
(a) The validity of the original baseline scenario shall be assessed. Such assessment shall include an evaluation of the impact of new relevant national and/or sectoral policies and circumstances on the validity of the baseline scenario.	Refer to section 1.11 of this PD, <i>The proposed project activity is in compliance with all local laws and regulations.</i> In addition to the regulatory surplus assessment described in section 2.5 , the regulations regarding the wastewater treatment are issued under Factory Act ¹⁰ , as well as the national policies , which will be regulated to the factory by identifying as the operation conditions attached with the operating license. Therefore, there is no impact to the original baseline of project activity as per the present operating license.
(b) Where it is determined that the original baseline is still valid, the GHG emissions associated with the original baseline scenario shall be reassessed using the latest version of the CDM Tool to assess the validity of the original/current baseline and to update the baseline at the renewable of a crediting period.	The assessment is provided in Table 3 , Table 4 and Table 6.
(c) Where it is determined that the original baseline scenario is no longer valid, the current baseline scenario shall be established in accordance with the VCS rules.	According to assessment result presented in Table 3 , Table 4 and Table 6 , the original baseline scenario is still valid. This section is not applicable.
(d) The project description, containing updated information with respect to the baseline, the estimated GHG emission reductions or removals and the monitoring plan, shall be submitted for validation.	The project description is updated and revised according to the latest approved version of AMS III.H , AMS I.C and AMS I.D including the relevant tools to the applied methodologies.

¹⁰ <http://www.wepa-db.net/policies/measures/currentsystem/thailand.htm>
https://www.jetro.go.jp/thailand/e_survey/factoryact.html

Methane avoidance component:

At the project location, open anaerobic lagoons without methane recovery represent the existing wastewater treatment system and the biogas reactor system is being introduced as a sequential stage with methane recovery to the existing lagoon system (as defined under applicability conditions for project activity measures under the applied methodology, see Section 2.2 above).

Therefore, the baseline scenario to the project activity is defined as follows:

“The existing anaerobic wastewater treatment system without methane recovery for the case of introduction of a sequential anaerobic wastewater treatment system with methane recovery”

The baseline scenario consists of 13 anaerobic lagoons, which were used to treat wastewater prior to project implementation. The lagoons has an average depth of 6 m. The following table gives the description of lagoons at the starch facility.

Table 2: Characteristics of the baseline open anaerobic lagoons

No.	Area	Depth	Volume
	m ²	m	m ³
1	2,100	6.0	12,600
2	15,000	6.0	90,000
3	4,800	6.0	28,800
4	4,800	6.0	28,800
5	4,800	6.0	28,800
6	4,200	6.0	25,200
7	6,900	6.0	41,400
8	5,520	6.0	33,120
9	5,600	6.0	33,600
10	5,600	6.0	33,600
11	5,600	6.0	33,600
12	15,000	6.0	90,000
13	4,953	6.0	29,718
Total	84,873		509,238

According to the principle design of the anaerobic pond, the average volume of waste water is about 2,400 m³/day¹¹ which gives a retention time of approximately 212 days. The ponds are minimum 2 meters in depth measured from the water surface. Therefore, the open lagoons of starch factory are under anaerobic process because the retention time and depth of ponds are higher than principle design value.

¹¹ Based on design value in proposal with 10 m³ of wastewater expected to be generated per tonne of dry starch production.

Table 3 : Validity of original baseline for methane avoidance component

Assessment as per CDM Tool	Justification
<i>Step 1:</i> Assess the validity of the current baseline for the next crediting period	
<i>Step 1.1:</i> Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies	The project complies with the national policies as the justification is provided in the previous section.
<i>Step 1.2:</i> Assess the impact of circumstances	There is no change in the circumstance that would impact the continuation of existing open lagoon system as a baseline scenario of the project.
<i>Step 1.3:</i> Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested.	The identified baseline scenario at the first validation of this project was the continuous using of the existing anaerobic open lagoons without any investment. This system requires extremely limited operation and maintenance due to the self-regulatory nature of the systems. Hence, lagoons are a very cost-effective solution, do not require advanced technology and are easy to operate and maintain ¹² . The technical lifetime of baseline system exceeds the crediting period for which renewal is requested.
<i>Step 1.4:</i> Assessment of the validity of the data and parameters	All data and parameters that were determined at the start of the crediting period are updated accordingly.

The justification provided above shows that the current baseline scenario for methane avoidance component is still valid for subsequent crediting period. Therefore, all data and parameters can be used for the renewed crediting period.

Electricity generation component:

According to clause 19 of AMS.I.D , the baseline scenario for Greenfield power plant , *The baseline scenario is that the electricity delivered to the grid by the project activity would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources into the grid.*

In absence of the project activity, the project would use electricity supplied from grid.

Table 4 : Validity of original baseline for electric energy generation component

Assessment as per CDM tool	Justification
<i>Step 1:</i> Assess the validity of the current baseline for the next crediting period	
<i>Step 1.1:</i> Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies	The project complies the national policies as the justification is provided in the previous section.

¹² Cinara, 2004 "Waste stabilization ponds for wastewater treatment, International Water and Sanitation Centre"
<http://www.irc.nl/page/8237>

Step 1.2: Assess the impact of circumstances	There is no change in the circumstance that would impact the continuation of using electricity from grid system as a baseline scenario of the project.
Step 1.3: Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested.	The continuation to use the electricity imported from grid as a most likely scenario for source of electricity supplied to project activity is still applicable for this crediting period.
Step 1.4: Assessment of the validity of the data and parameters	All data and parameters that were determined at the start of the crediting period are updated accordingly.

Thermal energy generation component:

According to AMS.I.C , *For renewable energy technologies that displace technologies using fossil fuels, the simplified baseline is the fuel consumption of the technologies that would have been used in the absence of the project activity, times an emission factor for the fossil fuel displaced.*

In absence of the project activity, the project would use fossil fuel in boiler to produce thermal energy,

As per clause 25 of AMS I.C ; *For project activities implemented in existing facilities, baseline calculations shall be based on operational data on energy use (e.g. electricity, fossil fuel) and plant output (e.g. thermal and/or electrical energy) using;*

- a) *Most recent three years operational data immediately prior to the start date of the project activity in case of existing facilities which has more than three years of operation history;*
- b) *A minimum of most recent one year data in case of existing facilities which has more than three years of operation history but do not have three years operational data; or*
- c) *A performance test/measurement campaign carried out prior to the implementation of the project activity in case of existing facilities which has more than three years of operation history but do not have operational data/information such as efficiency, energy consumption and output or the available data is not reliable due to various factors such as the use of imprecise or non-calibrated measuring equipment. The project proponent may follow the relevant provisions from the "Tool to determine baseline efficiency of thermal and electricity systems".*

The ex-ante estimation of the baseline emissions for the thermal energy component is based on the historical consumption of fuel oil per tonne of dry starch production i.e. specific fuel oil consumption is used to ex ante baseline emissions. Consequently, the simplified baseline here would be the fuel consumption of the technologies that would have been used in the absence of the project activity times and emission coefficient for the fossil fuel displaced. In this case, IPCC default value for emission coefficient of fuel oil will be used. Comparison between fuel oil consumption and starch production over the period for the year 2002, 2003, and 2005 (pre-project) is shown in **Table 5** below.

Table 5 : Comparison of fuel oil consumption and starch production¹³

Year	Starch production (kg)	Fuel oil consumption (liter)	Average fuel oil consumption (liters/kg of starch)
2002	63,776,092	2,169,000	0.0340
2003	70,620,232	2,428,000	0.0344
2005	24,394,730	839,000	0.0344

Please note that 2004 fuel oil consumption data has been misplaced and cannot be found. However, its absence does not mean that the accuracy of our emission reductions calculation has been compromised. To elaborate on this, HFO consumption record is used to determine parameter $Q_{FO, starch}$, a default value representing litre of fuel oil consumption per tonne of starch production, which we use to calculate emissions from HFO displacement as per the methodology deviation described in the PD. The applied value of 34.3 litres/tonne was deemed taking an average from historical record over 3 years (i.e. 2002, 2003 and 2005). With the values in these 3 years vary very little from 34.01 – 34.39 litres per tonne of dry starch, and the difference here being as little as 1-2%, it can be concluded that our estimated default value is realistic and representative despite the unavailability of data in 2004.

Table 6 : Validity of original baseline for thermal energy generation component

Assessment as per CDM tool	Justification
<i>Step 1:</i> Assess the validity of the current baseline for the next crediting period	
<i>Step 1.1:</i> Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies	The project complies the national policies as the justification is provided in the previous section.
<i>Step 1.2:</i> Assess the impact of circumstances	There is no change in the circumstance that would impact the continuation of HFO consumption in the thermal oil boilers as a baseline scenario of the project.
<i>Step 1.3:</i> Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested.	The thermal oil boiler system which has been operated before the implementation of project activity and was modified for the biogas burning, has been continuously inspected on annually basis as per the safety regulations for boiler and pressure vessel , issued under Factory Act ¹⁴ . The outcome of regulations is the factory has to do the annual inspection, approved by the Professional Mechanical Engineer. The result of inspection gives 'pass' which has a validity of one year, which is under the boiler regulations of Thailand.

¹³ Note that 2004 data is missing

¹⁴ <http://www.diw.go.th/hawk/content.php?mode=laws&tabid=1&secid=4&subid=1>

	It should be noted that the boiler is not a primary investment of the project activity as it uses biogas generated from the project for supplying heat to the starch factory. The usage of boiler depends on the operation of the starch factory. Which will not impact to the baseline situation of thermal energy component.
Step 1.4: Assessment of the validity of the data and parameters	All data and parameters that were determined at the start of the crediting period are updated accordingly.

The justification provided above shows that the current baseline scenario for thermal generation component is still valid for subsequent crediting period. Therefore, all data and parameters can be used for the renewed crediting period.

2.5 Additionality

As per the VCS standard v3.7 for the renewal of crediting period, a full reassessment of additionality is not required when renewing the project crediting period. However, regulatory surplus shall be demonstrated in accordance with Section 4.6.3) and the project description shall be updated accordingly.

Step 1: Regulatory surplus

The project shall not be mandated by any law, statute or other regulatory framework. For UNFCCC non-Annex I countries, laws, statutes, regulatory frameworks or policies implemented¹⁵ since 11 November 2001 that give comparative advantage to less emissions intensive technologies or activities relative to more emissions-intensive technologies or activities need not be taken into account. For all countries, laws, statutes, regulatory frameworks or policies implemented since 11 December 1997 that give comparative advantage to more emissions intensive technologies or activities relative to less emissions-intensive technologies or activities shall not be taken into account.

There is no other regulatory requirement for the implementation of a specific wastewater treatment technology such as anaerobic digester or aerobic treatment system to tapioca starch processing plants for effluent treatment¹⁶. The current law in Thailand, which allows the use of open lagoon systems and other waste treatment technologies that meet effluent standards for the discharge of treated wastewater into the environment (COD ≤ 120 mg/l and 5-day BOD not exceeding 20 mg/l)¹⁷. Therefore, The proposed project activity is a regulatory surplus as it is not being implemented to respond to laws or regulations.

¹⁵ Implemented in the context of this paragraph means enacted or introduced, consistent with use of the term under the CDM rules on so-called Type E+ and Type E- policies.

¹⁶ <http://www.wepa-db.net/policies/measures/currentsystem/thailand.htm>
https://www.jetro.go.jp/thailand/e_survey/factoryact.html

¹⁷ Notification by the Ministry of Industry, No. 2, B.E. 2539 (1996) issued under the Factory Act B.E. 2535 (1992); Re: Standard of Discharging Effluent from Factories. Note that an exception has been made to starch plants that 5-day BOD is not to exceed 60 mg/l. As well, the maximum permissible COD content of wastewater discharge is 400 mg/l for all types of industry.

The assessment of additionality from the prior PD is provided as follow.

Additionality assessment

Referring the definition stated in the VCS Program Guidelines (section 2.2), the ‘additional’ criteria rectified that “project-based GHG emission reductions and removals must be additional to what would have happened under a business as usual scenario if the project had not been carried out”. Within this scope, the issue of additionality has already been demonstrated in section 1.8 of this VCS PD.

The Attachment A to Appendix B of the simplified modalities and procedures for small-scale CDM project activities¹⁸, which is referred to in the applied small-scale CDM methodologies, In addition, the VCS project test (as per VCS 2007.1 section 5.8) has been used as additional guidance to structure the additionality discussion below.

In order to ensure that assessment of additionality is robust, alternative scenarios to the project activity have been identified for comparative assessment:

Alternatives Plausible alternatives available to the project participant	
Alternative (a)	Status-quo: operation of anaerobic open lagoon system without the capture and utilization of biogas
Alternative (b)	To develop new anaerobic wastewater treatment facilities with methane capture and utilisation (proposed project undertaken as a VCS)
Alternative (c)	To develop new aerobic wastewater treatment facilities
Alternative (d)	Direct discharge to nearby river

STEP 1: Regulatory surplus

Alternatives (a), (b) and (c) are in compliance with current regulations in Thailand which allows the use of open lagoon systems as well as other wastewater treatment technologies that meet effluent standards for the discharge of treated wastewater into the environment (COD $\leq$ 120 mg/l and 5-day BOD not exceeding 20 mg/l)¹⁹. There is no other regulatory requirement for the implementation of a specific wastewater treatment technology (such as whether to apply anaerobic digester or aerobic treatment system) to tapioca processing plants for effluent treatment. Thus, it is clear that alternatives (a), (b) and (c) do not face any legal barriers, and is regulatory surpluses to any enforced legal framework. Alternative (d) is, by contrast, in violation of the effluent discharge standards set by the laws and regulations in Thailand. Therefore, alternative (d) cannot be considered as a baseline scenario and is excluded from further assessment.

STEP 2: Implementation Barriers

Investment Barrier

Thailand is one of the largest producers of tapioca starch. The starch extraction process requires a vast volume of water which in turn produces large amount of wastewater. Open lagoon treatment system i.e., the status quo system is most widely practiced method to treat

¹⁸ http://cdm.unfccc.int/Reference/Guidclarif/ssc/methSSC_guid05.pdf

¹⁹ Notification by the Ministry of Industry, No. 2, B.E. 2539 (1996) issued under the Factory Act B.E. 2535 (1992); Re: Standard of Discharging Effluent from Factories. Note that an exception has been made to starch plants that 5-day BOD is not to exceed 60 mg/l. As well, the maximum permissible COD content of wastewater discharge is 400 mg/l for all types of industry.

starch processing wastewater^{20, 21}. This practice is low cost and usually least cost in both capital, and operation & maintenance cost^{22, 23}. Moreover, the open lagoon treatment system requires no further investment because the project proponent has already in place treatment facility. Therefore, alternative (a) does not face investment barriers.

Due to high BOD/COD contents of wastewater from tapioca starch plant, no operator is willing to consider alternative (c) as electricity consumption of the aerator would be extremely high. This constitutes high operational and maintenance cost through the project's lifetime with no expected revenue to topple the already high initial investment cost. As well, there are other means to meet the effluent standards regulated by the government that are more financially attractive. Therefore, it is possible to conclude that alternative (c) will also face investment barriers.

As per **Energy Conversation and Renewable Energy Division** and **Energy Policy and Planning Division** of the Ministry of Environment, Government of Thailand "*Most of the tapioca starch plants choose to retain wastewater in their open lagoons because of insufficient knowledge / confidence in the technology, high investment cost compared to cheap land price, the resulting operating cost throughout the treatment life*"²⁴. Therefore penetration of other advanced wastewater treatment technologies is very low in Thailand and biogas projects are considered as highly risky by the financiers. Hence, financing of biogas project in starch industry appears to be constraint²⁵. Due to high risks associated with such kind of projects even, without subsidies, it is almost impossible to produce a bankable document for the loan proposal²⁶.

To further demonstrate the investment barrier of the project activity, a simple investment analysis has been applied to the project to demonstrate the additionality of the project. The analysis has been made to assess the feasibility of the project with and without including the monetary benefits of VERs. The applied financial indicator used is the Internal Rate of Return (IRR). For this project activity, an average Minimum Lending Rate (MLR) of local commercial banks in Thailand on 12th July 2002 (investment decision date) at 7.2115%²⁷ is taken to reflect a minimum acceptable rate of return of a standard private investment. It should be noted that the MLR represents the most conservative choice of financial benchmarks for a project IRR comparison among the options provided by the CDM "Guidance on the assessment of investment analysis (version 02, EB41, Annex 45)". Given the lack of well-established sectoral benchmarks supplied by relevant national authorities, the MLR prior to the investment decision date is chosen as a very conservative indicator additionality assessment.

²⁰ Rajbhandari, B.K., Annachatre, A.P. 2004, Anaerobic ponds treatment of starch wastewater: case study in Thailand. Bioresource Technology 95 (2004) 135–143.

²¹ The Promotion of Biogas from Wastewater as An Alternative Energy and for Environmental Improvement, published by the Energy Conservation and Renewable Energy Division and Energy Policy and Planning Office (EPPO), 2007.

²² Cinara, 2004 "Waste stabilization ponds for wastewater treatment, International Water and Sanitation Centre" <http://www.irc.nl/page/8237>

²³ Mara, D., 2003, Waste Stabilization Ponds: Time for Aggressive Marketing <http://www.bvsde.paho.org/bvsacd/agua2003/mar.pdf>

²⁴ The Promotion of Biogas from Wastewater as An Alternative Energy and for Environmental Improvement, published by the Energy Conservation and Renewable Energy Division and Energy Policy and Planning Office (EPPO), 2007 Page no. 47.

²⁵ Renewable Energy in Asia: The Thailand Report. An overview of the energy systems, renewable energy options, initiatives, actors and opportunities in Thailand, 2005. Australian Business Council for Sustainable Energy, Page No. 5.

²⁶ Prasertsan, S. B. Sajjakulnukit (2006). Biomass and biogas energy in Thailand: Potential, opportunity and barriers. Renewable Energy 31:599–610.

²⁷ http://www.bot.or.th/English/Statistics/FinancialMarkets/Interestrates/_layouts/application/interest_rate/IN_Rate.aspx

Applying such a benchmark approach to the IRR analysis means that in the case that the estimated IRR is lower than the MLR benchmark, the project is financially additional and thus acts as a demonstration that the project faces investment barriers.

Investment analysis was undertaken using the data shown in Table 7.

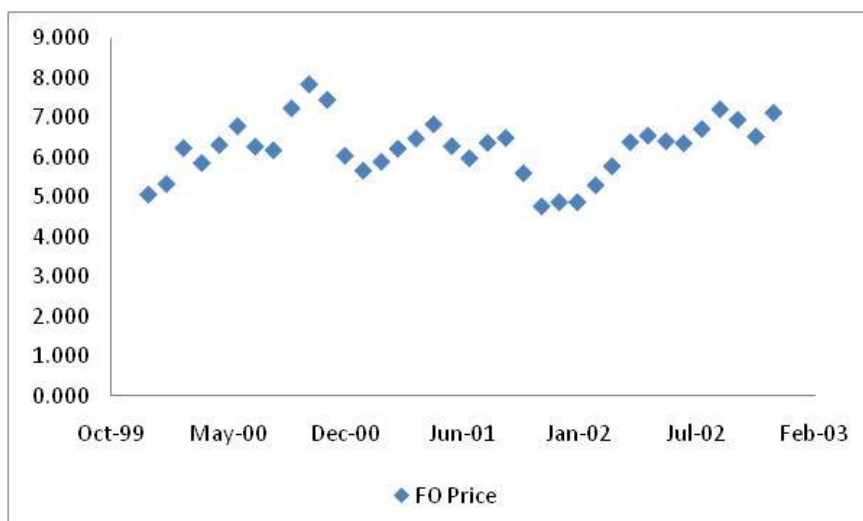
Table 7 : The basic financial parameters of the project

Total Investment (THB)	87,429,812	Based on actual payment ²⁸
Non-labour operating and maintenance costs (THB/year)	4,371,491	Assume at 5% of total investment cost
Manpower cost (THB/year)	1,896,000	Actual cost
Annual Biogas generated (Nm ³ /yr)	4,007,788	Calculated - based on COD removal
Annual electricity generated (MWh/yr)	3,812	Based on planned biogas usage
Price of electricity sold (THB/kWh)	2.1	Annual Report - 2002 EGAT
Fossil fuel replaced	Fuel oil	Baseline scenario
Amount of fossil fuel replaced (liter/year)	1,054,686	Based on planned biogas usage
Price of fossil fuel (THB/liter)	6.89	Weighted average oil price based on invoice and ex-refinery price for 2.5 years
Operation period (years)	15	Based on document from technology supplier
Discount rate	7.21%	MLR (Bank of Thailand)

In consideration of discussions carried out during validation process, following explanation is provided on the assumption of fuel oil price in the PD. Ideally fuel price indicator shall be based on a three year average price to take into account the price volatility of the fuel oil. In the case of the project activity, fuel oil price (wholesale market price) is available only for a period of 1.5 years before investment as per actual invoices (from January 2001 to July 2002). These prices are compared with the publicly available ex-refinery price²⁹ for the same period and the correlation is used to backpolate the wholesale price. Since ex-refinery prices in Thailand are publicly available for the period starting only from January 2000, the average wholesale price to be applied in the IRR analysis can only be backpolated for a period of 2.5 years prior to the investment decision. The price variation over the 2.5 year period in the ex-refinery price is depicted in the graph below in order to show the oil price fluctuation over time .

²⁸ The cost of project activity based on actual payment is justifiable as per industrial standards i.e. information available on similar projects. Please note that comparison of proposal cost and actual cost of two South Pole's projects (i.e. or Bangna Starch Wastewater Treatment and Biogas Utilization Project and Chorchaiwat Wastewater Treatment and Biogas Utilisation project) have been submitted to the DOE. It is observed that variation in amount is maximum up to +3.17%; this range is covered very aptly in the sensitivity analysis.

²⁹ <http://www.eppo.go.th/info/price/P05.xls>



Ex-refinery prices in Thailand

Source: <http://www.eppo.go.th/info/price/P05.xls>

The effect of uncertainty due to variations in the fuel oil price is analysed via sensitivity analysis. In order to estimate likely fluctuations of the fuel oil price over time, the variation of the annual average historic oil prices against the average oil price over a larger period of time is analysed based on publicly available ex-refinery prices. The basic assumption for same is that ex-refinery price would have a direct correlation with market wholesale price. The development of the wholesale price in the period from 2000 to Jun 2002, indicates that a variation of +/-10% in oil prices is quite appropriate for the sensitivity analysis as the annual average price fluctuates with maxima of +4% and – 6% around the average price of 2.5 years. For more information, please refer to the IRR calculation sheet.

Table 8 : Financial indicator showing the feasibility of the project with and without VER revenues

Develop project activity without VER revenues	IRR (%)	4.65%
Develop project activity with VER revenues	IRR (%)	9.65%

In the case whereby the benefits of VERs have not been taken into account, the project activity is deemed unattractive from a financial perspective. This can be seen in Table 8, where IRR is estimated at 4.65%. With the applied indicator being unfavorable relative to the benchmark level, it can be concluded that the project faces capital or investment return constraints. In other words, the IRR indicator has demonstrated that there are other alternatives which are deemed more attractive (e.g. status quo system).

Sensitivity analysis

Purpose of sensitivity analysis is to show whether the conclusion regarding the financial attractiveness is robust to reasonable variations in the critical assumptions. The project IRR could vary significantly when certain parameters are changed. The parameters most likely to vary are: the initial investment, the price of electricity, the price of fossil fuel, the operating and management costs and level of biogas generation. These parameters are thus increased and decreased by 10%. From this, it can be concluded that the IRR always remains below the

benchmark when varying these parameters, disabling thus any investment in this project without VER revenues.

Table 9: Sensitivity analysis of important parameters

Sensitivity Analysis IRR	IRR after mentioned change in	IRR after mentioned change in	IRR after change in biogas volume	IRR after change in power selling price	IRR after change in investment
-10%	3.27%	5.78%	1.96%	3.27%	6.99%
-5%	3.97%	5.22%	3.33%	3.97%	5.78%
0%	4.65%	4.65%	4.65%	4.65%	4.65%
5%	5.32%	4.08%	5.93%	5.32%	3.60%
10%	5.98%	3.49%	7.16%	5.98%	2.60%

Technological Barriers

Lack of skilled and trained manpower

Alternative (a) have been used extensively and is commonly regarded as a cost effective solution for wastewater treatment in tapioca starch production plants in Thailand. There are few risks associated with this option because it does not involve any advanced technology and is easy to operate and maintain and need no skilled labor³⁰. In addition, the related technology and the necessary human resource capacity are considered to be readily available in Thailand. From this, it can be concluded that alternative (a) does not face any technological barrier.

The operational and maintenance requirements of alternative (b) include possessing the means to maintain pond circulation (once they covered), maintaining biochemical equilibrium within the digesters and a detailed monitoring (including equipment and material maintenance) program to maintain system performance levels. With such requirements, there is a need for skilled and experienced operators; the availability of such personnel locally is limited as such biogas systems are still relatively rare in the Thai tapioca starch production industry³¹. Therefore, lack of skilled and qualified person poses a significant barrier to the success of the project. Additional investment in training of the operators and other personnel has to be borne by the project proponent, particularly in the initial phase of the project. Expert intervention from time to time is also required, until in-house expertise in the process is developed. Lack of skilled and trained manpower may lead to more mechanical breakdowns, decreased process efficiency and inferior biogas quality and quantity, leading to additional financial burden on the project proponent.

Alternative (c) is a well established conventional practice for treatment of domestic and industrial wastewater. However, there is no experience of this type of technology being applied to tapioca starch factories in Thailand; and due to commercial reason, no operators are taking this option into their investment consideration. Acknowledging the lack of interest in this technology, technological barriers are deemed irrelevant. Alternative (d) has already been excluded.

Risk of technology failure

Alternative (b) is seen as a high risk with limited performance guarantee. The process depends on the equilibrium among the various microbial species activity. Therefore, such biological systems require constant monitoring to ensure that the system remains in balance. There are

³⁰ Mara, D., 2003, Waste Stabilization Ponds: Time for Aggressive Marketing Page no 1 <http://www.bvsde.paho.org/bvsacd/agua2003/mar.pdf>

³¹ S. Prasertsan, B. Sajjakulnukit, 2005, Biomass and biogas energy in Thailand: Potential, opportunity and barriers <http://www.energy-based.nrct.go.th/Article/Ts-3%20biomass%20and%20biogas%20energy%20in%20thailand%20potential,%20opportunity%20and%20barriers.pdf>.

multiple variables that affect the performance of the system, such as incoming organic load, temperature, pH/alkalinity and retention time. Changes in these variables can affect the equilibrium among the microbial species which in turn can affect the quantity and quality of the biogas necessary for energy production. Problems with biogas plants are often difficult to diagnose, often requiring high level understanding of the biological system. It can take significant time to readjust the balance and achieve expected biogas yields. Because of the technical risks associated with alternative (b), the low risk open ponds option is prevailing practice for treatment of wastewater at tapioca starch plants in Thailand and that most manufacturers prefer to retain wastewater from tapioca starch plant in open ponds. This is verified by a report from 2007 by the Energy Conservation and Renewable Energy Division and Energy Policy and Planning Office of Thailand³² (EPPO report).

In fact, Chol Charoen Co., Ltd. is one of the first starch factories in Thailand in which the AFFR system is being implemented. Being a pilot demonstration project of a newly introduced biogas system, there is an inherent risk that the project may see operational failure and from this, it is justifiable to conclude that some technological barriers exist for alternative (b).

Similarly, alternative (c) is also not a common option in Thailand. As well, similar technology risks are applicable to the aerobic systems due to common nature of microbial functioning.

Institutional Barriers

Although there are some slight discomforts to local community associated with odour from the previous anaerobic open lagoon based system (alternative (a)), it is considered as the standard operating practice in the Thai tapioca starch industry. The existing system entails operation of closed water cycle systems with no discharge of final effluents to the aquatic environment, thus there is no regulatory requirement for facilities to alter their current practice. With the open lagoon system already able to meet the desirable quality of treated wastewater, owners are generally reluctant to switch to a closed anaerobic system for biogas recovery. In addition, alternative (b) and (c) face certain social barriers in the sense that there is a low understanding of the technologies involved, and in particular the safety issues that surround the collection and storage of biogas relevant to alternative (b). This reluctance can be interpreted as an ability of the local labor force at the time of investment to absorb new technologies. This although is a minor barrier, it is deemed reasonable considering the local situation.

While discussions on these technologies are becoming more noticeable within the industry, the technical understanding on the involved processes (biological, chemical and physical) remains poor, thus uptake on these technologies remain slow. With increased availability of operational experience, this barrier is likely to become less relevant over time.

STEP 3: Common Practice

According to the GHG Protocol for Project Accounting, common practice refers to the predominant technologies or practices in a given market, as determined by the degree to which those technologies or practices have penetrated the market. In demonstrating the market penetration rate of this project activity or “similar” projects³³, some background into the starch production industry in Thailand must be given. At the time of writing (04/02/2009), there is an

32 Seminar Document: The Promotion of Biogas from Wastewater as An Alternative Energy and for Environmental Improvement, published by the Energy Conservation and Renewable Energy Division and Energy Policy and Planning Office (EPPO), 2007

33 According to the tool for the demonstration and assessment of additionally, projects are considered “similar” in the case where they are located in the “same country/region”, are of “similar scale”, and “take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, access to financing, etc”.

average of 8³⁴ million of rais³⁵ of tapioca cultivation areas in Thailand, amount to 85 native starch factories³⁶, most of which located in the eastern (33%) and north-eastern (46%) regions. Most of the wastewater management systems in these factories are based on open anaerobic lagoons³⁷, which require little investment, have low operation and maintenance costs and fulfil the national regulations for wastewater discharge. Out of 85 starch factories, 27 have installed anaerobic digesters. Based on this calculated market penetration rate of 31.8% alone, a conclusive statement cannot be made as to whether the project activity is a common practice as per the GHG Protocol for Project Accounting. The protocol itself is unclear and leaves much room for interpretation with such statement as: “the level of penetration that represents common practice may differ between sectors and geographic areas and may depend on the diversity of different baseline candidates within a geographic area”. Nevertheless, it is possible to demonstrate that compared with projects that have received no carbon finances; the project shall not be a common practice in the Thai starch industry. It must be stressed that, according to VCS 2007.1, this criterion alone is sufficient for proving that the project satisfies the common practice condition.

Referring to the condition that ‘project type shall not be common practice in sector/region, compared with projects that have received no carbon revenue’, it can be demonstrated here that all the 27 closed anaerobic system projects mentioned have all submitted an application to acquire environmental credit (either in the form of CER or VER) in order to assist the financial burden from the investment of this costly set of technologies. Therefore, it is clear that the project activity is not a common practice under this definition.

To elaborate on this, out of these 27 projects (based on data on 04st February, 2009³⁸), 8 projects have received the letter of approval from the Thai DNA and are either registered (Table 10), under registration (Table 11), under review (Table 12), or under validation (Table 13) within the CDM program framework. Another 9 projects have recently made request to receive the letter of approval from the Thai DNA and are initiating the CDM application process (Table 14). Moreover, one project has sold its credits in the voluntary carbon market and another nine are currently undergoing validation and initial verification under VER standards³⁹ (Table 15). These projects intended to register under CDM; however, due to delays in the establishment of the Thai DNA and the subsequent standstill of the DNA’s work during the political turmoil surrounding the military coup and the interim government from 2006-2007, these projects could not apply for CDM and opted for the voluntary carbon market. Thus none of the 27 installed biogas projects are being implemented without taking additional revenues from carbon credits into account. This reinforces the credibility in our statement that the project is not a common practice as per VCS 2007.1 requirement.

Table 10 : Registered project by the CDM Executive Board

No.	Project Title	Project Developer
1	Korat Waste to Energy (KWTE) ⁴⁰	Korat Waste to Energy Company Ltd.

³⁴ <http://www.thaitapiocastarch.org/crop.asp>

³⁵ A rai is a unit of area, which is equal to 1,600 square meters (40 m x 40m), used for measuring land area. It is commonly used in Thailand.

³⁶ <http://www.thaitapiocastarch.org/article05.asp>

³⁷ <http://www.thaitapiocastarch.org/article01.asp>

³⁸ See http://www.tgo.or.th/english/index.php?option=com_content&task=view&id=17&Itemid=28;

³⁹ South Pole Carbon Asset Management Ltd.

⁴⁰ <http://cdm.unfccc.int/Projects/DB/KPMG1175141470.89/view>

Table 11 : Projects requesting registration by the CDM EB

No.	Project Title	Project Developer
1	CYY Biopower Wastewater treatment plant including biogas reuse for thermal oil replacement and electricity generation Project, Thailand ⁴¹	CYY Bio Power Co Ltd
2	Cassava Waste To Energy Project, Kalasin, Thailand (CWTE project) ⁴²	Asia Modified Starch Co., Ltd. (AMSCO)

Table 12 : Projects undergoing review requests

No.	Project Title	Project Developer
1	Siam Quality Starch Wastewater Treatment and Energy Generation Project in Chaiyaphum, Thailand ⁴³	Siam Quality Starch Co.,Ltd
2	Jiratpattana Biogas Energy Project ⁴⁴	Thai Biogas Energy Company
3	Chao Khun Agro Biogas Energy Project ⁴⁵	Thai Biogas Energy Company

Table 13 : Projects available for public comments on the UNFCCC CDM website

No.	Project Title	Project Developer
1	ES Bio Energy Wastewater Treatment and Energy Generation Project at Srakaew ⁴⁶	Eastern Sugar Power Co., Ltd.
2	Biogas from Ethanol Wastewater for Electricity Generation ⁴⁷	Pornvilai International Group Trading Co., Ltd. (PVL)

Table 14 : Projects having requested Letter of Approval from Thai DNA⁴⁸

No.	Project Title	Project Developer
1	Wastewater treatment with Biogas System in a Starch Plant for Energy and Environment Conservation in Nakorn Ratchasima	Sima Interproduct Co.,Ltd.
2	Wastewater treatment with Biogas System in a Starch Plant for Energy and Environment Conservation in Chachoengsao	Sima Interproduct Co.,Ltd.
3	Northeastern Starch (1987) CO.,Ltd. -- LPG Fuel Switching Project	Northeastern Starch (1987) Co. Ltd.
4	Khon Kaen Fuel Ethanol Project	Khon Kaen alcohol Co.,Ltd

⁴¹ <http://cdm.unfccc.int/Projects/DB/RWTUV1218617500.62/view>

⁴² <http://cdm.unfccc.int/Projects/DB/TUEV-SUED1218551520.16/view>

⁴³ <http://cdm.unfccc.int/Projects/DB/SGS-UKL1217944948.76/view>

⁴⁴ <http://cdm.unfccc.int/Projects/DB/DNV-CUK1218619436.44/view>

⁴⁵ <http://cdm.unfccc.int/Projects/DB/DNV-CUK1218616482.16/view>

⁴⁶ <http://cdm.unfccc.int/Projects/Validation/DB/DEEQYPX12PF7ARJFO65LN7UQTNK873/view.html>

⁴⁷ <http://cdm.unfccc.int/Projects/Validation/DB/7UD55FPNACFME93NJI31VAUFG4WC15/view.html>

⁴⁸ http://www.tgo.or.th/english/index.php?option=com_content&task=view&id=17&Itemid=29

5	Avoidance of methane emission from the wastewater treatment facility in K.S. Bio-Plus Co. Ltd., Thailand	K.S. Bio-Plus Co. Ltd.
6	Advanced wastewater management at Rajburi Ethanol Plant	Rajburi Ethanol Co., Ltd.
7	Blue Fire Bio wastewater treatment and biogas utilization project	Blue Fire Bio Co.,Ltd
8	Biogas project, Cargill Siam Borabu	Cargill Siam Ltd.
9	Chantaburi Starch Wastewater Treatment and Biogas Utilisation Project	Chantaburi Starch Power Co., Ltd.

Table 15 : Projects under VER market⁴⁹

No.	Project Title	Project Developer
1	Banpong Tapioca Flour wastewater treatment and biogas utilisation project	Banpong Tapioca Flour Industrial Co.,Ltd.
2	Wastewater Treatment with Biogas production (UASB) and heat utilization at General Starch Co Ltd	General Starch Ltd.
3	SD BioSupply wastewater treatment and biogas utilization project	SD Biosupply Co.,Ltd
4	VP BioSupply wastewater treatment and biogas utilization project	VP Biosupply Co.,Ltd
5	Chol Charoen Group Wastewater Treatment with Biogas System (Srakaew)	Srakaew Chareon Co., Ltd.
6	Chol Charoen Group Wastewater Treatment with BiogasSystem (Kampangpet)	Kean Chareon Co., Ltd,
7	Chol Charoen Group Wastewater Treatment with Biogas System (Khonkaen)	Kean Chareon Co., Ltd.,
8	Chol Charoen Group Wastewater Treatment with Biogas System (Chacherngsao)	S.C. Industry Co., Ltd.,
9	Chakangrao Starch wastewater treatment and biogas utilization project	Chakangrao Starch Co.,Ltd.
10	Thanawat wastewater treatment and biogas utilization project	Thanawat Biogas Co.,Ltd.

Conclusion of the project test:

The proposed project activity is a regulatory surplus as it is not being implemented to respond to laws or regulations. Our project test has shown that it would not be an attractive investment option unless the revenue from carbon credits is taken into account. The project also faces significant technological barriers in being a pilot demonstration plant for the AFFR technology, therefore, facing great risk of performance failure especially with the unavailability of local skilled labour. The project can thus be concluded as additional in that it reduces GHG emissions that would have been emitted by anaerobic lagoons, fossil fuel based grid electricity and consumption of fuel oil in starch drying process. Hence, according to the Attachment A to Appendix B of the Simplified Modalities of the simplified modalities and procedures for small-scale CDM project activities and the VCS Program Guidelines, the project activity would lead

⁴⁹ South Pole Carbon Asset Management Ltd.

to a lower GHG emission reductions below what would have happened under a baseline scenario.

2.6 Methodology Deviations

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.

3 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

3.1 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 CO₂e)
- $BE_{ww,discharge,y}$ = Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y (t CO₂e). 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 CO₂e). 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:

$$BE_{ww,treatment,y} = \sum_i (Q_{ww,i,y} \times COD_{inflow,i,y} \times \eta_{COD,BL,i} \times MCF_{ww,treatment,BL,i}) \times B_{o,ww} \times UF_{BL} \times GWP_{CH_4} \quad \text{Equation (2)}$$

Where:

- $Q_{ww,i,y}$ = Volume of wastewater treated in baseline wastewater treatment system i in year y (m³). 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/m³). 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 16
- 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) ⁵⁰
UF_{BL}	=	Model correction factor to account for model uncertainties (0.89) ⁵¹
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 16 : IPCC default values⁵² for Methane Correction Factor (*MCF*)

Type of wastewater treatment and discharge pathway or system	<i>MCF</i> 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
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 ⁵³	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.

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

⁵⁰ Project activities may use the default value of 0.6 kg CH₄/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.

⁵¹ Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

⁵² Default values from chapter 6 of volume 5. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

⁵³ Please refer SSC_664, "Clarification on methane correction factors for treated water used for irrigation under AMS-III.H ver. 16".

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:

$$BE_y = EG_{PJ,y} \times EF_{grid,y} \quad \text{Equation (1)}$$

Where:

BE_y	=	Baseline emissions in year y (t CO ₂)
$EG_{PJ,y}$	=	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:

$$EG_{PJ,y} = EG_{PJ,facility,y} \quad \text{Equation (2)}$$

Where:

$EG_{PJ,facility,y}$	=	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y (MWh)
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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 CO₂/MWh) of the current generation mix. The data of the year in which project generation occurs must be used.

Determination of $EF_{grid,y}$

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 TGO⁵⁴. 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	

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.*

$$EF_{grid,CM,y} = EF_{grid,OM,y} * w_{OM} + EF_{grid,BM,y} * w_{BM} \quad \text{Equation (16)}$$

Where :

$EF_{grid,BM,y}$	Build margin CO ₂ emission factor in year y (t CO ₂ /MWh)
$EF_{grid,OM,y}$	Operating margin CO ₂ 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:

$$BE_{thermal,CO_2,y} = \left(\frac{EG_{thermal,y}}{\eta_{BL,thermal}} \right) \times EF_{FF,CO_2} \quad \text{Equation (3)}$$

Where:

$BE_{thermal,CO_2,y}$	=	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)

⁵⁴http://ghgreduction.tgo.or.th/t-ver/images/Grid_Emission_Factor_2559_-_Finalised.pdf

- EF_{FF,CO_2} = CO₂ 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 CO₂/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 17 : Summary of Baseline Emissions (BE) calculation

Baseline Emissions as per AMS.III.H		
Design capacity of Starch mill	240	t/day
Annual starch production ($Q_{starch,y}$)	54,316	t/y
Wastewater generation	10.00	m ³ /t
Operating days	315	d/y
Wastewater flow ($Q_{ww,i,y}$)	543,157	m ³ /year
COD _{ww,untreated,y}	23,000	mg/l
Efficiency of lagoon system ($\eta_{COD,BL,i}$)	87%	
COD out - based on baseline system efficiency	2,919	mg/l
Model correction factor (UF_{BL})	0.89	
Baseline COD removal baseline	0.020081	t/m ³
$B_{O,ww}$	0.25	tCH ₄ /tCOD
$MCF_{ww,treatment,BL,i}$	0.8	
GWP_{CH_4}	25	
BE_{ww,treatment,y}	48,537	t CO₂ e/year
MD_y	49,970	t CO₂ e / year

COD removal efficiency of AFFR system	80%	
COD _{www,treated,y}	4,600	mg/l
COD removed - project activity (anaerobic)	0.0184	t/m ³
Density of CH ₄ at Normal temp and pressure ($\rho_{CH_4,n}$)	0.7160	kg/m ³
Methane percent in biogas	55%	
Biogas generation potential = $BG_{burnt,combusted,y}$	5,075,720	Nm ³

Baseline Emissions as per AMS.I.C		
Thermal energy supplied ($EG_{thermal,y}$)	69.92	TJ/year
DE - Efficiency of boiler ($\eta_{BL,thermal}$)	100%	
Emission Factor of Residual Fuel Oil ($EF_{CO_2,I,y}$)	77.4	tCO ₂ /TJ
BE_{thermal,CO₂,y}	5,409	tCO₂e/year

Baseline Emissions as per AMS.I.D		
Electricity generation ($EG_{PJ,y}$)	4,475.81	MWh/y
DE - Efficiency of generator	100%	
Grid emission factor ($EF_{grid,CM,y}$)	0.5637	tCO ₂ /MWh
BE_y	2,523	tCO₂e/year

3.2 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 (8)

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 (1)

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:

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

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 16 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)

$$PE_{fugitive,ww,y} = (1 - CFE_{ww}) \times MEP_{ww,treatment,y} \times GWP_{CH4} \quad \text{Equation (10)}$$

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)

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

Where:

$COD_{removed,PJ,k,y}$ = The chemical oxygen demand removed⁵⁵ 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 16 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:

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

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 methodological tool “Project emissions from flaring” 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 ($f_{CH4,default}$) 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

⁵⁵ Difference between the inflow COD and the outflow COD.

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:

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

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 below.

Table 18 : 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 19 : Summary of Project Emissions (PE) calculation

Project Emissions as per AMS.III.H		
Rated power capacity (P_{el})	139	kWh
Annual Power Consumption ($EC_{PJ,y}$)	1,158	MWh/year
Emission Factor of electricity ($EF_{grid,CM}$)	0.5637	tCO ₂ /MWh
$TDL_{j,y}$	6.073%	
PE_{power,y}	692	tCO₂e/year
Wastewater flow ($Q_{ww,i,y}$)	543,157	m ³ /year
CODout from project activity	0.0046	t/m ³
COD - reduction in open lagoon	87%	
$B_{o,ww}$	0.25	tCH ₄ /tCOD
Model correction factor (UF_{PJ})	1.12	
$MCF_{ww, treatment, PJ, k}$	0.8	
PE_{ww, treatment,y}	12,216	tCO₂e/year
CFE_{ww}	0.9	
$MEP_{ww, treatment,y}$	2,239	t CH ₄ /year
PE_{fugitive,y}	6,268	tCO₂e/year
Biogas to be flared ($BG_{burnt, ToFlare,y}$)	0	Nm ³ /year
	0	kg/year
Flare efficiency - FE ($\eta_{flare-m}$)	0%	
PE_{flare, y}	0	tCO₂e/year

3.3 Leakage

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

3.4 Net GHG Emission Reductions and Removals

As per AMS III.H

Emission reductions shall be estimated ex ante in the PDD using the equations provided in the baseline, project and leakage emissions sections above. Emission reductions shall be estimated ex ante as follows:

$$ER_{y,ex\ ante} = BE_{y,ex\ ante} - (PE_{y,ex\ ante} + LE_{y,ex\ ante}) \quad \text{Equation (14)}$$

Where:

$ER_{y,ex\ ante}$	=	Ex ante emission reduction in year y (t CO ₂ e)
$LE_{y,ex\ ante}$	=	Ex ante leakage emissions in year y (t CO ₂ e)
$PE_{y,ex\ ante}$	=	Ex ante project emissions in year y calculated as paragraph 41 (t CO ₂ e)
$BE_{y,ex\ ante}$	=	Ex ante baseline emissions in year y calculated as per paragraph 27 (t CO ₂ e)

For cases 2(f) , ex post emission reductions shall be based on the lowest value of the following, as per paragraph 46 of the methodology;

- a) The amount of biogas recovered and fuelled or flared (MD_y) during the crediting period, that is monitored ex post;
- b) Ex post calculated baseline, project and leakage emissions based on actual monitored data for the project activity.

For cases 2(f): it is possible that the project activity involves wastewater and sludge treatment systems with higher methane conversion factors (MCF) or with higher efficiency than the treatment systems used in the baseline situation. Therefore the emission reductions 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. The emission reductions achieved in any year are the lowest value of the following:

$$ER_{y,ex\ post} = \min \left((BE_{y,ex\ post} - PE_{y,ex\ post} - LE_{y,ex\ post}), (MD_y - PE_{power,y} - PE_{biomass,y} - LE_{y,ex\ post}) \right) \quad \text{Equation (15)}$$

Where:

$ER_{y,ex\ post}$	=	Emission reductions achieved by the project activity based on monitored values for year y (t CO ₂ e)
$BE_{y,ex\ post}$	=	Baseline emissions calculated as per paragraph 27 using ex post monitored values
$PE_{y,ex\ post}$	=	Project emissions calculated as per paragraph 41 using ex post monitored values
MD_y	=	Methane captured and destroyed/gainfully used by the project activity in the year y (t CO ₂ e)

In the case of flaring/combustion MD_y will be measured using the conditions of the flaring process:

$$MD_y = BG_{burnt,y} \times w_{CH_4,y} \times D_{CH_4} \times FE \times GWP_{CH_4} \quad \text{Equation (16)}$$

Where:

$BG_{burnt,y}$	=	Biogas ⁵⁶ flared/combusted in year y (m ³)
$w_{CH_4,y}$	=	Methane content ¹³ of the biogas in the year y (volume fraction)
D_{CH_4}	=	Density of methane at the temperature and pressure of the biogas in the year y (t/m ³)
FE	=	Flare efficiency in year y (fraction). If the biogas is combusted for gainful purposes, e.g. fed to an engine, an efficiency of 100 per cent may be applied

⁵⁶ Biogas volume and methane content measurements shall be on the same basis (wet or dry).

As per AMS I.D and AMS I.C

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y$$

Equation (9)

Where:

ER_y = Emission reductions in year y (t CO₂e)

BE_y = Baseline emissions in year y (t CO₂e)

PE_y = Project emissions in year y (t CO₂e)

LE_y = Leakage emissions in year y (t CO₂e)

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 1	56,469	19,177	0	37,292
Year 2	56,469	19,177	0	37,292
Year 3	56,469	19,177	0	37,292
Year 4	56,469	19,177	0	37,292
Year 5	56,469	19,177	0	37,292
Year 6	56,469	19,177	0	37,292
Year 7	56,469	19,177	0	37,292
Year 8	56,469	19,177	0	37,292
Year 9	56,469	19,177	0	37,292
Year 10	56,469	19,177	0	37,292
Total	564,690	191,770	0	372,920

4 MONITORING

4.1 Data and Parameters Available at Validation

Data / Parameter	GWP_{CH_4}
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, <i>Project shall transition to the updated GWP at their project crediting period renewal.</i>
Purpose of Data	Calculation of baseline and project emissions
Comments	-

Data / Parameter	$B_{0,ww}$
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 version18
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	$\eta_{\text{COD,BL,i}}$																																																																														
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%⁵⁷. <table><tr><th>Sample No.</th><th>Parameter s</th><th>Unit</th><th>COD inlet</th><th>COD outlet</th><th>%COD removal</th></tr><tr><td>1</td><td>COD</td><td>mg/L</td><td>24,773</td><td>278</td><td>98.8778</td></tr><tr><td>2</td><td>COD</td><td>mg/L</td><td>23,912</td><td>472</td><td>98.0261</td></tr><tr><td>3</td><td>COD</td><td>mg/L</td><td>21,173</td><td>381</td><td>98.2005</td></tr><tr><td>4</td><td>COD</td><td>mg/L</td><td>22,917</td><td>160</td><td>99.3018</td></tr><tr><td>5</td><td>COD</td><td>mg/L</td><td>19,232</td><td>162</td><td>99.1577</td></tr><tr><td>6</td><td>COD</td><td>mg/L</td><td>18,073</td><td>260</td><td>98.5614</td></tr><tr><td>7</td><td>COD</td><td>mg/L</td><td>24,168</td><td>466</td><td>98.0718</td></tr><tr><td>8</td><td>COD</td><td>mg/L</td><td>23,987</td><td>397</td><td>98.3449</td></tr><tr><td>9</td><td>COD</td><td>mg/L</td><td>20,736</td><td>735</td><td>96.4554</td></tr><tr><td>10</td><td>COD</td><td>mg/L</td><td>25,827</td><td>486</td><td>98.1182</td></tr><tr><td>11</td><td>COD</td><td>mg/L</td><td>25,611</td><td>704</td><td>97.2512</td></tr><tr><td>12</td><td>COD</td><td>mg/L</td><td>26,976</td><td>580</td><td>97.8499</td></tr></table>	Sample No.	Parameter s	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
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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

⁵⁷ 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.

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 ⁵⁸ .
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	FE
Data unit	%
Description	Flare efficiency
Source of data	Methodology tool : Project emissions from flaring
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.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	DE
Data unit	%
Description	Destruction efficiency of the electricity generator
Source of data	Default value from AMS III.H version 18.0
Value applied	100%
Justification of choice of data or description of measurement methods and procedures applied	From the description for equation 16 of the applied methodology , <i>If the biogas is combusted for gainful purposes, e.g. fed to an engine, an efficiency of 100 per cent may be applied.</i>
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	EF _{CO2,i,y}
Data unit	tCO ₂ /TJ
Description	Emission factor of fossil fuel replaced – Residual Fuel oil

⁵⁸ 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

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
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	

	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.						

4.2 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
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 applied	543,157 m ³ /year (estimated for ex-ante calculation)
Monitoring equipment	Wastewater flow meter: 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	-

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
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 applied	0.023 – design value
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	-

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
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 applied	0.0046
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	-

Data / Parameter	S _{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 applied	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 _{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 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 (at least hourly measurements are undertaken, if less, confidence/precision level of 90/10 shall be attained)
Value applied	5,075,720 - assumed that all biogas generated is used at boiler and generators
Monitoring equipment	Biogas flow meter: Thermal mass 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 emissions
Calculation method	-
Comments	-

Data / Parameter	$B_{\text{burnt,TOFlare,y}} / V_{\text{RG,m}}$
Data unit	Nm ³
Description	Amount of biogas sent to flare system in the year y
Source of data	Measured using gas flow meter
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 (at least hourly measurements are undertaken, if less, confidence/precision level of 90/10 shall be attained)
Value applied	0
Monitoring equipment	Biogas flow meter: Thermal mass 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 project emissions
Calculation method	-
Comments	-

Data / Parameter	$W_{\text{CH}_4,y}$
Data unit	%
Description	Methane content in biogas in the year y
Source of data	Measured using gas analyser
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 applied	55 ⁵⁹
Monitoring equipment	Methane gas analyzer
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	-

⁵⁹ Methane – biogas – production guide version 1, <http://www.small-farm-permaculture-and-sustainable-living.com/support-files/methane-1.pdf>

Comments	-
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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 applied	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	$EC_{PJ,y}$
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 applied	1,158
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 $PE_{\text{power},y}$. 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 applied	6.073% (based on most recent data in 2014 published by International Energy Agency ⁶⁰)
Monitoring equipment	-
QA/QC procedures to be applied	Not applicable
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 ⁶¹
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

⁶⁰ <http://data.worldbank.org/indicator/EG.ELC.LOSS.ZS>

⁶¹ 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

Value applied	4,475.81
Monitoring equipment	Power monitoring devices installed at the generators.
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	$EG_{\text{thermal},y}$
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 applied	69.92
Monitoring equipment	Fuel oil flow meter
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, $EG_{\text{thermal},y}$ 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.
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	$FC_{i,j,y}$
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 applied	530,513
Monitoring equipment	Flow meter for fuel oil
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	$Q_{\text{starch},y}$
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 applied	54,316 tonnes (based on average values from 2002-2005; pre-project start date)
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	-

4.3 Monitoring Plan

1. Monitoring management

The required monitoring equipment was installed by the technology contractor. Flow meters are periodically calibrated to recognized procedures by the external parties and sampling is carried out by the biogas plant operators according to appropriate industrial standards.

Data acquisition for the gas and wastewater flow meters is executed through the monitoring devices installed at the biogas plant. Lab data is fed into the operations report through a manual data entry user interface.

The plant is operated by the trained operators who also collect data under the supervision of the QA manager who is in charge of filing and processing data. Figure 5 outlines the structure of operational and management of the project activity.

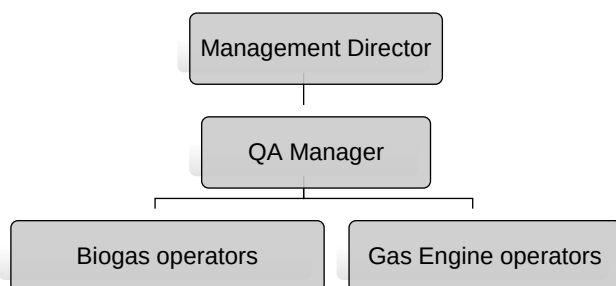


Figure 5 : Organization structure

2. Quality Assurance and Quality Control

The QA manager is responsible for monitoring overall performance of the plant, ensures proper and timely calibration, data acquisition and storage.

3. On-site procedures

The operations procedure creates daily logs of plant performance which is recorded manually onsite.

Procedures for calibration of equipment

Calibrations of equipment are usually organized from external agencies as per applicable national standards. At least once in three years calibrating is ensured by project proponent.

4. Data storage and filing – Electric Workbook

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

5. Emergency preparedness

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

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

5 SAFEGUARDS

5.1 No Net Harm

There is no any negative environmental and socio-economic impacts created by project activity.

5.2 Environmental Impact

Being a project based on renewable energy biogas project, it does not fall under the purview of the Environmental Impact Assessment (EIA) notification of the Ministry of Natural Resources and Environment (MONRE). Nevertheless, a brief overview of environmental impacts related to the project activity is summarised here.

Odour – air pollution occurred as a result of starch factory wastewater treatment plant can generally be limited to undesirable odour. Other aspects of air pollution such as smoke, dust etc., are not significant, and therefore can be neglected.

Wastewater from starch factories generates a large quantity of malodorous gases as a result of the decomposition of organic matter. In the old anaerobic lagoon treatment system, wastewater from starch factories is detained in a series of deep open ponds which allows organic matters to decompose biologically over a long period of time. Since these ponds are not covered, the undesirable odour causes annoyance to nearby communities.

Odour at low concentration can cause psychological stress rather than physical harm to the body. Offensive odours can cause poor appetite for food, lowered water consumption, impaired respiration, nausea, vomiting and mental perturbation. These effects can have an impact on socio-economic condition in the community such as deterioration of human health, a decline in property value and lowered capital investment.

Considering the use of the new closed anaerobic system, wastewater is routed to the AFFR system implemented. Most of the gas generated will be captured and stored. Due to its economic value, the biogas will be combusted for thermal and power generation, and not released directly to the atmosphere. Therefore, when the project activity is operating properly, the odour problem will be reduced significantly compared with the anaerobic lagoon system.

Wastewater pollution – although Chol Charoen Co., Ltd., has already installed the wastewater treatment system, there are some aspects of environmental impacts that should still be considered, which are:

- Non-standard effluent discharge – although the closed anaerobic systems installed in the project activity have design COD removal efficiency of around 80%, the effluent from such systems will nevertheless remain rich in nutrients. A post-treatment system is required before the effluent can be discharged outside the facilities so as to meet the wastewater effluent standards. Generally, it is a good practice to design the system such that the water quality in the final pond meets the effluent standards, even though water is reused within the factory and not discharged outside. Since both old and new systems have put in anaerobic open ponds as post-treatment system and the factory plans to reuse all the treated wastewater for washing tapioca and irrigation of internal plantation, the impact from non-standard effluent discharge is unlikely under both circumstances.
- Wastewater overflow - wastewater overflow might happen during the rainy season if the precipitation rate is higher than the outflow rate of the final pond for a sustained period of

time. Wastewater overflow can lead to a variety of problems that have significant environmental impacts. Excess nutrients in the wastewater 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.

Safety – since biogas will be stored in large quantity, the issue of gas safety becomes a concern. However, the risk of any explosion will be very unlikely because the biogas, once leaked from its storage, will disperse quickly upward and will not build up above ground surface. This is due to the lower molecular weight of methane CH₄ (main content of biogas) compared to nitrogen N₂ (main content of air). Nonetheless, to avoid any risk of fire, no matter how unlikely, ignition sources, including smoking in the proximity of the biogas plant must be strictly prohibited.

Overall, impact assessment of the new wastewater treatment operation compared with the old system operation shows a satisfactory result. Most environmental aspects are actually expected to improve after implementing the closed wastewater treatment system. Only gas safety will have negative impacts compared to the anaerobic lagoons, but such impact is not significant and mitigations measures are, therefore, not required except for a no-smoking sign.

5.3 Local Stakeholder Consultation

Initial Stakeholder Consultation was carried out by Chol Charoen Co., Ltd. Stakeholder groups were identified and informed through oral and written means.

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.

5.4 Public Comments**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. The communication between project owner and all stakeholders can be reachable via telephone and company office.

APPENDIX 1: ADDITIONAL INFORMATION

Table 20 : Assumptions for ex-ante estimation

Ex-ante estimation from the first crediting period			
Wastewater production	m ³ /yr	543,157	
Influent COD	kg COD/m ³	23.000	
COD removed	kg COD/m ³	18.4	
B _{o,ww}	kg CH ₄ /kg COD	0.25	
MCF _{ww,treatment,PJ,k}	fraction	0.8	
Methane percent in biogas (W _{CH₄})	%	55%	Assume <u>lower</u> bound of theoretical CH ₄ con
Density of methane at given temprature (ρ _{CH₄,n})	kg/m ³	0.716	
Biogas production	m ³ /y	5,075,720	

Estimations for thermal energy			
Starch production (Q _{starch,y})	54,316	tonnes/y	
Q _{FO,starch}	34.3	l/tonnes	
Annual HFO requirement	1,860,917	litres	Historical data
D _{FO}	0.93	kg/litres	
NCV of Heavy Fuel Oil (NCV _{i,y})	0.0404	TJ/tonne	IPCC default
Thermal energy requirement of starch plant	69.92	TJ/y	
NCV of methane	0.050	TJ/tonne	
Methane required for starch plant	1397.9	tonnes	
Fraction of total biogas sent to boiler (w _{CH₄})	50%		Assumption from prev. val
Biogas sent to boiler	2,537,860	Nm ³ /y	
CH ₄ amount to be sent to boiler	999.4	t CH ₄ /y	
HFO replaced - project	1,237	tonne/y	
HFO used - project (FC _{i,j,y})	493	tonne/y	
	530,513	litres/y	

Estimations for electricity component			
Biogas available for electricity generation	2,537,860	Nm ³	
NCV of biogas	20.93	MJ/Nm ³	National default value - DEDE
Efficiency of gas engine	33.71%		32.73 for 500GFZ , 34.68 for 600GFZ
Power generation potential	4,475.81	MWh/y	