



**Project Description
(VCS 2007.1 standard)**

**Chol Charoen Group Wastewater Treatment with
Biogas System I (Khonkaen)**

Date of completion: November 13rd, 2009 (VCS PD Version 3.1)

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1 Description of Project:

1.1 Project title

Chol Charoen Group Wastewater Treatment with Biogas System I (Khonkaen)

VCS PD Version: 3.1

Document Completing date: 13/11/2009

1.2 Type/Category of the project

The project activity involves recovery of fugitive biogas from the wastewater released from tapioca starch processing plant. The recovered biogas is used in a boiler to generate heat for the starch drying process and used to generate electricity in order to meet the power requirement of the starch processing plant and may later be supplied to national-owned grid. After satisfying the above demands, surplus biogas is flared for safety purpose. The project has a total electrical generation capacity of less than 15 MW_{el}, thermal generation capacity less than 45 MW_{th} and will generate emission reductions less than 60 ktCO₂e per year. The type/category of the project is thus according to Appendix B, *Simplified Modalities and Procedures for Small-Scale CDM Project Activities*, as follow:

Methane avoidance component:

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

Electricity generation component:

Type I:	Renewable energy projects
Category I.D:	Grid connected renewable electricity generation
Sectoral Scope 1:	Energy industries (renewable/non-renewable sources)
Version:	14

Fuel replacement component

Type I:	Renewable energy projects
Category I.C:	Thermal energy production with or without electricity
Sectoral Scope 1:	Energy industries (renewable/non-renewable sources)
Version:	15

The project activity is not a grouped project.

1.3 Estimated amount of emission reductions over the crediting period including project size:

Expected VERs per annum:	16,280 ton CO ₂ e/year
VERs expected over 10 years crediting period:	162,800 ton CO ₂ e

The project is neither micro- nor mega-project with the estimated emission reductions being in between 5,000 to 1,000,000 ton CO₂e/year.

The project proponent has chosen a 10-years crediting period for the project activity.

Estimated reduction estimation is shown in Table 1 below:

Table 1: Estimated amount of emission reduction	
Years	Annual estimation of emission reductions in ton CO₂e
2009	16,280
2010	16,280
2011	16,280
2012	16,280
2013	16,280
2014	16,280
2015	16,280
2016	16,280
2017	16,280
2018	16,280
Total emission reduction (ton CO₂e)	162,800
Total number of crediting years	10
Annual average over the crediting period of emission reduction (ton CO₂e)	16,280

1.4 A brief description of the project:

Chol Charoen Group Wastewater Treatment with Biogas System I (Khonkaen), hereafter, ‘the project activity’, involves methane recovery and utilisation to an existing open anaerobic effluent treatment system (lagoons). It has been in operation since 2nd October 2006 (project start date) at Kean Chareon (1) Co. Ltd., a Tapioca starch factory in Khonkaen, Thailand.

This starch factory has a mean daily production capacity of 175 tonnes of dried starch, generating 2,000 m³ of wastewater per operational day¹. Under the previous system, wastewater released from the starch plant was treated in 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 27 °C², there is a suitable anaerobic environment within the ponds, with the anaerobic bacteria, that breakdown the organic compounds in the wastewater³. This consequently lead to methane generation from the organic content (characterised by chemical oxygen demand or COD) of the wastewater.

¹ Can be cross-checked with monthly wastewater report to local authority

² Data requested from the Thai Meteorological Department

³ http://pcd.go.th/info_serv/water_wt.html

The project activity involves the installation of two anaerobic covered lagoon facilities (converted from open lagoons) to complement the existing anaerobic open lagoon based system. The two covered lagoon digesters, together, are designed with volumetric capacity of around 177,375 m³ of wastewater⁴. The COD removal efficiency of such system is typically at 80%⁵ and its retention time is estimated at around 90 days. The implementing system enables recovery of biogas that would have been released into the atmosphere and utilise it for thermal and electricity generation. In the case of thermal energy generation, the captured biogas will be co-fired in existing heat generating devices for the process of drying the wet starch (displacing fuel oil under the previous system). In addition, the power produced by this captured biogas will not only facilitate the electricity requirement of the plant, it may also be fed to national grid under the pending power purchase agreement with the Provincial Electricity Authority (PEA). Excess biogas (if any) will then be flared in an open flare system.

Please note that the biogas generation happens in tandem to the starch plant operation, except for a gap of few hours during the start up. The biogas generated during the normal operation is used in the boiler, usually co-fired with fuel oil for stability of heat generation for starch drying process, as well used for power generation process. Biogas is stored in the storage unit available, and used as per availability in storage. In case not enough biogas is available (low production and low storage amount), the boiler uses 100% fuel oil and biogas can be stored till substantial amount is available to start the co-firing process.

The quality of the treated wastewater, although is not discharged outside the factory (thus not subject to effluent standards), will nevertheless improve substantially due to higher efficiency and improved process control under the covered lagoon system as compared to its open lagoon counterpart. In fact, such efficiency improvement of the biogas reactor system allows the starch factory to use the treated effluent of better quality, from the last open lagoon into the raw tapioca cleaning process; thus further ensuring the conservation of water supply. Not only the project activity contributes to a reduction of anthropogenic GHG emissions, it also delivers a number of benefits in the form of sustainable development. The project indeed creates new jobs and increases income to the region via fostering of contracts to local firms for the construction, operation and maintenance of the plant.

Furthermore, the implementation of this project activity can reduce odour and nuisance normally associated with open lagoon wastewater system. Utilisation of methane for fuel oil replacement and electricity generation can be regarded as a mean to reduce dependency on import energy products, which in turn improves the energy security status of Thailand. In addition, it can be expected that the proposed project activity will promote technological excellence and enriching further research in biotechnology in the region.

Table 2: Summary on baseline and project conditions

Project/Baseline Component	Brief Description
Lagoon System	11 lagoons, commissioned along with the operation start date of starch plant in 1988. The approximate retention time of the open lagoon system is around 200 days
Covered lagoons	Two covered lagoons have been converted from existing open lagoons. Typically, the COD removal efficiency of this system is around 80%. The hydraulic retention time is

⁴ Refer to drawing of covered lagoons

⁵ <http://dsp-psd.pwgsc.gc.ca/Collection/M92-253-2002E.pdf>

	approximately at 90 days. The covered lagoon system started operation in October 2006, first month of biogas usage.
Boiler	There are two dual-fired boilers with thermal capacity with a capacity of 3.488 and 3.78 MW _{th} respectively. The boiler has biogas consumption capacity of 1,603 Nm ³ /hr at full operation capacity. This is much higher than the per hour biogas generation rate of 208 Nm ³ /hr. Please note that the boilers are purchased approximately 7-8 years ago and in a default scenario shall last through the first crediting period of 10 years assuming default lifetime of 25 years.
Gas engines	Altogether, there are electricity generation sets, with total capacity of 1.904 MW _e . The gas engines have biogas consumption capacity of 866 Nm ³ /hour at full operation capacity. Again, it should be iterated that this is much higher than the per hour biogas generation rate of 208 Nm ³ /hour.
Flare	Open flare system is available at the plant. This is an automatic flare system that will operate when pressure is higher than 3mbar. There is also a flame arrester to ensure the safe operation of the flare system.
Capacity of auxiliary drives	Total capacity of the auxiliary drives amount to 276.868 kW; the same can be referred in the GHG calculation sheet as well as in the document submitted during validation.

1.5 Project location including geographic and physical information allowing the unique identification and delineation of the specific extent of the project:

The proposed project activity is located at Kean Charoen (1) Co., Ltd, in Kranuan district, Khonkaen province, situated in the Northeast of Thailand approximately 450 km from Bangkok. The project activity location is depicted in Figure 1.

Street address: 261 Moo 4, Huanakhum, Kranuan, Khonkaen, 40170, THAILAND

Geographical coordinates: 16° 48.498'N Latitude 103° 05.148'E Longitude

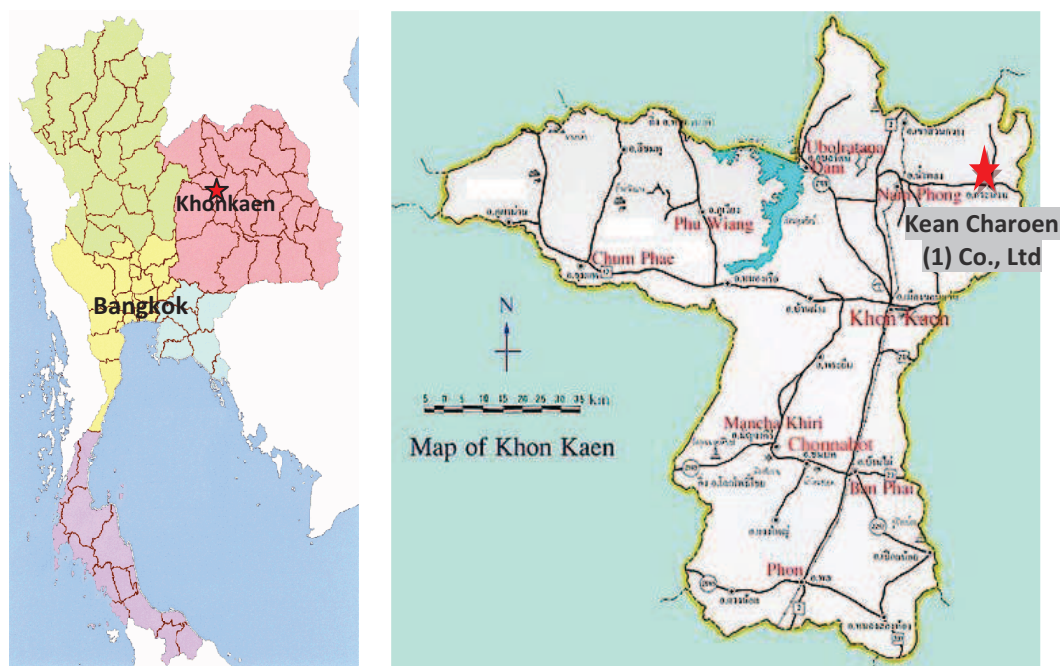


Figure 1: The starch plant location



Figure 2: GPS project activity boundaries

1.6 Duration of the project activity/crediting period:

Project start date: 2nd October 2006⁶(the date when emissions reduction began). This is the date on which hot oil boiler become operational with the utilisation of biogas.

⁶ Based on first operational log sheet of biogas sent to boiler

Crediting period start date: 15th July 2009. Due to insufficiency of monitoring equipments, the operational period prior 15th July 2009 will be neglected from our claim of emission reduction. This is in line with the principle of conservativeness as per VCS 2007.1.

The duration of the project activity is estimated to last 15 years⁷. After the initial crediting period of ten years, subsequent renewals of the crediting time may be considered depending on the status of the project activity and baseline revision at that time.

According to gas engine lifetime confirmations from individual technology providers, a lifetime of 15 years is assumed.

The lifetime of boiler can be assumed as 25 years for default value, and the boiler nameplate shows the boiler manufacturing year as 1999 and 2002. It can be assumed that boiler shall function normally during the first crediting period.⁸

1.7 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 11 open lagoons (with retention time of around 200 days). The open lagoon system, which has been modified to integrate a closed anaerobic lagoon system, is still in use as secondary treatment of the tapioca raw effluent.

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 is used for combustion of methane in the project scenario.

1.8 A description of how the project will achieve GHG emission reductions and/or removal enhancements:

In the absence of the project activity, wastewater from the starch processing plant would have been treated in open anaerobic lagoons. After the implementation of the covered anaerobic lagoons, generated biogas is recovered and used as an alternative to fossil fuel and for electricity generation. From this, GHG emission reduction can be achieved in three ways:

- Avoidance of fugitive methane emissions to the atmosphere;
- Avoidance of carbon dioxide emissions from replacement of fossil fuel with biogas in thermal generation system and;
- Avoidance of carbon dioxide emissions through displacement of fossil-based electricity from national grid.

⁷ Average operation period of a cover lagoon wastewater treatment system in Thailand is 15 years, <http://teenet.chiangmai.ac.th/btc/introbiogas02.php>

⁸ http://cdm.unfccc.int/EB/050/eb50_repan15.pdf - Tool to determine the remaining lifetime of equipment.

1.9 Project technologies, products, services and the expected level of activity:

Before the implementation of the project, the wastewater is treated by an open lagoon system, consisting of 11 anaerobic lagoons⁹. This mode of treatment is the prevalent practice in this kind of industry, particularly where there is a relative abundance of land.

Under the project implementation, the effluent from the starch factory is first mixed together in a mixing tank before being sent to anaerobic digesters with biogas recovery (2 covered lagoons), before continuing to the remaining 9 open anaerobic deep lagoons. The project activity implements a simple, effective and reliable covered lagoon technology to capture lagoon-produced biogas.

Technology description

Each of two covered lagoons installed here will consist of a synthetic high-density polyethylene (HDPE) geo-membrane which is sealed by means of strip-to-strip welding and a peripheral anchor trench dug around the perimeter of the existing lagoons. The welded seams of the covered system will be tested to ensure air-tight coupling between all HDPE pieces. HDPE is an excellent product for large applications requiring UV, ozone and chemical resistance; these attributes make it one of the most commonly used geo-membranes worldwide. This covering approach effectively enables capture/combustion of the biogas produced in the covered lagoons.

The two covered lagoon digesters, together, are designed with volumetric capacity of wastewater of around 177,375 m³.

Anaerobic treatment

The effluent from the starch processing plant flows into two covered lagoons through an influent distribution system at the bottom of the reactor. In these methane reactors, organic compounds in wastewater are transformed mainly into biogas by anaerobic bacteria in the system. Using a typical anaerobic biodegradability value of raw tapioca wastewater of 80%, the production of biogas is estimated to be 10,654 m³ per day (with methane percentage being at 55%¹⁰). This represents the expected level of activity.

Biogas handling

The captured biogas will be routed to the combination boilers for the generation of thermal energy necessary for the starch drying process. Note that the two boilers together have a total capacity 7,268 kW_{thermal} (3,488 + 3,780). Later, a gas-based power generation facility has been installed with the total capacity being at 1,904 kWe (952 x 2). Excess biogas, if any, will then be sent to high temperature open flares to destroy methane gas as it is produced. The flaring system will be used only in the case of emergency.

Secondary treatment and final wastewater

⁹ All the baseline lagoons have depth greater than 2 m, thus with the ambient temperature being above 15 °C they can all regarded as anaerobic lagoons.

¹⁰ Average methane content of biogas has a broad range of 55-80%; a lower value of 55% is chosen for the calculation of this project to demonstrate conservative principle.
<http://www.oregon.gov/ENERGY/RENEW/Biomass/biogas.shtml>

The wastewater will continue to flow from the covered anaerobic section to a series of 9 open lagoons. After the whole treatment process, the COD concentration of the wastewater will be very low and it is recycled back for further utilisation at the starch factory¹¹. 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 application¹².

Table 3: Secondary treatment and final wastewater

No.	Lagoon	Depth (m)
1	Anaerobic pond 1 ('anaerobic lagoon')	4.0
2	Anaerobic pond 2 ('anaerobic lagoon')	4.0
3	Anaerobic pond 3 ('anaerobic lagoon')	3.5
4	Anaerobic pond 4 ('anaerobic lagoon')	3.5
5	Anaerobic pond 5 ('anaerobic lagoon')	3.0
6	Anaerobic pond 6 ('anaerobic lagoon')	3.0
7	Anaerobic pond 7 ('anaerobic lagoon')	2.5
8	Anaerobic pond 8 ('anaerobic lagoon')	2.5
9	Anaerobic pond 9 ('anaerobic lagoon')	2.0

Figure 3: List of equipments included in project boundary

No.	Equipment	Rated power (HP)	Installed amount	No. of use	Total HP (actual operation)
1	Wastewater pump No.1	25	1	1	25
2	Wastewater pump No.2	25	1	1	25
3	Water treatment pump No.1	50	1	1	50
4	Water treatment pump No.2	30	1	1	30
5	Water treatment pump No.3	30	1	1	30
6	Pqygen pump	0.25	1	1	0.25
7	Circulation gas pump No. 1.1	5	1	1	5
8	Circulation gas pump No. 1.2	5	1	1	5
9	Circulation gas pump No. 1.3	5	1	1	5
10	Circulation gas pump No. 1.4	5	1	1	5
11	Circulation gas pump No. 1.5	5	1	1	5
12	Circulation gas pump No. 1.6	5	1	1	5
13	Circulation gas pump No. 1.7	5	1	1	5

¹¹ Either for washing cassava roots or use for irrigation purpose of internal farmlands.

¹² The sludge will be used for fertiliser purpose.

14	Circulation gas pump No. 1.8	5	1	1	5
15	Circulation gas pump No. 1.9	5	1	1	5
16	Circulation gas pump No. 1.10	5	1	1	5
17	Flare	0.25	1	1	0.25
18	Chiller No. 1	12.69	1	1	12.69
19	Chiller No. 2	12.69	1	1	12.69
20	Gas blower 1	22	1	1	22
21	Gas blower 2	22	1	1	22
22	Fan Blower No. 1	0.5	1	1	0.5
23	Fan Blower No. 2	0.5	1	1	0.5
24	Fan Blower No. 3	1	1	1	1
25	Fan Blower No. 4	1	1	1	1
26	Blower air No. 1	5	3	3	15
27	Blower air No. 2	5	4	4	20
28	Gas blower No.3	22	1	1	22
29	Gas blower No.4	22	1	1	22
30	Chiller No. 3	9.46	1	1	9.46
Total summation of electricity consumption (HP)					371.34
Total summation of electricity consumption (kW)					277

1.10 Compliance with relevant local laws and regulations related to the project:

The proposed project activity is in compliance with all local laws and regulations from the local government section and the Ministry of Industry, Thailand as following.

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 discharge out of the factory ¹³	This project did not discharge wastewater outside of the factory, instead the wastewater is used for the washing process or in the plantation area

The project's compliance to the local laws and regulations is confirmed by a valid operation license.

1.11 Identification of risks that may substantially affect the project's GHG emission reductions or removal enhancements:

¹³ 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.

Major risks that may affect the project's GHG emission reductions are related to the operation of the biogas reactor system. This could however be avoided through staff training and well outlined operation procedures. Leakage of biogas or malfunction of the flare system might also effect the operation of the project; thus reducing its emission reduction potential. In this project, produced biogas is expected to be well utilised in both boiler and gas engine so the problem of leakage is estimated to be negligible. It should also be noted that the project activity has been well operated since its implementation and there are no clear identified risks that could affect the removal enhancements of the project.

1.12 Demonstration to confirm that the project was not implemented to create GHG emissions primarily for the purpose of its subsequent removal or destruction.

The baseline scenario described in this VCS PD consisting of open lagoons, fuel oil fired boiler and consumption of grid electricity; a system that has been in used for many years prior to the implementation of this project activity. This demonstrates that GHG emissions from the previous system would anyway have been emitted to the atmosphere and thus acts as a confirmation that they were not created for the purpose of its subsequent removal or destruction.

1.13 Demonstration that the project has not created another form of environmental credit (for example renewable energy certificates).

The project has not applied and has no plan to apply to any other form of environmental credit. A letter from project proponents was provided to certify such statement.

1.14 Project rejected under other GHG programs (if applicable):

Not applicable, the project has not applied to any other GHG programs.

1.15 Project proponents roles and responsibilities, including contact information of the project proponent, other project participants:

The project participants are listed in the following tables:

Role	Project owner (responsible for implementation and operation of the project activity)
Organization:	Kean Charoen Co., Ltd.
Address:	1004/201 Soi Watchannai, Ratchadapisek Rd, Bangpongpan, Yannawa, 10120
City:	Bangkok
Country:	Thailand
Telephone:	+66 2 294 5315-6, 2945646
FAX:	+66 2 294 3215
Represented by:	Ung Mengchua
Title:	Mr.
Salutation:	President

Role	Carbon consultant (responsible for development of emission reductions through the Voluntary Carbon Standard)
Organization:	South Pole Carbon Asset Management Ltd.
Street/P.O.Box:	Technoparkstrasse 1
City:	Zurich
Postfix/ZIP:	8005
Country:	Switzerland
E-Mail:	i.puhl@southpolecarbon.com
URL:	www.southpolecarbon.com
Represented by:	Ingo Puhl
Title:	Managing Partner
Salutation:	Mr.
Mobile:	+ 66 86 778 2869
Direct tel:	+ 66 2 678 8979

1.16 Any information relevant for the eligibility of the project and quantification of emission reductions or removal enhancements, including legislative, technical, economic, sectoral, social, environmental, geographic, site-specific and temporal information.):

The project and the associated quantification of emission reductions are eligible from a number of perspectives as follow:

Legislative:

The project meets all the statutory requirements. Evidence of permits for the implementation of the project such as operation permit, and property deed, among others, is provided to the DOE for the validation process.

Technical:

The covered lagoon biogas reactor system 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, 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 Northeastern 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.

Economic:

New jobs were 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 utilization 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 is applied under the framework of VCS; this is

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

Social:

The project activity provides direct and indirect employment to the local community during construction of the project activity as well as during operation. During construction, employment was offered for a lot of local unskilled labors contributing to social well being and economic well being. The involvement of local employees in the project activity helps to enhance the skills of the labour 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 results 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 are 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 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 are significantly reduced. Overall, the project has positive impacts on the local environment by improving air quality through reduction in odour and cleaner emissions. This can in turn improve the standard of living of the local population. The capacity of this technological process to replace fuel oil and generate electricity can also be regarded as a potential for reducing dependency on fossil fuels and for promoting diversification of energy resources. Ensuring energy security in this way can be seen as a contribution to sustainable development, particularly during this era of growing fuel prices.

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.

Temporal information:

The project will not double count the GHG emissions during the ten years renewable of

the crediting period.

There is no information relevant for its eligibility which is not already described in this VCS PD.

1.17 List of commercially sensitive information (if applicable):

Not applicable - no commercially sensitive information has been excluded, and all information shall be shared during validation of the VCS PD.

There are no trade secrets, financial, commercial, scientific, technical or other information whose disclosure could reasonably be expected to result in a material financial loss or gain, prejudice the outcome of contractual or other negotiations or otherwise damage or enrich the person or entity to which the information relates.

2 VCS Methodology:

2.1 Title and reference of the VCS methodology applied to the project activity and explanation of methodology choices:

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

Methane avoidance component:

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

Fuel replacement component:

Type I:	Renewable energy projects
Category I.C:	Thermal energy production with or without electricity
Sectoral Scope 1:	Energy industries (renewable /non-renewable sources)
Version:	15

Electricity generation component:

Type I:	Renewable energy projects
Category I.D:	Grid connected renewable electricity generation
Sectoral Scope 1:	Energy industries (renewable /non-renewable sources)
Version:	14

AMS. III.H., refers to:

- “Tool to determine project emissions from flaring gases containing methane”, Annex 13, EB 28

AMS.I.C., refers to:

- “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion” version 1.2.
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” version 1.0;

AMS.I.D., refers to:

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

These methodologies and tools can be found on the UNFCCC’s website at the following address:

<http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html>

2.2 Justification of the choice of the methodology and why it is applicable to the project activity:

Appendix B of the simplified modalities and procedures for small-scale CDM project activities provides indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity. As per this document, the proposed VCS project falls under AMS III.H., AMS I.C. and AMS I.D.

Applicability of AMS III.H.

The project activity is in line with the approved methodology AMS III.H., version 13; specific features of project and applicability of the methodology are discussed below:

Applicability Criteria	Project Status
<i>This methodology comprises measures that recover biogas from biogenic organic matter in wastewaters by means of one, or a combination, of the following options:</i> (i) <i>Substitution of aerobic wastewater or sludge treatment systems with anaerobic systems with biogas recovery and combustion;</i> (ii) <i>Introduction of anaerobic sludge treatment system with biogas recovery and combustion to an existing wastewater treatment plant without sludge treatment;</i> (iii) <i>Introduction of biogas recovery and combustion to an existing sludge treatment system;</i> (iv) <i>Introduction of biogas recovery and combustion to an existing anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an on site industrial plant;</i>	In absence of the project activity the wastewater was being treated in open lagoons. These open lagoons have depth greater than 2 meters, without aeration, and the ambient temperature on a monthly average basis being greater than 15 °C. In addition, the wastewater generation rate is at around 2,000 m³ day and the COD concentration of the wastewater is at 16,912 mg/L i.e. 16.9 kg/m³. With the minimum interval between two consecutives sludge removal during the baseline scenario also being greater than 30 days, the baseline open lagoons satisfied the anaerobic conditions specified under AMS III.H. (version 13). With the project activity involving the installation of 2 covered lagoons to treat high COD wastewater generated and methane

(v) <i>Introduction of anaerobic wastewater treatment with biogas recovery and combustion, with or without anaerobic sludge treatment, to an untreated wastewater stream;</i> (vi) <i>Introduction of a sequential stage of wastewater treatment with biogas recovery and combustion, with or without sludge treatment, to an existing 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)</i>	recovery. Therefore, it also satisfies the applicability criterion (vi).
<i>The recovered biogas from the above measures may also be utilised for the following applications instead of combustion/flaring:</i> (a) <i>Thermal or electrical energy generation directly; or</i> (b) <i>Thermal or electrical energy generation after bottling of upgraded biogas; or</i> (c) <i>Thermal or electrical energy generation after upgrading and distribution:</i> (i) <i>Upgrading and injection of biogas into a natural gas distribution grid with no significant transmission constraints; or</i> (ii) <i>Upgrading and transportation of biogas via a dedicated piped network to a group of end users; or</i> (d) <i>Hydrogen production.</i>	The project activity also involves the facility to capture biogas and further to utilize for heat and power generation. Hence, the project activity satisfies the criterion (a).
<i>If the recovered biogas is used for project activities covered under paragraph 2 (a), that component of the project activity can use a corresponding category under type I.</i>	The recovered biogas is used for heat and power generation as mentioned above and these components of the project activity use the categories under type 1 methodology, i.e., AMS I.C and AMS I.D.
<i>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 requirements in the General Guidance for SSC methodologies concerning these topics.</i>	This is neither a Greenfield project, nor does it result in a capacity addition of the wastewater or sludge treatment system compared to the designed capacity of the baseline treatment system, thus this applicability criterion is of no relevance.
<i>The location of the wastewater treatment plant shall be uniquely defined as well as the source generating the wastewater and described in the PD.</i>	The unique location of the project activity is clearly defined in section 1.5 of this VCS PD. Similarly, the source of the generating wastewater is

	well described in section 1.4, 1.9 and 2.3 in this VCS PD. Hence, this applicability criterion being satisfied.
<i>Measures are limited to those that result in aggregate emission reductions of less than or equal to 60 kt CO₂ equivalent annually from all type III components of the project activity.</i>	Annual emission reductions from all type III components of the project activity will be less than the defined cap (60 kt CO ₂ e). Hence, the project activity satisfies this applicability criterion as well.

Applicability conditions under AMS I.C.

The project activity is in line with the approved methodology AMS I.C., version 15; specific features of project and applicability of the methodology are discussed below:

Applicability Criteria	Project Status
<i>This category comprises renewable energy technologies that supply user with thermal energy that displaces fossil fuel use. These units include technologies such as solar thermal water heaters and dryers, solar cookers, energy derived from renewable biomass and other technologies that provide thermal energy that displaces fossil fuel.</i>	The project activity also involves the facility to capture biogas and further to utilize for heat generation. Therefore the project activity fulfils this applicability criterion. In addition, the project activity does not involve the co-gen facility.
<i>Biomass-based co-generating systems that produce heat and electricity are included in this category.</i>	Not applicable.
<i>The total installed/rated thermal capacity of the project equipment is equal or less than 45 MW_{thermal}.</i>	The hot oil boilers with rated capacity of 7.268 MW _{thermal} are part of project activity, which is less than 45 MW _{thermal} threshold. Hence, the project activity satisfies this applicability criterion.
<i>For co-fired systems the aggregate installed capacity (specified for fossil fuel use) of all systems affected by the project activity shall not exceed 45 MW_{thermal}. Cogeneration projects that displace/avoid fossil fuel consumption in the production of thermal energy (e.g. steam or process heat) and or/electricity shall use this methodology. The capacity of the project in this case shall be the thermal energy generation capacity i.e. 45 MW_{thermal}</i>	The total installed/rated thermal energy generation capacity of the project equipment is equal to 7.268 MW _{thermal} , which is less than 45 MW _{thermal} thresholds. Hence, the project activity satisfies this applicability criterion.
<i>The following capacity limits apply for biomass cogeneration units:</i> <i>a) If the project activity includes emission reductions from both the thermal and electrical energy components, the total</i>	Not applicable

<i>installed energy generation capacity (thermal and electrical) of the project equipment shall not exceed 45 MW thermal. For the purpose of calculating this capacity limit the conversion factor of 1:3 shall be used for converting electrical energy to thermal energy (i.e., for renewable project activities, the maximal limit of 15 MW(e) is equivalent to 45 MW thermal output of the equipment or the plant);</i> <i>b) If the emission reductions of the cogeneration project activity are solely on account of thermal energy production (i.e., no emission reductions accrue from electricity component), the total installed thermal energy production capacity of the project equipment of the cogeneration unit shall not exceed 45 MW thermal;</i> <i>c) If the emission reductions of the cogeneration project activity are solely on account of electrical energy production (i.e., no emission reductions accrue from thermal energy component), the total installed electrical energy generation capacity of the project equipment of the cogeneration unit shall not exceed 15 MW.</i>	
<i>In case electricity and/or steam/heat produced by the project activity is delivered to another facility or facilities within the project boundary, a contract between the supplier and consumer(s) of the energy will have to be entered into specifying that only the facility generating the energy can claim emission reductions from the energy displaced.</i>	AMS I.C. component of this project activity is only applicable to the fuel oil displacement in the starch drying process of Kean Charoen starch plant. Since the project activity and the starch plant belong to the same owner, this applicability criterion is already satisfied.
<i>Project activities that seek retrofit or modify an existing facility for renewable energy generation are included in this category.</i>	Under the project activity, the burner is retrofitted with combination fuel burner such that the boiler can be co-fired using both fuel oil and the biogas collected from the reactors.
<i>The capacity limits specified in the above paragraphs apply to both new facilities and retrofit projects.</i>	Total rated thermal generation capacity is less than 45 MW_{thermal} thresholds. Hence, the project activity being in compliance with this applicability criterion.
<i>Charcoal based biomass energy generation project activities are eligible to apply the methodology only if the charcoal is produced from renewable biomass sources.</i>	Not applicable.

Applicability conditions under AMS I.D.

The project activity is in line with the approved methodology AMS I.D., version 14; specific features of project and applicability of the methodology are discussed below:

Applicability Criteria	Project Status
<i>This category comprises renewable energy generation units, such as photovoltaics, hydro, tidal/wave, wind, geothermal and renewable biomass, that supply electricity to and/or displace electricity from an electricity distribution system that is or would have been supplied by at least one fossil fuel fired generating unit.</i>	The project activity will use biogas as fuel to generate electricity. This in turn displaces fossil-fuel based grid electricity by PEA. Therefore, the project activity satisfies this applicability condition.
<i>If the unit added has both renewable and non-renewable components (e.g. a wind/diesel unit), the eligibility limit of 15 MW 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</i>	The generation sets used in the project activity are used only for the combustion of biogas. The renewable component has a total generation capacity of an approximate 1.904 MWe. Hence, the project activity satisfies the applicability condition.
<i>Combined heat and power (co-generation) systems are not eligible under this category.</i>	Not applicable
<i>In the case of project activities that involve the 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 15 MW and should be physically distinct² from the existing units.</i>	Not applicable
<i>Project activities that seek to retrofit or modify an existing facility for renewable energy generation are included in this category. To qualify as a small-scale project, the total output of the modified or retrofitted unit shall not exceed the limit of 15 MW.</i>	Not applicable

2.3 Identifying GHG sources, sinks and reservoirs for the baseline scenario and for the project:

As per the AMS III.H., AMS I.C. and AMS I.D., the project boundary shall respectively include the following:

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

“The physical, geographical site of the project equipment producing the renewable energy delineates the project boundary. The boundary also extends to the industrial, commercial or residential facility, or facilities, consuming energy generated by the system and the processes or equipment that is affected by the project activity.

“The physical, geographical site of the renewable energy generation source delineates the project boundary”.

There are no physical unit or process that removes a GHG from the atmosphere (sink) nor the physical unit or component of the biosphere, geosphere or hydrosphere with the capability to store or accumulate a GHG removed from the atmosphere by a greenhouse has sink or a GHG captured from a greenhouse gas source (reservoir) relevant in the project boundary. However, following the methodology: AMS III.H., AMS I.C., and AMS I.D., the associated GHG sources (physical units or processes that release a GHG into the atmosphere) for the baseline and project activity scenarios are presented in Table 4 below:

Table 4: Source of GHG emissions under baseline and project scenarios

	Source	Gas	Included	Justification
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 consumption	CO ₂	Included	Fossil fuel based grid electricity is consumed for the operation of the wastewater treatment system in the baseline scenario.
		CH ₄	Excluded	Excluded for simplification. This is conservative
		N ₂ O	Excluded	Excluded for simplification. This is conservative
	Thermal energy Generation	CO ₂	Included	Emission from fuel oil consumption in the baseline scenario.
		CH ₄	Excluded	Excluded for simplification. This is conservative
		N ₂ O	Excluded	Excluded for simplification. This is conservative
Project activity	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	CO ₂	Included	On-site electricity consumed by project activity which is not generated from biogas will be accounted for.

		CH ₄	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N ₂ O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	On-site fossil fuel consumption	CO ₂	Included	Emission from fuel oil consumption in the project scenario.
		CH ₄	Excluded	Excluded for simplification. This is conservative
		N ₂ O	Excluded	Excluded for simplification. This is conservative

The flow diagram of the development of biogas system is shown step-by-step in these figures below (— · — · boundary line).



Figure 4: The baseline system boundary

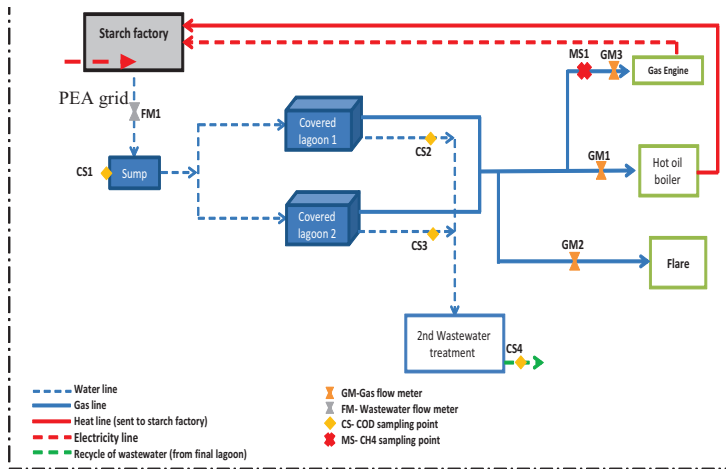


Figure 5: The project system boundary

2.4 Description of how the baseline scenario is identified and description of the identified baseline scenario:

Methane avoidance component:

At the project location, open anaerobic lagoons without biogas recovery represent the existing wastewater treatment system and methane recovery and combustion system is being introduced to an existing anaerobic wastewater treatment system (as defined under applicability conditions for project activity measures under Paragraph 1 (vi) of the applied methodology, see Section 2.2 above).

Therefore, the baseline scenario to the project activity is the existing anaerobic wastewater treatment system without biogas recovery for the case of introduction of a sequential anaerobic wastewater treatment system with methane recovery.

The baseline scenario consists of 11 anaerobic lagoons, which were used to treat wastewater prior to project implementation. The baseline condition of the project as described is already sufficient in meeting all relevant regulations and legislation.

Table 5: Open lagoons (prior to project implementation)¹⁴

No.	Lagoon	Depth (m)
1	Anaerobic pond 1 ('anaerobic lagoon')	4.0
2	Anaerobic pond 2 ('anaerobic lagoon')	4.0
3	Anaerobic pond 3 ('anaerobic lagoon')	4.0
4	Anaerobic pond 4 ('anaerobic lagoon')	4.0
5	Facultative pond 1 ('anaerobic lagoon')	3.5
6	Facultative pond 2 ('anaerobic lagoon')	3.5
7	Aerobic pond 1 ('anaerobic lagoon')	3.0
8	Aerobic pond 2 ('anaerobic lagoon')	3.0
9	Aerobic pond 3 ('anaerobic lagoon')	2.5
10	Polishing pond 1 ('anaerobic lagoon')	2.5
11	Polishing pond 2 ('anaerobic lagoon')	2.0

Thermal energy generation component:

Thermal energy is necessary in the process of starch drying. In the absence of project activity, this process would have been done through utilization of fuel oil. A deviation in coherence with paragraphs 15 and 10 of AMS.I.C version 15 is used to calculate the baseline emissions from this component. Refer to section 4.1 for further explanation. For reference, an average fuel oil consumption over the period between the years 2005-2006 (pre-project period) is calculated at 0.0396 liters per kg of dry starch.

Electricity generation component

In accordance to Paragraph 7 of the methodology AMS I.D. (Version 14), with this project activity being a wastewater treatment project and the recovered biogas is used for electricity generation, the baseline shall be calculated using Paragraph 9 in the methodology:

“For all other systems, the baseline emissions are the product of electrical energy baseline EG_y expressed in kWh of electricity produced by the renewable generating unit multiplied by an emission factor”.

¹⁴ Please refer to design drawing submitted to the DOE during validation.

The Emission Factor can be calculated in a transparent and conservative manner as follows:

- (a) 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

- (b) The weighted average emissions (in kg CO₂e/kWh) of the current generation mix. The data of the year in which project generation occurs must be used. Calculations must be based on data from an official source (where available) and made publicly available.”

The project activity uses combined margin approach as the same is made available by official source¹⁵ by Department of Alternative Energy Development and Efficiency, Ministry of Energy. The approach is selected since the data and estimation is made available by a national authority.

2.5 Description of how the emissions of GHG by source in baseline scenario are reduced below those that would have occurred in the absence of the project activity (assessment and demonstration of additionality):

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”.

The Attachment A to Appendix B of the simplified modalities and procedures for small-scale CDM project activities¹⁶ 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 has been identified for comparative assessment:

<i>Alternatives</i>	<i>Plausible alternatives available to the project participant</i>
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

¹⁵ http://www2.dede.go.th/cdm/520126_GridEmission2007.pdf

¹⁶ http://cdm.unfccc.int/Reference/Guidclarif/ssc/methSSC_guid05.pdf

the environment (COD $\leq$ 120 mg/l and 5-day BOD not exceeding 20 mg/l)¹⁷. 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 are 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 starch processing wastewater^{18, 19}. This practice is low cost and usually least cost in both capital and operation & maintenance cost^{20, 21}. 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 financial 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 operation and maintenance cost through the project's lifetime with no expected revenue to topple the already high 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”²². 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,

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.

¹⁸ Rajbhandari, B.K., Annachhatre, A.P. 2004, Anaerobic ponds treatment of starch wastewater: case study in Thailand. *Bioresource Technology* 95 (2004) 135–143.

¹⁹ 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.

²⁰ Cinara, 2004 “Waste stabilization ponds for wastewater treatment, International Water and Sanitation Centre” <http://www.irc.nl/page/8237>

²¹ Mara, D., 2003, Waste Stabilization Ponds: Time for Aggressive Marketing <http://www.bvsde.paho.org/bvsacd/agua2003/mar.pdf>

²² 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.

financing of biogas project in starch industry appears to be constraint²³. 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 proposal²⁴.

In recent years (2003- 2005), Ministry of Environment started a pilot demonstration of biogas system in starch industry in four different wastewater treatment technologies. Nine factories have been selected and received financial support from the Energy Conservation Promotion Fund (ENCON)²⁵. In addition to these factories, the other tapioca starch mills have also implemented biogas plants considering CDM revenues to overcome the risk and financial barriers²⁶. From this, it is therefore a reasonable conclusion that such support schemes demonstrate that these projects faced significant barriers and would not have been developed in the absence of external support.

Alternative (b) also involves high investment and O&M costs, as well as possessing the risk of not being able to achieve a financially justified return from biogas production. This risk can certainly be regarded as an investment barrier. It should also be mentioned that although alternative (b) is an expensive option, it may be possible that the monetary benefits of VERs can cover the additional expenses.

As mentioned, due to high operation cost, starch production operators are not willing to take alternative (c) for investment consideration. With alternative (d) deemed a violation to national regulations, this leaves only alternative (b) being worthy of a simple investment analysis.

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 is the Internal Rate of Return (IRR). For this project activity, an average Minimum Lending Rate (MLR) of local commercial banks in Thailand on 1st June 2005 (investment decision date) at 5.9125%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.

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 can then be considered as financially additional and thus acts as a demonstration that the project activity faces investment barriers.

²³ 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.

²⁴ Prasertsan, S. B. Sajjakulnukit (2006). Biomass and biogas energy in Thailand: Potential, opportunity and barriers. Renewable Energy 31:599–610.

²⁵ Energy Policy and Planning Office, Ministry of Energy, Seminar on the Promotion of Production of Biogas from Wastewater as an Alternative Energy and for Environmental Improvement, At Ballroom, Sirikit Convention Centre 29 August 2007, pp.46-47,

²⁶ The pilot project of CDM development program in "bundle" pattern among medium size starch manufacturers and small size starch manufacturers http://www.thaitapiocastarch.org/cooperation_detail.asp?id=5

²⁷

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

Investment analysis was undertaken using the data shown in Table 6:

Table 6: The basic financial parameters of the project

Total Investment (THB) ²⁸	60,001,734	Based on actual payment
Non-labour operating and maintenance costs (THB/year)	3,000,087	Assume at 5% of total investment cost
Manpower cost (THB/year)	1,812,000	Actual cost
Annual Biogas generated (Nm ³ /yr)	2,397,270	Calculated - based on COD removal
Annual electricity generated (MWh/yr)	2,371	Based on planned biogas usage
Price of electricity sold (THB/kWh)	2.13	Annual report - 2005 EGAT
Fossil fuel replaced	Fuel oil	Baseline scenario
Amount of fossil fuel replaced (liter/year)	630,864	Based on planned biogas usage
Price of fossil fuel (THB/liter)	7.82	3-year average HFO price
Operation period (years)	15	Typical lifetime from literature review
Crediting years	10	VCS PD
Exchange rate (THB/Euro)	49.63	At investment decision date
Expected VERs (tCO ₂ e/year)	16,280	VCS PD
VER price (Euro/tCO ₂ e)	5.0	Assumption
Discount rate	5.91%	MLR (Bank of Thailand)

In consideration with the discussions carried out during validation process, following explanation is provided on the assumption of fuel oil price in the PD. Three year average price is used to take into account the price volatility of the fuel oil. The effect of uncertainty and possible 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 historic oil prices against the average oil price is analysed. The development of the wholesale price in the period from June 2002 to May 2005 indicates that a variation of +/-10% in oil prices is quite appropriate for the sensitivity analysis as the average price in the peak years (minimum and maximum) fluctuates with maxima of +8.7% and -8.2% around the 3-year average price. Given the volatility in oil prices prior to the investment decision, which is demonstrated in the figure below, the selected approach is deemed realistic. For more information, please refer to the IRR calculation sheet.

Figure 6: Wholesale HFO price development in Thailand²⁹

²⁸ The cost of project activity based on actual payment is justifiable as per industrial standards i.e. information available on similar projects. The application also takes into account the time value of money, which is conservative. Please note that comparison of proposal cost and actual cost of three South Pole's projects (i.e. or Bangna Starch Wastewater Treatment and Biogas Utilization Project, Chorchaiwat Wastewater Treatment and Biogas Utilisation project and NE Biotech wastewater treatment and power production project) have been submitted to the DOE. It is observed that variation in amount is in range of +3.17% and -1.21%; this range is covered very aptly in the sensitivity analysis.

²⁹ <http://www.eppo.go.th/petro/price/index.html>

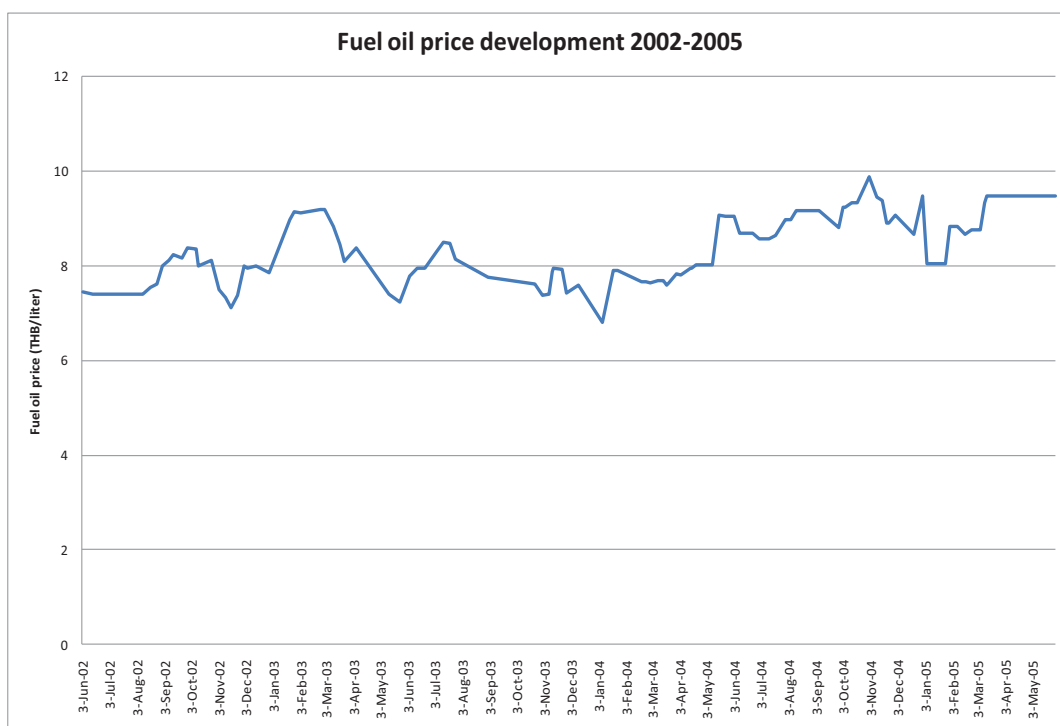


Table 7: Comparative financial indicators with and without VER revenues

Develop project activity without VER revenues	IRR (%)	2.72%
Develop project activity with VER revenues	IRR (%)	10.10%

In the case whereby the benefits of VERs have not been taken account, the project activity is deemed unattractive from a financial perspective. This can be seen in Table 7 where IRR is estimated at 2.72%. 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 8: Sensitivity analysis of important parameters

Sensitivity Analysis IRR	IRR after mentioned change in price of HFO (%)	IRR after mentioned change in cost of O&M (%)	IRR after change in biogas volume (%)	IRR after change in power selling price (%)	IRR after change in investment (%)
-10%	1.36%	4.07%	-0.15%	1.28%	4.27%
-5%	2.04%	3.40%	1.32%	2.01%	3.46%
0%	2.72%	2.72%	2.72%	2.72%	2.72%
5%	3.38%	2.02%	4.07%	3.41%	2.03%
10%	4.04%	1.31%	5.37%	4.09%	1.39%

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 labour³⁰. 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,

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/Ts3%20biomass%20and%20biogas%20energy%20in%20thailand%20potential,%20opportunity%20and%20barriers.pdf>.

such biological systems require constant monitoring to ensure that the system remains in balance. There are 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).

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, operators 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 inability of the local labour 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

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”.

(04/02/2009), there is an 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 finance; 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 finance’, 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 4th February, 2009³⁸), 8 projects have received the letter of approval from the Thai DNA and are either registered (Table 9), under registration (Table 10), under review (Table 11), or under validation (Table 12) 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 13). Moreover, one project has sold its credits to the voluntary carbon market and another nine are currently undergoing validation and initial verification under VER standards³⁹ (Table 14). 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 requirement.

Table 9: 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 10: 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 11: 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 12: 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 13: 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
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.

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/7UD55FPNACFME93NJI31VAUFG4WCI5/view.html>

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

Table 14: 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 (Chonburi)	Chol 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. It faces several implementation barriers (due to risk of performance failure and unavailability of local skilled labour), and our project test has also shown that it would not be an attractive investment option. The project is thus additional and reduces GHG emissions that would have been emitted by an anaerobic lagoon, 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 to a lower GHG emission reductions below what would have happened under a baseline scenario. With the project meeting the required conditions under Test 1, “The project test”, a conclusion can be reached that the project is an additionality.

3 Monitoring:

3.1 Title and reference of the VCS methodology (which includes the monitoring requirements) applied to the project activity and explanation of methodology choices:

VCS Program approved methodologies are used to monitor the emissions reductions. AMS III.H., “Methane Recovery in Wastewater Treatment” (version 13), is applied to

⁴⁹ South Pole Carbon Asset Management Ltd.

the proposed project activity for the methane avoidance components. In the methane utilisation components, AMS I.C. “Thermal energy production with or without electricity” (version 15) and AMS I.D. “Grid connected renewable electricity generation” are applied (version 14). Methodology choices have already been justified in section 2.2.

AMS. III.H., refers to:

- “Tool to determine project emissions from flaring gases containing methane”, Annex 13

AMS.I.C., refers to:

- “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion” version 1.2.
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” version 1.0;

AMS.I.D., refers to:

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

These methodologies and tools can be found on the UNFCCC’s website at the following address:

<http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html>

3.2 Monitoring, including estimation, modelling, measurement or calculation approaches:

Details on the monitoring approaches used in quantifying and reporting GHG emissions and/or removals relevant for the project and baseline scenario shall be elaborated in section 3.3 and 3.4. However, the overall monitoring procedures include the following criteria:

- Purpose of monitoring – to verify the emission reductions using actual data
- Types of data and information to be reported, including units of measurement – see section 3.3
- Origin of the data – see section 3.3
- Monitoring, including estimation, modelling, measurement or calculation approaches – calculation for monitoring will be made based on recorded data required by the applied methodologies available. Please refer to section 2.3 for the location of the monitoring equipments. For reference, there will be 3 gas flow meters in total; one will be installed at the gas line going to gas engines, another will be installed by the boiler and the last one will be installed by the flare system. In addition, there will be 1 wastewater flow meter installed by wastewater line going into the covered lagoon system. Electricity meters are incorporated with the electricity generation sets. Please note that the online gas analyser is also available for measurement of biogas going into gas engines. The plant also has a portable gas analyser which will be primarily used at the boiler. In circumstances whereby methodology deviations are necessary, this will be clearly pointed out in section 4.1 of this VCS PD and again in the monitoring report associated with the verification process.
- Monitoring times and periods, considering the needs of intended users – vary; depend on the parameters. For more detail, please refer to section 3.3 of this VCS PD.

- Monitoring roles and responsibilities – project proponents will be involved in collection of monitoring information.
- GHG information management systems – the acquainted data shall be kept at the starch processing plant for a minimum of 2 years after the crediting period.

The project proponent shall apply the stated GHG monitoring criteria and procedures on a regular basis during project implementation. In addition, related meters and equipments will be calibrated on a regular basis (generally on a once in three years basis).

3.3 Data and parameters monitored / Selecting relevant GHG sources, sinks and reservoirs for monitoring or estimating GHG emissions and removals:

Certain parameters are based on default values throughout crediting period and others are to be routinely record as part of the monitoring plan. In the following section we shall discuss about these parameters, starting with parameters with fixed values.

Parameters with fixed default values, throughout the crediting period:

Data / Parameter:	GWP_{CH4}
Data unit:	-
Description:	Global warning potential of methane gas
Source of data used:	Default value from AMS III.H.
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied :	Intergovernmental Panel on Climate Change, Climate Change 1995: The Science of Climate Change (Cambridge, UK: Cambridge University Press, 1996)
Any comment:	

Data / Parameter:	B_{o, ww}
Data unit:	kg CH ₄ /kg COD
Description:	Methane producing capacity of COD in wastewater.
Source of data used:	IPCC default value, corrected as per methodology AMS III.H., is used for estimation
Value applied:	0.21 kg CH ₄ /kg COD
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC adjusted value
Any comment:	-

Data / Parameter:	UF_{BL}
Data unit:	Factor
Description:	Model correction factor to account for model uncertainties
Source of data used:	AMS III.H., Version 13
Value applied:	0.94
Justification of the choice of data or	According to the AMS III.H., correction factor will be used for estimation of baseline emissions.

description of measurement methods and procedures actually applied :	
Any comment:	-

Data / Parameter:	UF_{PJ}
Data unit:	Factor
Description:	Model correction factor to account for model uncertainties
Source of data used:	AMS III.H., Version 13
Value applied:	1.06
Justification of the choice of data or description of measurement methods and procedures actually applied :	According to the AMS III.H., correction factor will be used for estimation of project activity emissions.
Any comment:	-

Data / Parameter:	MCF_{ww, treatment, BL, lagoon}
Data unit:	Fraction
Description:	Methane correction factor for the baseline anaerobic wastewater treatment systems
Source of data used:	Table III.H.1. of AMS III.H., Version 13 page no 6
Value applied:	0.8
Justification of the choice of data or description of measurement methods and procedures actually applied :	The baseline wastewater treatment system consists in a succession of deep lagoons (depth more than 2 metres) therefore MCF value is chosen as 0.8.
Any comment:	IPCC Default values from chapter 6 of volume 5 page no 6.21. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Data / Parameter:	MCF_{ww, treatment, PJ, CL}
Data unit:	-
Description:	Methane correction factor for project wastewater treatment system covered lagoon equipped with biogas recovery
Source of data used:	Table III.H.1 from AMS III.H., Version 13
Value applied:	MCF _{ww, treatment, PJ, k} = 0.8
Justification of the choice of data or description of measurement methods and procedures actually applied :	The project wastewater treatment system equipped with biogas recovery is a UASB, therefore MCF value is chosen as 0.8.
Any comment:	

Data / Parameter:	MCF_{ww, treatment, PJ, lagoon}
Data unit:	Fraction
Description:	Methane correction factor for project wastewater treatment system k

Source of data used:	Table III.H.1. of AMS III.H., Version 13 page no 6
Value applied:	0.8
Justification of the choice of data or description of measurement methods and procedures actually 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.
Any comment:	IPCC Default values from chapter 6 of volume 5 page no 6.21. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Data / Parameter:	COD removal efficiency – baseline					
Data unit:	%					
Description:	COD removal efficiency of baseline wastewater treatment system					
Source of data used:	Measured – Colorimetric analysis					
Value of data applied for the purpose of calculating expected emission reductions:	87.16%					
Justification of the choice of data or description of measurement methods and procedures actually 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 97.93% ⁵⁰ .					
	Sample No.	Parameters	Unit	COD inlet	COD outlet	%COD removal
	1	COD	mg/L	15,690	235	98.50%
	2	COD	mg/L	17,845	295	98.35%
	3	COD	mg/L	17,930	375	97.91%
	4	COD	mg/L	14,290	270	98.11%
	5	COD	mg/L	18,065	345	98.09%
	6	COD	mg/L	16,370	390	97.62%
	7	COD	mg/L	16,710	230	98.62%
	8	COD	mg/L	19,100	375	98.04%
	9	COD	mg/L	17,355	485	97.21%
	10	COD	mg/L	15,770	490	96.89%
	Average COD			16,913	349	97.93%
	Any comment:	-				

Data / Parameter:	CFE_{ww}
Data unit:	Fraction
Description:	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems.
Source of data used:	Equation 10 in AMS III.H, Version 13 methodology (page

⁵⁰ 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.

	12)
Value applied:	0.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	A default value as per AMS III.H.
Any comment:	-

Data / Parameter:	EF_y
Data unit:	t CO ₂ /Mwh
Description:	CO ₂ emission factor for grid power
Source of data used:	“The calculation of emission factor for an electricity system in Thailand 2007”, DEDE.
Value applied:	0.5057
Justification of the choice of data or description of measurement methods and procedures actually applied :	EF _y is calculated according to the “Tool to calculate the emission factor for an electricity system” as determined in the respective small-scale methodology for grid connected electricity generation (AMS I.D. version 14).
Any comment:	Conservative choice and publically available data.

Data / Parameter:	EF_{CO2}
Data unit:	tCO ₂ /TJ
Description:	Emission factor of fossil fuel replaced – Residual Fuel oil
Source of data used:	IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23
Value applied:	77.4 tCO ₂ /TJ
Justification of the choice of data or description of measurement methods and procedures actually 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.
Any comment:	-

Data / Parameter:	NCV_{FO}
Data unit:	GJ/tonne
Description:	NCV of fuel oil i.e. fossil fuel displaced by biogas
Source of data used:	‘Thailand Energy Situation 2005’ http://www.dede.go.th/dede/fileadmin/user/wpd/static/thai_ene_2005/41Convers.pdf
Value applied:	42.76
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value from official source in Thailand.
Any comment:	-

Data / Parameter:	NCV_{biogas}
Data unit:	MJ/Nm ³

Description:	NCV of biogas
Source of data used:	'Thailand Energy Situation 2005' http://www.dede.go.th/dede/fileadmin/user_upload/static/thai_ene_2005/41Convers.pdf
Value applied:	20.93
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value from official source in Thailand.
Any comment:	-

Data / Parameter:	Q_{FO, starch}
Data unit:	l/tonne
Description:	Liters of fossil fuel required per tonne of dry starch historically
Source of data used:	Historic data
Value applied:	39.6 litres/tonne
Justification of the choice of data or description of measurement methods and procedures actually applied :	Based on average values from 2005 and 2006 (January-October) 2005 = 40.0 litres/tonne 2006 (January-October) = 39.2 litres/tonne
Any comment:	-

Data / Parameter:	D_{CH4}
Data unit:	Kg/m ³
Description:	Density of methane at normal conditions
Source of data used:	Tool to determine project emissions from flaring gases containing methane.
Value applied:	0.716
Justification of the choice of data or description of measurement methods and procedures actually applied :	CDM EB as per EB28 Meeting report (Annex 13)
Any comment:	

Data / Parameter:	D_{FO}
Data unit:	Kg/liter
Description:	Density of fuel oil
Source of data used:	http://www.engineeringtoolbox.com/fuels-densities-specific-volumes-d_166.html
Value applied:	0.93
Justification of the choice of data or description of measurement methods and procedures actually applied :	Publically available information
Any comment:	-

Data / Parameter:	FE
Data unit:	%
Description:	Flare efficiency
Source of data used:	Tool to determine project emissions from flaring gases containing methane.
Value applied:	50%
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value for open flare as per Tool to determine project emissions from flaring gases containing methane has been applied.
Any comment:	–

Data / Parameter:	DE
Data unit:	%
Description:	Destruction efficiency of the electricity generator
Source of data used:	SSC WG
Value applied:	100%
Justification of the choice of data or description of measurement methods and procedures actually applied :	According to clarification from SSC WG “ <i>in the case that the biogas is combusted for a gainful use of the released energy as in an engine or a power plant, a destruction efficiency of 100% can be used for the portion of biogas that is combusted when applying AMS III.H., i.e. use a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use</i> ” ⁵¹
Any comment:	–

Data / Parameter:	P_{el}
Data unit:	kW
Description:	Total electrical capacity of the equipments installed in the project activity
Source of data to be used:	Plant data
Value applied:	277 kW ⁵²
Justification of the choice of data or description of measurement methods and procedures actually applied :	Extract from nameplate of the electrical equipments.
Any comment:	-

The following parameters must be monitored throughout the crediting period:

Data / Parameter:	Q_{v,ww}
Data unit:	m ³
Description:	Volume of wastewater treated in the year y

⁵¹ Please refer to paragraph 29 SSC WG 22 external report, page 6. Please note that the respond to this query, F-CDM-SSCwg ver 01 SSC_324 dated 29/07/2009, can be accessed through the following

link: <http://cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKEUHEF5LB07QICT1P>

⁵² Please refer to section 1.9 in this PD for more clarity on the available equipments.

Source of data to be used:	Measured continuously – Volumetric flow meters
Value of data applied for the purpose of calculating expected emission reductions:	For ex-ante estimation: 441,833 m ³ (based on design value)
Description of measurement methods and procedures to be applied:	The electromagnetic volumetric flow meter with an acceptable level of accuracy is installed at the plant. For reference, the newly purchased wastewater flow meter has test records showing an uncertainty level of up to 0.07% (+/-) 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. Please note that continuous measurement will be made and cumulative reading will be recorded daily. In case the flow meter value is not available for a particular day, the same shall be estimated in a conservative manner.
QA/QC procedures to be applied:	Once in three year calibrations for flow meter is to be conducted via an external agency according to an approved national or international standard. This calibration is plan for off season to ensure data accuracy and sufficiency in operation days. For reference, the calibration for this new meter has been calibrated according to ISO 9104
Any comment:	

Data / Parameter:	COD_{ww, untreated, v}
Data unit:	mg/l
Description:	COD of water entering the covered lagoon reactor system
Source of data to be used:	Measured (in every operational day) – Colorimetric analysis
Value of data applied for the purpose of calculating expected emission reductions:	For ex-ante estimations: 16,913 mg/l (historical average values)
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 by the operators in the plant operation report on a daily basis. In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
QA/QC procedures to be applied:	The colorimetric method is well documented and well accepted either by national or international standards. In addition, to ensure accuracy in our measurements, the plant shall periodically send wastewater samples to be tested by external laboratory and compare these results with internal measurements. At least once per year.
Any comment:	The figures here are simple average, however all calculations are based on weighted daily measurements of COD and wastewater for a transparent estimate of VERs.

Data / Parameter:	COD_{out, lagoon, PJ, v}
Data unit:	tonnes/m ³
Description:	COD of water coming out of the last lagoon
Source of data to be used:	Measured– Colorimetric analysis (measurement in every operational day)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	For ex-ante estimations: 0.000434 tonnes/m ³
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 by the operators in the plant operation report on a daily basis. In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
QA/QC procedures to be applied:	The colorimetric method is well documented and well accepted either by national or international standards. In addition, to ensure accuracy in our measurements, the plant shall periodically send wastewater samples to be tested by external laboratory and compare these results with internal measurements. At least once a year.
Any comment:	-

Data / Parameter:	COD_{out, CL, v}
Data unit:	tonnes/m ³
Description:	COD of water coming out of the cover lagoon
Source of data to be used:	Measured– Colorimetric analysis (measurement in every operational day)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	For ex-ante estimations: 0.00338 tonnes/m ³
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 by the operators in the plant operation report on a daily basis. In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
QA/QC procedures to be applied:	The colorimetric method is well documented and well accepted either by national or international standards. In addition, to ensure accuracy in our measurements, the plant shall periodically send wastewater samples to be tested by external laboratory and compare these results with internal measurements. At least once a year.
Any comment:	There are two measurements: - one after Cover lagoon 1 - one after Cover lagoon 2 The average of the two measurements is used

Data / Parameter:	BG_{combusted, y}
Data unit:	Nm ³
Description:	Amount of biogas combusted for gainful use
Source of data to be used:	Calculated from a summation of total biogas utilised in boilers, generation sets.
Value of data applied for the purpose of calculating expected emission reductions:	For ex-ante estimations: 2,397,270Nm ³ (Calculate from design values – see attached calculation sheet).
Description of measurement methods and procedures to be applied:	BG_{combusted, y} is estimated by summing the volume of biogas sent to the boiler and generation sets. Measurements of volume of biogas sent to boiler and gas engines shall be continuously using gas flow meters. In recording these parameters, 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. Please note that continuous measurement will be made and cumulative reading will be recorded daily. In case the flow meter values are not available for reason such as faulty meter, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
QA/QC procedures to be applied:	The flow meters at each utilizing facility shall be subject to once in three year calibration according to the equipment's specifications and applicable industrial standards. This will certainly help in ensuring that our calculation will be of a reasonable level in terms of accuracy. For reference, the newly purchased gas flow meter has been calibrated and is traceable to the National Institute of Standards and Technology to an uncertainty of +/-1.0% of reading +/- 0.2% of full scale measurements traceable to NIST Standards in accordance with Mil-Std-45662A.
Any comment:	-

Data / Parameter:	W_{CH4}
Data unit:	%
Description:	Methane content in biogas
Source of data to be used:	Measured – Gas analyser system to monitor % of methane in biogas
Value of data applied for the purpose of calculating expected emission reductions:	For ex-ante estimations: 55% (assumed value)
Description of measurement methods and procedures to be applied:	Online monitoring equipment is incorporated to increase the accuracy. Data from here will be recorded and stored electronically on a continuous basis.
QA/QC procedures to	Once in three year calibrations for the gas analyser is to be

be applied:	conducted via an external agency. This calibration is planned for off season to ensure data accuracy and sufficiency in operation days. In the case of breakdown of the online gas analyser, periodic measurements will be done using portable gas analysers at 95% confidence level.
Any comment:	-

Data / Parameter:	BG_{TOFlare, y}
Data unit:	Nm ³
Description:	Amount of biogas flared
Source of data to be used:	Measured using gas flow meter
Value of data applied for the purpose of calculating expected emission reductions:	0 Nm ³ (biogas is expected to be fully utilized by boiler and genset).
Description of measurement methods and procedures to be applied:	The gas flow meter with an accepted level of accuracy will be installed at the plant. Measurements of volume of biogas sent to flare shall be done continuously using gas flow meter. 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. Please note that continuous measurement will be made and cumulative reading will be recorded daily.
QA/QC procedures to be applied:	Once in three year calibrations for flow meter is to be conducted via an external agency. This calibration is planned for off season to ensure data accuracy and sufficiency in operation days. In case the flow meter values are not available for reason such as faulty meter, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
Any comment:	-

Data / Parameter:	q_{FO, y}
Data unit:	Litres
Description:	Quantity of fossil fuel used in boiler in year y
Source of data to be used:	Usage data (monitored from boiler panel). Value is used for conservative estimation of biogas / methane used in replacement of fossil fuel during an year y.
Value of data applied for the purpose of calculating expected emission reductions:	For ex-ante estimations: 630,864 liters (calculated as per GHG calculation sheet – note that it is equivalent to 587 tonne of fuel oil at density of 0.93)
Description of	Fuel oil meter is incorporated to the hot oil boiler.

measurement methods and procedures to be applied:	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. In case the oil meter values are not available for reason such as faulty meter, the same shall be estimated in a conservative manner.
QA/QC procedures to be applied:	Usage data is cross-check with fuel oil purchase records maintained at the project site. Energy balance shall also ensure aptness of monitored data depending on energy consumption of dry starch production before project implementation.
Any comment:	-

Data / Parameter:	$Q_{\text{starch}, y}$
Data unit:	Tonnes
Description:	Quantity of dry starch produced
Source of data to be used:	Based on operational log sheet at the plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	For ex-ante estimation: 38,660 tonnes (Average starch production data in 2005-2008 is applied here)
Description of measurement methods and procedures to be applied:	A proper record of all starch produced shall be maintained at the project site. 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.
QA/QC procedures to be applied:	Production data can cross-checked with sales record if necessary. Accuracy in the monitoring parameter can be assured since it is the main income source of the starch plant.
Any comment:	-

Data / Parameter:	EG_y
Data unit:	MWh/y
Description:	Net electricity production by the generators during year y
Source of data to be used:	Measured – Electricity meters installed at the generation sets. Power sale invoices if power is sold to PEA.
Value of data applied for the purpose of calculating expected emission reductions:	For ex-ante estimations: 2,223 MWh (Estimation based on design values).
Description of measurement methods and procedures to be applied:	Measured electronically on a continuous basis. Data will be recorded manually on a daily basis in the plant operation report. 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.
QA/QC procedures to	The electricity meter shall be subject to periodic calibration

be applied:	according to the equipment's specifications and applicable industrial standards (generally on a once in three year basis).
Any comment:	-

Data / Parameter:	EC_y
Data unit:	MWh
Description:	Electricity consumption by wastewater treatment plant in year y
Source of data to be used:	Maximum rated consumption is calculated by multiplying total electrical capacity with 8,760 hours and 10% additional factor to be conservative.
Value of data applied for the purpose of calculating expected emission reductions:	For ex-ante estimations: 2,668 MWh (Maximum rated consumption is estimated here).
Description of measurement methods and procedures to be applied:	Calculation based on maximum rated consumption is conducted in a conservative manner (as per paragraph 35 in AMS III. H., version 13).
QA/QC procedures to be applied:	In the absence of electric meter for the electricity consumption of project activity, maximum rated consumption shall be used to calculate the emissions from PE _{power, y} . Since this approach has taken into account the distribution losses of 10% and the calculation is based on an assumption that the electrical appliances will be running at full capacity for the entire year, the QA/QC aspect has already been assured.
Any comment:	-

Data / Parameter:	Sludge removed and its application
Data unit:	Tonnes / and type of application
Description:	The quantity of organic material / sludge removed from the covered lagoon system and its application.
Source of data to be used:	Weighing equipment available at site are used before using the material for any other purpose. Plant record every time sludge is removed from the system
Value of data applied for the purpose of calculating expected emission reductions	For ex-ante estimations: 0 tonne (assumption – as sludge will be used aerobically for soil application, this will not affect the calculation of emission reduction).
Description of measurement methods and procedures to be applied:	Proper log records shall be maintained for sludge removal and disposal at the project site.
QA/QC procedures to be applied:	Calibration of weighbridge will be done on a once in three year basis.
Any comment:	This parameter is included in the unlikely event that the sludge is removed from the covered lagoons.

Data / Parameter:	Q_{biogas, flare, h}
Data unit:	Nm ³ /hr
Description:	Biogas sent to flare during a particular hour h

Source of data to be used:	Log record shall be maintained on an hourly basis to ascertain net amount of biogas has gone to flare unit during a particular hour.
Value of data applied for the purpose of calculating expected emission reductions	For ex-ante estimations the value is assumed 0 for conservative estimation of IRR.
Description of measurement methods and procedures to be applied:	Biogas flow meter is used. 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.
QA/QC procedures to be applied:	Periodic calibrations (Once in three years) for flow meter are ensured via an external agency. This calibration is usually undertaken in off season to ensure data accuracy and data sufficiency. If the reading for a particular hour is not available, the same is estimated on a conservative basis.
Any comment:	

Data / Parameter:	$\eta_{\text{flare-h}}$
Data unit:	%
Description:	Flare efficiency
Source of data to be used:	"Tool to determine project emissions from flaring gases containing methane"
Value of data applied for the purpose of calculating expected emission reductions:	50% default factor for an open flare
Description of measurement methods and procedures to be applied:	The efficiency of the flaring process is defined as 50% based on the default factor for open flares. The default factor of 50% might be only applied if a flame is detected at the flare for more than 20 minutes in hour h, whenever biogas is sent to the flare system. If the biogas is sent to the flare for a period shorter than one hour, the flare detection signal shall be available for at least 1/3 of this period, following the same logic of the flaring tool (20 minutes out of 1 hour). If these conditions are not met, 0% default value should be used for this period. The flame detection signals shall be recorded electronically on a continuous basis. A comparison of the time stamp of the flame detection signal to the time stamp of biogas flow meter records, measuring the biogas flow into the flare system, shall be used as basis for calculation of the flame detection time period. Other flare specific parameters, which might be required to monitor whether the flare operates within the specified range of operating conditions shall be monitored according to the manufacturer's specifications.
QA/QC procedures to be applied:	Maintenance of the flare system shall be conducted periodically as per supplier's specifications to ensure optimal operation.
Any comment:	-

3.4 Description of the monitoring plan

The monitoring plan is expected to cover a number of parameters. Recording of monitored parameters is controlled by the monitoring management, quality insurance and quality control described below:

- Monitoring management

The project will hire people to operate the biogas generation and utilisation plants. The required monitoring equipments are installed by the operators who are in consultation with the equipment suppliers and under the supervision of the plant manager as well as their immediate supervisors. Flow meters are to be calibrated generally on once in three year basis using recognised procedures and sampling is carried out by onsite staffs according to appropriate industrial standards.

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

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

The plant will form a team to maintain and operate the project activity and monitor the parameters required by the methodology. The team composed of one plant manager dealing with data processing and transfer, two heads of boiler team, one head of biogas team, one head of gas generator team, one head of maintenance team and 8 operators. Figure 7 outlines the structure of operational and management of the project activity.

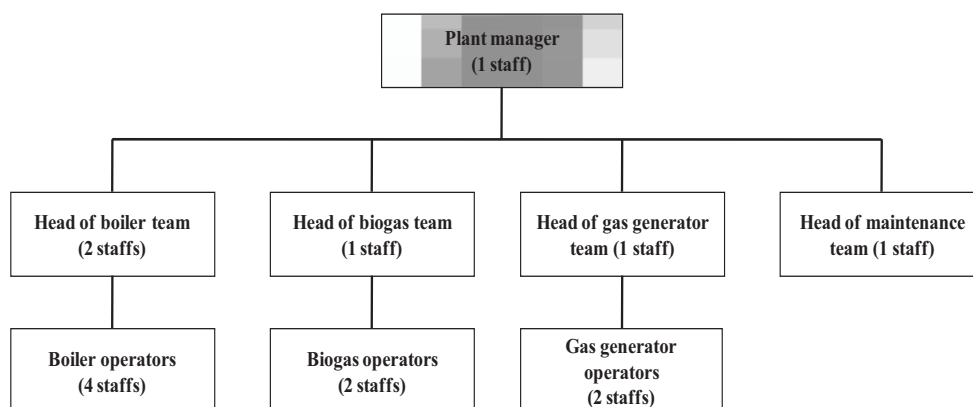


Figure 7: Organisation chart showing the persons involved in the project activity

- Quality insurance and Quality control

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

- On-site procedures

Plant performance is recorded daily in log sheets and later stored in electronic format for periodic download onsite or remote transfer for further processing. In terms of procedures for calibration of equipment, the on-site operators carry out calibration

according to international standards. Note that the plant in-charge operators are responsible for executing timely calibration as per the specification from the equipment supplier or at least once in three years.

- Data storage and filing – electric workbook

All relevant data is first stored manually in operational log sheets, then electronically in a computer unit, with external storage media and transferred. A daily log is printed. All parameters monitored under the monitoring plan will be 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.

- 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 instantly on the control screens else at the time of data logging, due to mismatch between expected biogas generation from wastewater quantities processed or other way around.

4 GHG Emission Reductions:

4.1 Explanation of methodological choice:

The project follows the AMS III. H. small scale methodology for Methane Recovery in Wastewater Treatment, Version 13, to estimate the amount of GHG emitted into the atmosphere. The project also uses AMS I. C. small scale methodology (Version 15) for Thermal energy emissions as well as AMS I. D. (Version 14) for calculating emission from fossil-fuel based grid-connected electricity.

Baseline emissions for the systems affected by the project activity may consist of:

Baseline Emissions for AMS III.H

- Emissions on account of electricity or fossil fuel used ($BE_{power,y}$);
- Methane emissions from baseline wastewater treatment systems ($BE_{ww,treatment,y}$);
- Methane emissions from baseline sludge treatment systems ($BE_{s,treatment,y}$);
- Methane emissions on account of inefficiencies in the baseline wastewater treatment systems and presence of degradable organic carbon in the treated wastewater discharged into river/lake/sea ($BE_{ww,discharge,y}$);
- Methane emissions from the decay of the final sludge generated by the baseline treatment systems ($BE_{s,final,y}$).

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

Equation 1

Where:

Parameter	Details
BE_y	Baseline emissions in year y (tCO ₂ e)
$BE_{power,y}$	Baseline emissions from electricity or fuel consumption in year y

	(tCO ₂ e)
BE _{ww, treatment, y}	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO ₂ e)
BE _{s, treatment, y}	Baseline emissions of the sludge treatment systems affected by the project activity in year y (tCO ₂ e)
BE _{ww, discharge, y}	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y (tCO ₂ e).
BE _{s, final, y}	Baseline methane emissions from anaerobic decay of the final sludge produced in year y (tCO ₂ e).

Baseline emission from electricity and fuel consumptions (BE_{power,y})

As per paragraph 19 of AMS III.H., (version 13), baseline emission from electricity consumption (BE_{power, y}) are determined as per the procedures described in AMS I.D. For emissions from fossil fuel consumption, the emission factor for the fossil fuel shall be used (tCO₂/tonne).

$$BE_{power,y} = (BE_{elec,y} + BE_{heat,y}) \quad \text{Equation 2}$$

Where:

Parameter	Details
BE _{power, y}	Baseline emissions from electricity or fuel consumption in year y
BE _{elec, y}	Baseline emissions from electricity consumption in year y
BE _{heat, y}	Baseline emission from fossil fuel consumption in year y

There is no consumption of fossil fuels in waste water treatment system in baseline scenario, thereby BE_{heat, y} = 0.

For BE_{elec,y} the power consumed in baseline case is negligible and is ignored for conservative estimation of baseline emissions.

Baseline emissions of the wastewater treatment systems affected by the project activity:

Methane emissions from the baseline wastewater treatment systems affected by the project (BE_{ww,treatment,y}) are determined using the methane generation potential of the wastewater treatment systems as per the paragraph 20 of AMS III.H., version 13. The following equation is used.

$$BE_{ww,treatment,y} = \sum_i Q_{ww,i,y} * COD_{removed,i,y} * MCF_{ww,treatment,BL,i} * B_{o,ww} * UF_{BL} * GWP_{CH4} \quad \text{Equation 3}$$

Where:

Parameter	Details
Q _{ww, i, y}	Volume of wastewater treated in baseline wastewater treatment system i in year y (m ³)
COD _{removed, i, y}	Chemical oxygen demand removed by baseline treatment system i in year y (tonnes/m ³) calculated as COD _{removed, i, y} = COD _{ww, untreated, y} * COD removal efficiency
MCF _{ww, treatment, BL, i}	Methane correction factor for the baseline anaerobic wastewater treatment i (MCF values as per table III.H.1)
i	Index for baseline wastewater treatment system (open lagoon system) i = lagoon
B _{o, ww}	Methane producing capacity of the wastewater (IPCC lower value)

	for domestic wastewater of 0.21 kg CH ₄ /kg COD) ⁵³
UF _{BL}	Model correction factor to account for model uncertainties (0.94) ⁵⁴
GWP _{CH4}	Global warming potential (value of 21)

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}) is taken as zero.

The generated sludge in the baseline scenario is close to null in which it is anyway used aerobically for soil application. There is no sludge treatment system. Therefore baseline methane emissions from sludge treatment and anaerobic decay of the final sludge (BE_{s, treatment, y} and BE_{s, final, y}) produced are neglected from baseline emissions.

Baseline Emissions for AMS ID

Baseline emissions from electricity generation (BE_{gen,y})

As per AMS I. D., paragraph 10, the baseline is the MWh produced by the renewable generating unit multiplied by an emission coefficient as follows:

$$BE_y = BE_{gen,y} = EF_y * EG_y \quad \text{Equation 4}$$

Where:

Parameter	Details
EG _y	The quantity of electricity supplied by the project activity during the year “y” (MWh)
EF _y	Thailand National Grid emission factor (tCO _{2e} /MWh)

Baseline Emissions for AMS IC

Emissions from steam/heat displacement by the project activity (BE_{heat,y})

According to paragraph 15 of AMS I.C., the baseline emissions are estimated based on the amount of heat/steam delivered by the equipment (as per equation below).

The deviation explained in later section of the PD takes into account the baseline efficiencies and a simplified approach is explained here to estimate the baseline emissions, the approach is based on historical consumption of fuel oil per tonne of starch generation. The deviation addresses the coherence with §15 and 10 of the methodology.

$$BE_{thermalCO2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{CO2} \quad \text{Equation 5}$$

Where:

Parameter	Details
EG _{thermal}	The net quantity of steam/heat supplied by the project activity during the year y (TJ)
η _{BL, thermal}	The efficiency of the plant using fossil fuel that would have been used in the absence of the project activity.

⁵³ The IPCC default value of 0.25 kg CH₄/kg COD was corrected to take into account the uncertainties. Project activities may use the default value of 0.6 kg CH₄/kg BOD, in case 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 formulas, 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.

⁵⁴ Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

EF _{CO2}	The CO ₂ emission factor per unit of energy of the fuel that would have been used in the baseline plant in (tCO ₂ / TJ), obtained from reliable local or national data if available, otherwise, IPCC default emission factors are used.
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Since the monitoring mechanism is not available for the measurement of baseline input/output thermal energy, a conservative approach for calculation of BE_{y, heat} has been adopted by the project proponent. For verification, with a quantity of dry starch that is produced during a particular year, a minimum required quantity of fossil fuel (fuel oil) can be estimated from quantity of fossil fuel used per unit of dry starch historically. For the same year, if the data for fossil fuel consumed is available, then the remaining energy must be supplied by biogas. This is a conservative approach to estimate the fuel oil that, in the absence of project activity, would be used in the starch drying process. It must be noted that the efficiency of the boiler when used in dual-fuel mode is lower than at regular single-fuel conditions (HFO only). This drop in efficiency leads to a lower biogas to HFO displacement rate. The drop in thermal efficiency for boilers in dual-fuel operation mode can be explained by a number of reasons as listed below:

- **Higher hydro/moisture loss makes boiler efficiency lower with biogas** - The efficiency of a heating equipment depends on several factors; one of the important ones being the C:H ratio in the fuel; which is higher for the fuel oil and lower for biogas. Lower C:H ratio leads to higher quantity of H₂O as combustion product, which decreases the thermal efficiency of the boiler. This is typically called "hydrogen loss". In addition, the biogas has much higher moisture percentage as compared to fuel oil, thus increasing the moisture losses from the equipment, making it less efficient fuel for burning. The hydrogen sulfide content in the biogas adds to the hydrogen loss.
- **Higher dry flue gas loss reduces boiler efficiency lower with dual fuel firing** - Air in excess of the theoretical calculations (called excess air) is always added for proper and complete combustion. In case of dual fuel firing, due to the different mixing properties of the fuel with the air, this quantity of excess air added is always higher due to the reduced probability of achieving proper air-fuel mixing due to varying fuel properties. At the end of the combustion process, the quantity of unused air is exhausted through the flue gases thus removing away unusable heat in the boiler, such a loss being partly accounted in the dry flue gas loss (the rest is the unusable heat from the high temperature flue gas itself). This can be understood by the fact that the air enters the furnace at ambient temperature but the flue gases are typically at a much higher temperature, 200-300 deg.C for most low-pressure boiler systems. Thus if the quantity of excess air pumped into the furnace is higher, which is the case for most such dual fuel fired systems, the dry flue gas loss is also higher, bringing down the efficiency of the boiler. The excess air quantity adjustment is a matter of experience and over a period of time boiler operators do understand how to do this and achieve better efficiencies than what they start with. Thus it is expected that during the initial stages of operation, this loss is higher
- **Variation in biogas quality and quantity influences the air regulation mechanism, thus lower the efficiency of the system** - The varying quantity and quality of biogas influences the air regulation mechanism continuously, never allowing it to achieve a steady state operation, thus lowering the efficiency of the system.

The statements above can be confirmed through interview with technical expert if necessary. In addition, the energy balance for a particular year, considering amount of biogas and fossil fuel used, would easily justify the assumption that energy input

required in dual fuel system is higher than in baseline system. Assuming an approximate 10% loss in efficiency, the assumption to replace 100% fuel oil usage is conservative.

On the basis of historical records fossil fuel used per tonne of starch production is determined. In future, the starch production in a particular year is monitored and used to estimate the amount of fossil fuel that would be used in absence of project activity. This represents baseline consumption of fossil fuel and takes into account the historical efficiency of the fossil fuel heat generating device. In a particular year the actual amount of fossil fuel used is subtracted from baseline fossil fuel consumption (calculated) value to estimate the amount of fossil fuel replaced. This assumption is conservative as all the effect of efficiency loss is borne by biogas and not by fossil fuel.

$$BE_{\text{thermalCO}_2y} = (Q_{\text{starch},y} * Q_{\text{FO,starch}} - q_{\text{FO},y}) * D_{\text{FO}} * \text{NCV}_{\text{FO}} * \text{EF}_{\text{co}_2} / 10^6$$

Deviation 1

Where:

Parameter	Details
$Q_{\text{starch},y}$	Quantity of dry starch produced in year “y” (tonnes)
$Q_{\text{FO,starch}}$	Quantity of fossil fuel per unit of dry starch (liter/tonne)
$q_{\text{FO},y}$	Quantity of fossil fuel consumed at the project site in year “y” (litres)
D_{FO}	Density of fossil fuel (kg/litre)
NCV_{FO}	Net Calorific value of the fuel oil (TJ/ton)

It must be noted that the deviation does not only estimates baseline emissions on the amount of heat/steam generated by the boiler, it also take into account CO₂ emissions from on-site consumption of fossil fuels due to the project activity. In other words, it represents the emission reduction from the heat generation component.

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

- (i) CO₂ emissions on account of power and fuel used by the project activity facilities (PE_{power, y});
- (ii) Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation (PE_{ww, treatment, y});
- (iii) 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});
- (iv) 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});
- (v) Methane emissions from the decay of the final sludge generated by the project activity treatment systems (PE_{s, final, y});
- (vi) Methane fugitive emissions on account of inefficiencies in capture systems (PE_{fugitive, y});
- (vii) Methane emissions due to incomplete flaring (PE_{flaring, y});
- (viii) Methane emissions from biomass stored under anaerobic conditions which does not take place in the baseline situation (PE_{biomass, y}).

$$PE_y = \left\{ PE_{power,y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y} \right\} \quad \text{Equation 6}$$

Where:

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

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

Emissions from electricity consumption by the project activity facilities are calculated according to the paragraph 19 of AMS III.H., as given below.

$$PE_{power,y} = EF_y * EC_y \quad \text{Equation 7}$$

Where:

Parameter	Details
EC_y	Electricity consumption by the project activity (MWh)
EF_y	Thailand National Grid emission factor (tCO ₂ e/MWh)

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

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

Where:

Parameter	Details
P_{el}	Total electrical capacity of the equipments installed in the project activity (kW) – for reference, this is 277 kW for this project activity.
EF_y	Thailand National Grid emission factor (tCO ₂ e/MWh)

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

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

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

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

Equation 9

Where:

Parameter	Details
$Q_{ww,k,y}$	Volume of wastewater treated in project wastewater treatment system k in year y (m ³)
$COD_{y, removed, PJ, k}$	Chemical oxygen demand removed by project wastewater treatment system k in year y (tonnes/m ³), measured as the difference between inflow COD and the outflow COD in system k. $COD_{y, removed, PJ, k} = COD_{y, out, CL} - COD_{y, out, PJ, lagoon}$
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC default value of 0.21 kg CH ₄ /kg COD)
$MCF_{ww, treatment, PJ, k}$	Methane correction factor for project wastewater treatment system k
UF_{PJ}	Model correction factor to account for model uncertainties (1.06)
GWP_{CH4}	Global Warming Potential for methane (value of 21 is used)
k	Wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation = series of the 9 anaerobic ponds. k=lagoon

Methane emissions from sludge treatment systems ($PE_{s,treatment,y}$)

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

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 discharge 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.

Emissions from anaerobic decay of the final sludge produced ($PE_{s, final, y}$)

If the sludge is controlled combusted, disposed in a landfill with methane recovery, or used for soil application, this term can be neglected, and the final disposal of the sludge shall be monitored during the crediting period.

In this project activity, the final sludge produced is sold to local farmers for soil application. Sale receipts of sludge are kept for monitoring purpose. With this term being neglected, $PE_{s, final, y} = 0$.

Emissions on account of inefficiencies in capture system ($PE_{fugitive y}$)

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

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

Equation 10

Where:

Parameter	Details
$PE_{y, fugitive ww,}$	Fugitive emissions through capture inefficiencies in the anaerobic

	wastewater treatment in the year y (tCO _{2e})
PE _{y,fugitive,s}	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y (tCO _{2e})

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

These emissions are calculated as follows

$$PE_{fugitive,ww,y} = (1 - CFE_{ww}) * MEP_{ww,treatment,y} * GWP_{CH4} \quad \text{Equation 11}$$

Where:

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

Note that:

$$MEP_{ww,treatment,y} = Q_{y,ww} * B_{o,ww} * UF_{PJ} * \sum_k COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k} \quad \text{Equation 12}$$

Where:

Parameter	Details
COD _{removed, PJ, k, y}	The chemical oxygen demand removed ⁵⁵ by the treatment system k of the project activity equipped with biogas recovery in the year y (tonnes/m ³). COD _{removed,PJ,k,y} =COD _{ww,untreated,y} - COD _{y,out,HCLU}
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 III.H.1)
UF _{PJ}	Model correction factor to account for model uncertainties (1.06)
k	Treatment system of the project activity equipped with biogas recovery. k=CL

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

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

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

Methane emissions due to incomplete flaring in year y are calculated as per the “Tool to determine project emissions from flaring gases containing methane” (tCO_{2e}). The project proponent has installed an open flare system. For the determination of the flare efficiency, the default value of 50% (for open flare) will be used for the calculation of project emissions from flaring gases. Steps 1 to 7 of the “Tool to determine project emissions from flaring gases containing methane” (hereafter the flaring tool) are used to determine the project emissions from flaring of the residual gas stream.

STEP 1: Determination of the mass flow rate of the residual gas that is flared

⁵⁵ Difference of inflow COD and the outflow COD

According to the step 1 of the flaring tool, to calculate mass flow rate of residual gas that is calculated as per the following equation:

$$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h} \quad \text{Equation 13}$$

Where:

Parameter	Details
$FM_{RG,h}$	Mass flow rate of the residual gas in hour h (kg/h)
$\rho_{RG,n,h}$	Density of the residual gas at normal conditions in hour h (kg/m ³)
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h (m ³ /h)

Where:

$$\rho_{RG,n,h} = \frac{P_n}{\frac{Ru}{MMRG_h} * T_n} \quad \text{Equation 14}$$

Where:

Parameter	Details
$\rho_{RG,n,h}$	Density of residual gas at normal conditions in hour h (kg/m ³)
P_n	Atmospheric pressure at normal conditions (pa)
Ru	Universal ideal gas constant (Pa.m ³ /kmol.k)
$MMRG_h$	Molecular mass of the residual gas in hour h (kg/kmol)
T_n	Temperature at normal conditions (K)

and:

$$MM_{RG,h} = \sum_i (fv_{i,h} * MM_i) \quad \text{Equation 15}$$

Where:

Variable	Description
$MM_{RG,h}$	Molecular mass of the residual gas in hour h (kg/kmol)
$fv_{i,h}$	Volumetric fraction of component i in the residual gas in the hour h (%)
MM_i	Molecular mass of residual gas component i (kg/kmol)
i	The components CH ₄ , CO, CO ₂ , O ₂ , H ₂ , N ₂

As simplified approach, project participants may only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N₂).

STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

$$fm_{j,h} = \frac{\sum_i fv_{i,h} \cdot AM_j \cdot NA_{j,i}}{MM_{RG,h}} \quad \text{Equation 16}$$

Where:

Variable	Description
$fm_{j,h}$	Mass fraction of element j in the residual gas in hour h (%)
$fv_{i,h}$	Volumetric fraction of component i in the residual gas in the hour

	h (%)
AM _j	Atomic mass of element j (kg/kmol)
NA _{j,i}	Number of atoms of element j in component i
MM _{RG,h}	Molecular mass of the residual gas in hour h (kg/kmol)
j	The elements carbon, hydrogen, oxygen and nitrogen
i	The components CH ₄ , CO, CO ₂ , O ₂ , H ₂ , N ₂

STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis

This step is skipped since a default value will be used for the determination of the methane combustion efficiency of flare.

STEP 4: Determination of methane mass flow rate in the exhaust gas on a dry basis

This step is skipped since default value will be used for the determination of the methane combustion efficiency of flare.

STEP 5: Determination of methane mass flow rate in the residual gas on a dry basis

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas (FV_{RG,h}), the volumetric fraction of methane in the residual gas (fv_{CH₄,RG,h}) and the density of methane (ρ_{CH₄,n}) in the same reference conditions (normal conditions and dry or wet basis). Considering that the residual gas (biogas leaving the effluent treatment systems) is cooler than 60 degrees Celsius, the measured volumetric flow of the biogas and the volumetric fraction of methane in the biogas is expressed on a dry basis.

$$TM_{RG,h} = FV_{RG,h} * fv_{CH_4, RG,h} * \rho_{CH_4,n} \quad \text{Equation 17}$$

Where:

Parameter	Details
TM _{RG,h}	Mass flow rate of methane in the residual gas in the hour h (kg/h)
FV _{RG,h}	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (m ³ /h)
fv _{CH₄, RG,h}	Volumetric fraction of methane in the residual gas on dry basis in hour h
ρ _{CH₄,n}	Density of methane at normal condition (0.7168 kg/m ³)

It should be noted that according to the monitoring plan, volumetric flow meters prior to the flare system shall automatically measure temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm³). In such a case the value FV_{RG,h} can be based directly on the readings from the meters and the intermediate step to calculate the density of the gas is not necessary.

STEP 6: Determination of the hourly flare efficiency

The determination of the hourly flare efficiency depends on the operation of the flare (e.g. temperature), the type of flare used (open or enclosed).

In case of open flares, the flare efficiency in the hour h (η_{flare,h}) is:

- 0% if the flame is not detected for more than 20 minutes during the hour h

- 50%, if the flame is detected for more than 20 minutes during the hour h

For ex-ante calculations, the 50% default is applied. Ex-post calculations will be based on the monitored period of flare activity as described above.

STEP 7: Calculation of annual project emissions from flaring

According to the step 7 annual project emissions from flaring are calculated as the sum of emissions from each hour h, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour h ($\eta_{flare,h}$), as follows:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} * (1 - \eta_{flare-h}) * GWP_{CH_4} / 1000 \quad \text{Equation 18}$$

Where:

Parameter	Details
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour h (kg/h)
$\eta_{flare-h}$	Flare efficiency in hour h
GWP_{CH_4}	Global Warming Potential of methane valid for the commitment period (tCO ₂ e/tCH ₄)

It should be noted that, although not explicitly mentioned in the flaring tool, Steps 1 and 2 are not required for calculation of Steps 5 to 7, since all input values required in Steps 5 to 7 are either measured during the monitoring of the project or are calculated without use of the parameters defined under Steps 1 and 2. Hence, ex-ante and ex-post project emissions from flaring are calculated on the basis of Steps 5 to 7 described above.

Methane emissions from biomass stored under anaerobic conditions ($PE_{biomass,y}$).

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 omitted.

Leakage (LE_y):

The used technology is not equipment transferred from another activity, therefore according to the AMS.III.H, there is no leakage to be considered. All the equipment used in the project activity for power and heat generation is either already existing or brought for purpose of project activity and there is no shifting of old equipment takes place. Therefore, there is no leakage as per AMS.I.C and AMS.I.D.

Emission Reduction (ER_y):

As per the Paragraph 29 of AMS III.H, emission reduction are estimated ex-ante in the PD using formulas mentioned in baseline, project and leakage emissions sections above. Emission reductions are estimated ex-ante as follows;

$$ER_{y,ex-ante} = BE_{y,ex-ante} - (PE_{y,ex-ante} + LE_{y,ex-ante}) \quad \text{Equation 19}$$

Where:

Parameter	Details
$ER_{y,ex-ante}$	Ex ante emission reduction in year y (tCO ₂ e)
$BE_{y,ex-ante}$	Ex ante baseline emissions in year y (tCO ₂ e)
$PE_{y,ex-ante}$	Ex ante project emissions in year y (tCO ₂ e)

LE _{y, ex-ante}	Ex ante leakage emissions in year y (tCO ₂ e)
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According to the paragraph 31 AMS III.H., emission reduction achieved by the project activity is limited to the ex-post calculated baseline emissions minus project emissions using the actual monitored data for the project activity. Emission reductions achieved on any year are the lowest value of the following;

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

Equation 20

Where:

Parameter	Details
ER _{y, expost}	Emission reductions achieved by the project activity based on monitored values for year y (tCO ₂ e)
BE _{y, expost}	Baseline emissions calculated as per paragraph <i>ex post</i> monitored values
PE _{y, expost}	Project emissions calculated as per paragraph <i>ex post</i> monitored values
MD _y	Methane captured and destroyed/gainfully used by the project activity in the year y

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

$$MD_y = BG_{burnt,y} * w_{CH_4,y} * D_{CH_4} * FE * GWP_{CH_4}$$

Equation 21

Where:

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

As per answers to authors of query by the SSC WG “in the case that the biogas is combusted for a gainful use of the released energy as in an engine or a power plant, a destruction efficiency of 100% can be used for the portion of biogas that is combusted when applying AMS III.H., i.e. use a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use”⁵⁶. Based on this, the alternative MD_y value is deviated from the approved methodology and can be calculated as follows:

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

Deviation 2

Where:

Parameter	Details
BG _{TOFlare}	Biogas sent to flare in year y (Nm ³ /year)
FE	Flare efficiency (fraction)
BG _{combusted, y}	Biogas combusted for gainful use in year y (Nm ³ /year)

⁵⁶ <http://cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKEUHEF5LB07QICT1P>

DE	Destruction efficiency of biogas combusted for a gainful use (fraction)
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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.

The detailed formulae for deviations taken in the project are in the following section, a summary for same is compiled in following table.

Methodology and Formula that is deviated	Deviated approach or formula	Justification for deviation
Baseline emissions for estimating the fossil fuel replaced. Under the methodology AMS I.C., version 15 (paragraph 15), <i>the baseline emissions are estimated based on the amount of heat/steam delivered by the equipment</i>	The project proponent uses a conservative approach, based on amount of heat required for starch drying, which in turn is estimated on historic heat requirements per tonne of starch and compensating heat energy supplied by heavy fuel oil. 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 the quantity of methane burnt.	Due to incompleteness of the monitoring equipments, 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.
In the case that biogas is combusted for a gainful use of the released energy, it is unrealistic to assume a destruction efficiency of the flare system in the calculation of MD _y as prescribed in paragraph 32 of AMS III.H.	A destruction efficiency of 100% is used for the portion of biogas that is combusted for gainful use i.e. in boiler or gas engines. For the portion of biogas that is sent to flare, default flare efficiency is the same according to the prescribed value for an enclosed flare system.	This approach has been confirmed by the SSC WG who also agreed to include that such approach will be included in a future revision of AMS III.H. Based on this reference, it can be concluded that the approach is conservative and does not impact negatively on the conservativeness of emission reduction calculation and the additionality of the project.

4.2 Quantifying GHG emissions and/or removals for the baseline scenario:

The following section gives details of ex-ante estimation of baseline emissions for the project activity. The data sheet of calculations is provided to the DOE with this VCS PD.

The main calculation parameters and results are provided below:

Methodology: AMS III. H. (Methane avoidance component)		
Formula: $BE_{ww,treatment,y} = \sum_i Q_{ww,i,y} * COD_{removed,i,y} * MCF_{ww,treatment,BL,i} * B_{o,ww} * UF_{BL} * GWP_{CH4}$		
$Q_{ww,i,y} =$	441,833 m ³	Based on design value (according to wastewater analysis report of wastewater treated: 11.4 m ³ /tonne and 38,660 tonne of starch production per year (4 year average from 2005-2008).
$COD_{removed,i,y} =$	0.0147 t/m ³	Based on monthly reading multiply by 0.89 conservative factor
$COD_{ww,untreated,y} =$	16,913 mg/l	Historical average COD in covered lagoon
$B_{o,ww} =$	0.21 kgCH ₄ /kg COD	Default value
$MCF_{ww,treatment,BL,i} =$	0.8	Default value for anaerobic deep lagoons
UF_{BL}	0.94	Model correction factor from AMS III. H.
$GWP_{CH4} =$	21	Default value
Calculation: $BE_{ww,treatment,y} = 441,833 \times 0.0147 \times 0.8 \times 0.21 \times 0.94 \times 21 = \mathbf{21,599 \text{ tCO}_2e}$		
Methodology: AMS I. C. (Fuel replacement component)		
Formula: $BE_{thermal,CO2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{CO2}$ $BE_{thermal,CO2,y} = ER_{heat,y} = (Q_{starch,y} * Q_{FO,starch} - q_{FO,y}) * D_{FO} * NCV_{FO} * EF_{co2} / 10^6$		
$Q_{FO} =$	586 tonnes	Quantity of residual fuel oil is back-calculated from the amount of biogas expected to be utilised for thermal production i.e. 1,198,635 Nm ³ /y (50% of total biogas production). -> $Biogas_{boiler} \times NCV_{biogas} / NCV_{FO} = (1,198,635 \times 20.93) / 42.76 / 1000$
$NCV_{FO} =$	42.76 GJ/tonne	DEDE – Thailand Energy Situation
$EG_{thermal,y}$	25.09 TJ	Calculated from amount of HFO displaced: $Q_{FO} \times NCV_{FO} = (586.66.09 \times 42.76) / 1000$
$\eta_{bl,thermal}$	100%	Assume at 100% for conservativeness
EF_{CO2}	77.4 tCO ₂ /TJ	Emission factor of fossil fuel replaced (IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23)
Calculation: $BE_{thermal,CO2,y} = (25.09 / 100\%) \times 77.4 = \mathbf{1,940 \text{ tCO}_2e}$		
Methodology: AMS I. D. (Power generation component)		
Formula: $BE_{gen,y} = EF_y * EG_y$		
$EG_y =$	2,371	Based on info available for gas engines and biogas

	MWh	used for generation process. Efficiency of gas engine and NCV of biogas as well as accounting for 10% load factor = $V_{\text{biogas elec}} \text{ Nm}^3 \times 20,930 \text{ KJ/m}^3 \times 0.378/3600 \times 0.9$
$EF_y =$	0.5057 tCO ₂ /MWh	Grid emission factor
Calculation: $BE_y = 2,371 \times 0.5057 = 1,198 \text{ tCO}_2\text{e}$		

4.3 Quantifying GHG emissions and/or removals for the project:

The following section gives details of ex – ante estimation of project emissions for the project activity. The data sheet of calculations is provided to the DOE with this VCS PD.

The main calculation parameters and results are provided below:

Methodology: AMS I D (Power generation component)		
Formula: $PE_{\text{power},y} = EF_y * EC_y$		
EC_y	2,668 MWh	Based on power capacity installed (277 kW) at 8,760 hours.
EF_y	0.5057 tCO ₂ /MWh	Grid emission factor of Thailand
Calculation: $PE_{\text{power},y} = 2,668 \times 0.5057 = 1,349 \text{ tCO}_2\text{e}$		
Methodology: AMS III H (Methane avoidance component)		
Emissions in wastewater treatment system without biogas recovery		
Formula: $PE_{\text{ww,treatment},y} = Q_{\text{ww},k,y} * COD_{\text{removed,PJ},k,y} * MCF_{\text{ww,treatment,PJ},k} * B_{o,ww} * UF_{PJ} * GWP_{CH4}$		
$Q_{y,ww} =$	441,833 m ³	Based on design value of wastewater treated: 11.4 m ³ /tonne and 38,660 tonne of starch production per year (4 year average from 2005-2008).
$COD_{\text{removed,PJ},k,y} =$	0.00295 tonne/m ³	Based on COD removal by lagoon system after the project activity
$MCF_{\text{ww,treatment,PJ},k} =$	0.8	Default value
$B_{o,ww} =$	0.21kg CH ₄ /kg COD	Default value
UF_{PJ}	1.06	Default value
$GWP_{CH4} =$	21	Default value
Calculation: $PE_{\text{ww,treatment},y} = 441,833 \times 0.00295 \times 0.8 \times 0.21 \times 1.06 \times 21 = 4,871 \text{ tCO}_2\text{e}$		
Fugitive emissions in wastewater treatment system with biogas recovery		
Formula: $PE_{\text{fugitive,ww},y} = (1 - CFE_{\text{ww}}) * MEP_{\text{ww,treatment},y} * GWP_{CH4}$		
$CFE_{\text{ww}} =$	0.9	Default value
$MEP_{\text{ww,treatment},y} =$	1,065 tonnes	Methane emission potential of wastewater treatment systems equipped with biogas recovery:

		$MEP_{ww,treatment,y} = Q_{ww,y} * B_{o,ww} * \sum_j COD_{removed,PJ,k,y} * MCF_{ww,treatment,y} * UF_{PJ,with COD_{y,removed} = COD_{y,in} * \eta_{covered lagoon}} = 441,833 \times 0.21 \times 0.0135 \times 0.8 \times 1.06$
GWP _{CH4} =	21	Default value
Calculation: $998 \times (1-0.9) \times 21 = 2,236 \text{ tCO}_2\text{e}$		
Methane emissions due to incomplete flaring		
Formula: $PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} * (1 - \eta_{flare-h}) * GWP_{CH4} / 1000$		
$\eta_{flare,h}$	0.5	Efficiency of the open flare
$\sum TM_{RG,h}$	0t	No biogas flared (only emergency)
Calculation: $0 \times (1-0.5) \times 21 = 0 \text{ tCO}_2\text{e}$		

4.4 Quantifying GHG emission reductions and removal enhancements for the GHG project:

Year	Emission of project activity emissions (tCO ₂ e)	Estimation of baseline emissions (tCO ₂ e)	Estimation of leakage (tCO ₂ e)	Estimation of overall emission reductions (tCO ₂ e)
1	8,457	24,737	0	16,280
2	8,457	24,737	0	16,280
3	8,457	24,737	0	16,280
4	8,457	24,737	0	16,280
5	8,457	24,737	0	16,280
6	8,457	24,737	0	16,280
7	8,457	24,737	0	16,280
8	8,457	24,737	0	16,280
9	8,457	24,737	0	16,280
10	8,457	24,737	0	16,280
Total (tonnes CO ₂ e)	84,570	247,370	0	162,800

5 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 and 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 covered lagoon 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 Kean Charoen (1) 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 roots 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 CH_4 (main content of biogas) compared to nitrogen N_2 (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.

6 Stakeholders' comments:

Invitation procedure

The Gold Standard Initial Stakeholder Consultation was carried out by Kean Charoen Co., Ltd., with assistance from South Pole Carbon Asset Management Ltd. (Switzerland based company responsible for VCS project development).

Stakeholder groups (as defined by Gold Standard procedures) were identified and informed through oral and written means. Invitation letters were sent by fax and regular mails to participants locating far away from the project site. The invitation process was conducted within 2 weeks prior to the meeting date.

Place and date of meeting

The initial stakeholder consultation was held in the Auditorium of Huanakhum sub-district Administration Organization, which is located 10km away from the tapioca factory, on 10 July 2008 starting at 13:00. All invited stakeholder groups were able to participate the meeting and they were also able to examine the site location where the proposed project activity will be take place.

Meeting participants

The meeting was attended by local residents and representatives from the following stakeholder categories:

1. Local residents
2. Local government representatives

23 participants attended the meeting:

Participant	Occupation/Organisation
Noppadol Sawatsitang	Mayor Local government of Kranuan
Boonlhai Sriarsana	Squad Leader Kranuan Police Station
Sanongchat Mahongkum	Squad Leader Kranuan Police Station
Saewapong Durongdhumrongchai	Manager Provincial Electricity Authority of Kranuan
Sathit Siriburi	President Huanakhum Subdistrict Administration Organization
Bunleng Phasuk	Deputy Huanakhum Subdistrict Administration Organization
Swat Siriburi	Headman Bankumkrung Moo4
Saiyon Rawongsa	Assistant headman Bankumkrung Moo4

Sai Phimon	Assistant headman Bankhumcharoen Moo10
Vichai Kaewkeaw	Headman Bannumsamwang
Chaweng Ramanee	Headman Banhuanakhum Moo9
Kamjat Patcha	Headman Banthalad
Anan Wongsaharat	Village headman Huanakhum Subdistrict
Paisarn Ponratam	Village headman Huyyang Subdistrict
Thongsuk Phosri	Assistant village headman Huyyang Subdistrict
Samkan Siriphuthorn	Assistant village headman Banfang Subdistrict
Wapee Pinijmontri	Member Huanakhum Subdistrict Administration Organization (Bannumsamwang)
Surasit Siripreechapan	Member Huanakhum Subdistrict Administration Organization (Bankumkrung)
Rungnapa Mettarikanon	Environmental academician Regional Environment Office 10
Jitraporn Puengnang	Assistant officer of Laboratory Regional Environment Office 10
Piangtawan Theerasarn	Intern student Regional Environment Office 10
Ken Jumpadeng	Local resident Bankumkrung Moo4
Somboon Chaonua	Local resident Bannumsamwang

Language

Documentation and meeting were conducted in Thai (local language)

Meeting procedures

- Opening (10 min)
- Purpose of the consultation (10 min)
- Description of the project and environmental impacts by Kean Chareon Co.,Ltd. (20 min)
- Description of the Environmental Credits Scheme by South Pole Carbon Asset Management Ltd. (15 min)
- Description of the Gold Standard sustainable development matrix (10 min)
- Questions and Answers session (10 min)
- Completing checklists (Appendix E to the Gold Standard Project Developer's Manual) (20 min)

Meeting documents and protocols

On completion of the various meetings, the following documentation was collected and attested by the signatures of the stakeholders that were present:

1. Presence list with name, address and occupation.
2. Non-technical description of the project

3. Documentation on environmental impacts of the project
4. Filled out Appendix E of Gold Standard (checklist)
5. Notes for additional comments on the project activity

These documents are available as hardcopies and will be handed over to the designated operational entity (DOE) conducting the Gold Standard validation process.

Compilation of comments received

A. Oral hearing for local stakeholders:

The project activity and its environmental impacts were described to the stakeholders during the meeting. Stakeholders acknowledge that the improvement of the current wastewater treatment system by introduction of lagoon cover will reduce odour emissions to the surrounding area, which was previously a major concern for the surrounding community. According to the feedback provided both orally during the meeting and in writing through the Gold Standard questionnaires filled out by 23 participants, the stakeholders support and have a positive opinion about the project activity. They further believe that the project activity will benefit them and their families through reduction in odour nuisance. Therefore, this project activity is perceived as an environmental friendly project, which can improve the quality of life of the surrounding community. The project activity is expected to deliver multiple benefits in respect of sustainable development in Thailand including environmental, social and economic benefits, which are summarised below:

- Reduction of methane emission which is a potent Greenhouse gas (GHG);
- Reduction of the odour nuisance associated to the open lagoon waste water system, improving quality of life and health of surrounding communities
- Conservation of groundwater resources from the use of HDPE lining at the bottom of the lagoons, which can prevent wastewater from contaminating groundwater;
- Reduction in the use of non-renewable energy such as fuel oil, while at the same enhancing energy security by increasing diversity of fuel supply;
- Involvement of local communities through public participation meeting, in which most people encouraged the project activity;
- Increased employment by employing local people to construct and operate the project activity;
- Promoting technological excellence and innovation in Thailand by implementing a cleaner technology solution for wastewater treatment in the tapioca starch sector, which could be replicated across Thailand and the region; and
- Demonstrating the use of a new financial mechanism for funding of waste management projects via CDM revenues.

No major negative concerns have been raised during the initial stakeholder consultation, neither during the oral hearing nor in writing through the completed questionnaires. The Gold Standard questionnaire (Appendix E; to the Gold Standard Manual for CDM Developers), which consists of 23 questions, has been translated into Thai. From 23 questions, there are 5 questions presented below that were answered “yes” by some participants;

1. Question 1: Will construction, operation of decommissioning of the project activity use or affect natural resources or ecosystem, such as land, water, forests,

habitats, and materials or, especially any resource which are non-renewable or in short supply?

One “yes” answer. No specific comments. **Answer by project owner:** The aim of the project is to improve the current wastewater treatment facilities and avoid any harm or threat to natural resources or ecosystems surrounding the project. As compared to the baseline scenario, the risks associated to groundwater contamination are eliminated to the largest extent possible through installation of HDPE lining at the bottom of the lagoons. In terms of wastewater discharge to nearby water streams, it should be noted that the lagoon system is designed in such a way that there is no discharge of water. Most of the produced wastewater is constantly re-circulated as wash water for the starch production process or for irrigation of the internal plantation. The wastewater treatment plant includes safety and monitoring devices as well as safety and quality control procedures in order to avoid abnormal operating conditions, which could lead to abnormal wastewater discharges. The quality of the treated wastewater is constantly monitored and periodically checked by environmental authorities in order to avoid any contamination. The project represents a clear improvement as compared to the baseline, it fully complies with environmental regulations and any threats to the environment are being avoided to the extent that can be influenced by the project owner.

2. Question 11: Will the Project involve use, storage, transport, handling, production or release of substances or materials (including solid waste) which could be harmful to human health or raise concerns about actual or perceived risks to human health?

One “yes” answer. No specific comments. **Answer by project owner:** The project is not expected to cause any harm to human health. As compared to the baseline, the project activity improves quality of life and indirect risks to human health related odour emissions and pathogenic conditions that might arise in an open anaerobic lagoon. If the plant is not operated as it should, the project activity might lead to contamination of water at the discharge point and release of methane to the atmosphere. However, the wastewater treatment plant includes safety and monitoring devices as well as safety and quality control procedures in order to avoid abnormal operating conditions, which could lead to biogas leakage or abnormal wastewater discharge values. Biogas production, its use as a fuel in the boilers or its combustion in the flare systems is also constantly monitored. The project fully complies with safety and health regulations and any threats to human health are being avoided to the extent that can be influenced by the project owner.

3. Question 15: Will there be any risk of accidents during construction or operation of the Project which could affect human health?

One “yes” answer and one person that acknowledges the project will have significant impacts. No specific comments. **Answer by project owner:** The construction and operation of the plant is carried out in accordance with relevant safety standards and procedures. Accident risks are mitigated to the extent that can be influenced by the project owner.

4. Question 16: Will the Project result in social changes, for example, in demography, traditional lifestyles, employment?

16 “yes” answers. No specific comments. **Answer by project owner:** Given the overall very positive response to the project, it is assumed that the answers above highlight the beneficial social impacts of the project, as there was no explicit negative

remark. New jobs will be created for construction and operation of the plant. All these aspects are welcomed by local people and the government authorities.

5. Question 19: Is the project in a location where it is likely to be highly visible to many people?

14 “yes” answers. No specific comments. **Answer by project owner:** The project activity is visible to many people that work or live in the area. However, given the overall very positive response to the project activity, the visibility of the project is not considered to be negative.

Changes to Project design based on comments received

After receiving the comments from the stakeholder consultation process, there are no any comments including environmental, social and economic concerns which cause to change the project design. Hence, the project activity will be implemented as an original plan. It can be summarized that the proposed project activity is perceived as a positive example using a covered lagoon wastewater system to treat the wastewater generated from tapioca manufacturing in a cleaner way; and that the project is expect to contribute to sustainable development in Thailand.

7 Schedule:

Date	Event	Information and evidence
August 1988	Operational start of starch factory	Operational permit
1 June 2005	Investment decision date	Minutes of meeting
March 2006	Start construction of covered lagoon system	Progress summary to Managing Director
May 2006	Installation of HDPE plastic on covered lagoon	Progress summary to Managing Director
2 October 2006	Date of initiating the project. Operation start date of biogas system for fuel oil displacement	Operational log sheet provided by the factory
1 October 2007	Commissioning date of electricity generation set	Operational log sheet provided by the factory
10 July 2008	Stakeholder consultation meeting to meet VCS requirement (Other activities)	Extract of feedback from stakeholders
1 October 2021 (date of terminating the project)	Date of terminating the project	Estimate based on operational life time of 15 years.

Frequency of monitoring and reporting:

It is planned that the monitoring period and reporting of emission reductions from the project activity will be done on an annually basis. The monitoring frequency of each parameter will vary depending on their types and the requirements of the applied methodology. This is elaborated in section 3.3 of this VCS PD. In addition, the acquainted data shall be kept by the project proponents for a minimum of 2 years after the crediting period.

Generally speaking, calibration of equipments will be done on at a minimum of once in three year basis.

Project period:

The crediting period of the project is of 10 years (2009 – 2018).

The project has an estimated operational lifetime of 15 years.

After the initial crediting period of ten years, subsequent renewals of the crediting time might be considered according to the status of the project activity and baseline revision at that time.

8 Ownership:

8.1 Proof of Title:

Documents assessing the ownership of the wastewater treatment plant from Kean Charoen Co., Ltd. will be provided for the DOE during the validation process. Evidence of proof title include: company affidavit, operation permit, tax registry and land ownership document, among others.

8.2 Projects that reduce GHG emissions from activities that participate in an emissions trading program (if applicable):

Not applicable in Thailand.

ANNEX I

Table of abbreviations

BOD	Biological Oxygen Demand
CDM	Clean Development Mechanism
CER	Certified emission reduction
CDM	Clean Development Mechanism
CH₄	Methane
CO₂	Carbon dioxide
COD	Chemical Oxygen Demand
DNA	Designated National Authorities
DOE	Designated Operational Entities
EPPO	Energy Policy and Planning Office
EIA	Environmental Impact Assessment
ER	Emission reduction
GHG	Greenhouse Gas
HDPE	High-density polyethylene
IRR	Internal Rate of Return
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hour
MCF	Methane Conversion Factor
MLR	Minimum lending rate
MWh	Megawatt-hour
PD	Project Description
PEA	Provincial Electricity Authority
UASB	Upflow Anaerobic Sludge Blanket
UNFCCC	United Nations Framework Convention on Climate Change
VER	Voluntary Emission Reduction
VCS	Voluntary Carbon Standard