



Voluntary Carbon Standard Project Description

Date of completion: November 18th, 2009 (PD Version 3.1)

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1 Description of Project:

1.1 Project title

Title: P.S.C Starch wastewater treatment and biogas utilization project

VCS PD Version: 3.1

Document Completion date: November 18th, 2009

1.2 Type/Category of the project

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

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

Methane avoidance component:

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

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 :	36,973 tCO ₂ e/year
VERs expected over 10 years crediting period:	369,730 tCO ₂ e/year

Project falls in between micro project and mega project with the estimated emission reductions being in between 5,000 to 1,000,000 ton CO₂e/year. .

Emission reduction estimation for the total crediting period is shown in the table below.

Table 1: Estimated of emissions reductions over the crediting period

Years	Estimation of emission reductions in tCO₂e in monitoring period
2009 (Dec 1 st - Dec 31 st)	3,081
2010	36,973
2011	36,973
2012	36,973
2013	36,973
2014	36,973
2015	36,973
2016	36,973
2017	36,973
2018	36,973
2019 Jan 1 st - Nov 30 th)	33,892
Total	369,730

1.4 A brief description of the project:

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

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

The production capacity of the starch factory is 200 tonnes of dry starch equivalent products per day, and 240 tonnes of sweetener products per day. The processes generate 2800 m³ wastewater from the starch plant and 320 m³ wastewater from the sweetener plant on a daily basis at design operational capacity¹.

Under the previous system, wastewater from both factories was treated in 8 cascading open anaerobic lagoons. The minimum depth of these ponds is above 4.5 m from the water surface². The average atmospheric temperature in the region is 29 °C³. These conditions result

¹ Based on information exhibited in the EIA report

² See drawing for baseline lagoons

³ Data requested from the Thai Meteorological Department; can also be cross-checked in http://www.tmd.go.th/agromet_report.php

in anaerobic environment within the ponds, resulting in methane generation from the organic content (characterized by chemical oxygen demand or COD) of the wastewater.

The project activity involves an intertwined network of anaerobic treatment systems, which consist of two technologies (UASB system and covered lagoons), to maximize the collection of biogas and increase the efficiency of its use.

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

In October 2009, a new ethanol plant started operation in line with these existing facilities. In the absence of the project activity, the wastewater from the ethanol plant, with an approximate daily flow of 1,240m³/day, would have been treated in an open pond anaerobic system, for which the company has allocated an area of 300 rai⁴ or 48 ha. The project activity involves the construction of a new covered lagoon (CL3) with biogas recovery.

In short-term, the biogas generated by the overall system (UASB + CL1 + CL2 + CL3) will be used in 7 boilers. Four boilers would utilise biogas to generate steam for sweetener plant. Another two steam boilers use biogas for power and heat generation to necessitate the requirement of the starch plant. In addition, another hot oil boiler uses biogas to generate heat, which is also used in the starch plant. Later in the year 2010, the project owner plans to use all the biogas to generate steam from only two boilers and future priority would be to generate electricity. For greater clarity, this is illustrated in a flow diagram exhibited in section 2.3 (project boundary). It must be mentioned that due to unsteady fuel mixture of biomass and coal, the components of electricity production and fuel replacement will not be claimed for emission reduction.

Although the treated water is not discharged outside factory grounds and thus not subjected to effluent discharge standards, it is certain that the wastewater quality will be improved substantially. Higher efficiency and improved process control in the UASB system and covered lagoons will in fact allow the factories to reuse effluent from the lagoon system, should it be required.

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 by contracting 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 systems. Utilisation of biogas for energy generation can be regarded as a means to reduce dependency on imported energy products, which in turn improves the energy security status of Thailand. In addition, it can be expected that the proposed project activity promotes technological excellence and further research in biotechnology in the region.

⁴ One rai equals 1,600 m²

Table 2: Description of the project components

Project Component	Brief Description
Lagoon System ⁵	The lagoon system consists of 8 open lagoons with a total volumetric capacity of 581,200 m ³ . The retention time of the lagoons system is around 292 days ⁶ .
UASB	Up-flow Anaerobic Sludge Blanket has a minimum COD reduction efficiency of 70% ⁷ . It has a volumetric capacity of 8,000m ³ . The UASB system started operation in April 2005, which is also the first month of biogas usage in boiler.
Covered lagoon (CL1)	The first covered lagoon was constructed in June 2006. Typically, the COD removal efficiency of this system is around 70% ⁸ . It has a volumetric capacity of 32,400m ³ with corresponding hydraulic retention time of 7 days. The covered lagoon receives the wastewater coming from the starch factory.
Covered lagoon (CL2)	The second covered lagoon was constructed through a modification of the existing open lagoon in March 2007. The COD removal efficiency of this system is around 60% ⁹ . It has a volumetric capacity of 32,400m ³ with corresponding hydraulic retention time of 14 days. The covered lagoon receives the wastewater coming from the sweetener factory and from the UASB.
Covered lagoon (CL3)	The operation start of this lagoon is expected in January 2010. The COD removal efficiency of this system is around 70% ¹⁰ . It has a volumetric capacity of 32,400m ³ with corresponding hydraulic retention time of 12 days. The covered lagoon will receive the wastewater coming from the ethanol plant.
Gas storage device (or Gas Holder)	Acidification pond is covered with the HDPE sheet to serve as gas storage device or gas holder. The covered lagoons system can also be used for the purpose of gas storage.
Capacity of auxiliary drives	Total capacity of the auxiliary drives amount to an approximate of 209.2 kW taking into account the overall system at full implementation; 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 project site is located in the compound of the P.S.C. Starch factory at:
999 Nongyai-Bothong Road, Nongyai, Chonburi (roughly 150 km southeast of Bangkok)

⁵ Please refer to design drawing of baseline lagoons submitted during validation

⁶ Calculated based on volumetric capacity of lagoons and daily design wastewater generation rate

⁷ Based on performance report done internally for the operation of the biogas plants

⁸ *Ibid*

⁹ *Ibid*

¹⁰ Expected performance based on existing biogas systems

The GPS coordinates of the project are:

- Latitude 13°18'6.50"N
- Longitude 101°21'49.47"E¹¹



Chonburi Province ★

Figure 1: The map showing location of Chonburi province



PSC starch factory ★

Figure 2: Location of PSC starch in Chonburi province

¹¹ The coordinates were extracted from GPS during site visit and can be accessed using Google Earth or similar application

1.6 Duration of the project activity/crediting period:

Start date of Project Activity: 28th April 2005 (the date when emissions reduction began). This is the date on which biogas was first combusted in the boiler for thermal generation¹².

Crediting period start date: 1st December 2009 (plan to be in accordance with the installation of monitoring equipment). Due to insufficiency of monitoring equipments, the operational period prior December 1st 2009 will be neglected from our claim of emission reduction. This is in line with the principle of conservativeness as per VCS 2007.1.

VCS project crediting period: 10 years

The duration of the project activity is estimated to be 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.

1.7 Conditions prior to project initiation:

Pre-project scenario:

Prior to project initiation, the wastewater from the tapioca processing and sweetener processing plants were treated in a cascade of 8 anaerobic open lagoons, with a retention time of around 292 days. The minimum depth of the anaerobic lagoons in the baseline scenario is more than 4.5m from the water surface.

The sludge removal from lagoons is an irregular mechanism as anaerobic process does not lead to excessive sludge formation. The sludge removal from lagoons is a need based mechanism and observed interval of sludge removal is once a year during the past. The sludge removed is used for soil application as a fertilizer in the plant premises.

Project scenario:

Out of these 8 anaerobic lagoons existing in the baseline scenario, one lagoon was converted into a covered lagoon (CL 2), while the other ones (7 lagoons) are still in use as a secondary treatment of the effluent of CL2.

In addition, without a covered lagoon system, wastewater from the ethanol plant would be routed to the open lagoons, Note that treatment of wastewater in open anaerobic lagoons is a common practice in this industry. Further explanation is given in section 2.4.

The previous fuels for thermal energy generation are biomass and coal. For simplification and conservativeness, no emissions reductions are claimed for the power and thermal generation components.

Under the post-project scenario, any sludge removed from lagoons or anaerobic digester system is planned to be used for soil application. It is described in section 4.1

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

¹² Please refer to commissioning report from the contractor

Before the implementation of the project activity, the wastewater from starch and sweetener is treated in open anaerobic lagoons. In the absence of the project activity, the wastewater from the ethanol plant would also have been treated in the open anaerobic lagoons (further explanation is given in section 2.4).

After installation of the UASB system and covered lagoon system, the biogas generated is recovered and then utilized in four existing steam boilers for sweetener factory, one hot oil boiler in starch factory, and 2 steam boilers to produce heat and electricity. In total, there are 7 boilers. This utilization of biogas achieves emission reduction by avoiding fugitive methane emissions to the environment.

In other words, the project will thus achieve GHG emission reductions by avoiding methane emissions from the conventional open anaerobic lagoon system previously.

Although the project activity also avoids carbon dioxide (CO₂) emissions from the replacement of fossil fuels with biogas in thermal generation system, due to the complexity of the baseline for the heat component and for conservativeness, the project proponent chose not to consider these emission reductions.

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

This project has involved two different wastewater treatment technologies (as anaerobic digester systems), namely, UASB and covered lagoon. The details of these technologies are explained below:

Technology description:

UASB

UASB technology is used in the project for biogas generation from wastewater with a high concentration of organic content by anaerobic digestion. Being a two-stage technology, this involves an acidification system and a UASB Reactor. The organic matter in the wastewater is represented by its COD (chemical oxygen demand) and BOD (biochemical oxygen demand) values.

The UASB reactor can briefly be described as a system in which wastewater first passes through an expanded sludge bed containing a high concentration of biomass. The sludge in the reactor may exist in granular or flocculent form. Most of the organic matter removal takes place in the sludge bed. The remaining portion of the substrate passes through a less dense biomass, called the sludge blanket. Above the sludge blanket, the reactor has a three-phase gas-liquid-solid (GLS) separator, which separates the solid particles from liquid and gas, allowing liquid and gas to leave the system. The system is diagrammatically represented in the figure under section 2.3.

Covered lagoon

The project activity also utilizes a simple, effective and reliable technology to capture lagoon-produced biogas: installing sealed covers over existing anaerobic lagoons to create an anaerobic digester system. Each cover will consist of synthetic high density polyethylene (HDPE), which is sealed by means of strip-to-strip welding and a peripheral anchor trench dug around the perimeter of the existing lagoon. The welded seams of the cover system will be tested to ensure air-tight coupling between all strips of the HDPE membrane. HDPE is worldwide one of the most commonly used geo-membranes as it withstands UV light, ozone,

and a number of chemicals. This covering approach allows for capturing and combusting of the biogas produced in the covered lagoons.

The digester incorporates other features to enhance long-term reliability and efficiency including a sludge handling system that enables sludge removal without breaking the digester's air tight seal. Depending on site-specific conditions, other possible features to be installed are effluent recirculation and/or multiple agitators to gently turn over the wastewater, simulating the natural atmospheric and solar turbulence which will be blocked by the HDPE covers.

Currently, the captured biogas from all the stated biogas reactors is delivered and used as fuel in all 7 boilers. Later in the year 2010, the project proponent plans to use all the biogas to generate steam from only two boilers and their priority in the future would be to generate electricity. For greater clarity, this is illustrated in a flow diagram exhibited in section 2.3 (project boundary).

Secondary treatment system:

The discharge from the covered lagoons 2 flows to the 7 existing open lagoons for further treatment of wastewater.

Table 3.Characteristics of the secondary wastewater treatment system

No.	Type	Depth	Volume	Retention time
		m	m ³	days
1	Anaerobic Lagoon	4.5	26,325	13
2	Anaerobic Lagoon	5.5	42,900	13
3	Anaerobic Lagoon	5.5	50,050	20
4	Anaerobic Lagoon	5.5	42,900	24
5	Anaerobic Lagoon	5.5	42,900	21
6	Anaerobic Lagoon	5.5	349,800	21
7	Anaerobic Lagoon	5.5	349,800	167
Total	Anaerobic Lagoon	-	581,200	279

Note that the wastewater at the outlet of CL3 will flow into a series of newly built open anaerobic lagoons with total area of 300 rais.

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

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

		used in the plantation area.
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1.11 Identification of risks that may substantially affect the project's GHG emission reductions or removal enhancements:

Due to the use of two crucial technologies, which are the UASB and covered lagoon technology, in this project, the major risks are described according to the two separate technologies as follows:

Anaerobic digester systems:

UASB

The major risks from UASB that may substantially affect the project's GHG emission reductions are related to the performance of the biogas reactor system. Given the fact that biogas reactors rely on a biological process, the system is sensitive to variations in the effluent quality and quantity. Appropriate reactor design and experienced plant operators play a major role in the performance success of such systems. A malfunctioning biogas reactor might lead to less biogas production and a higher COD level of the wastewater leaving the reactor.

Covered lagoon

The major risks of the covered lagoon are related to the leakage of GHG in spite of the HDPE cover sheet. Given the large size of the covered lagoon, gases may leak if the seams of the membrane are welded poorly.

Note that all these issues are addressed in the emission reduction calculation and monitoring procedures as described in this VCS PD.

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.

Starch and sweetener plant

The baseline scenario described in this VCS PD consisting of open lagoons; a system that has been successfully operated 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

Ethanol plant

Without covered lagoons, effluent from ethanol would have been delivered to the open lagoons system, as it is common practice in the local ethanol production industry and for P.S.C. Starch products Co.,Ltd as well. It is further explained in section 2.4.

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.

permissible COD content of wastewater discharge is 400 mg/l for all types of industry. In addition, ethanol plants are not allowed to discharge any wastewater into natural water resources.

A letter from project proponents has been provided to certify such statement.

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

The project is not applying to any other form of environmental credit. A letter from project proponents has been provided to certify such statement.

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

Not applicable as the project did not apply under 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:	P.S.C. Starch Products Public Company Limited
Address:	999 Moo 5
City:	Nongyai, Chonburi
Country:	Thailand
Telephone:	+66 (38) 219 730-4
FAX:	+66 (38) 219 733
Represented by:	Sumol Sereethoranakul
Title:	Managing Director
Salutation:	Mr.

Role	Carbon Asset Management (responsible for development of emission reductions through the Voluntary Carbon Standard)
Organization:	Swiss Carbon Value Ltd.
Street/P.O.Box:	Technoparkstrasse 1
City:	Zurich
Postfix/ZIP:	8005
Country:	Switzerland
E-Mail:	p.buergi@southpolecarbon.com
URL:	www.southpolecarbon.com
Represented by:	Patrick Buergi
Title:	Managing Partner
Salutation:	Mr.
Mobile:	+ 66 81 841 1511
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 follows:

Legislative:

The project meets all the statutory requirements. Evidence of permits for the implementation of the project such as construction permit and operation permit is provided to the Designated Operational Entity (DOE).

Technical:

The advanced biogas reactor systems, UASB and covered lagoons, are implemented for using fuel for heat and electricity generation. As compared to the baseline scenario, the installed wastewater treatment system consists of an efficient process for wastewater treatment based on state of the art technology. The usage of a reactor allows reducing the water loss due to evaporation associated with higher hydraulic retention time in the open lagoon system, relative to the closed system in the UASB and covered lagoons, and achieves the same efficiency of COD removal in a reduced period of time.

The anaerobic digester requires special training of skilled staff to operate and maintain the biogas plant, creating employment and leading to knowledge transfer to the host country and especially to the rural region of the country. The use of this technology in wastewater treatment by the project owner will help to popularise the technological knowhow in the nearby areas for similar technologies in the country.

Also, the locally produced equipment may be put to use in other parts of Thailand for similar purposes. Geographically, transfer of technology and know-how has occurred mainly from urban to rural areas.

Economic:

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

Sectoral:

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

Social:

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

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

Environmental:

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

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

Geographic/site specific:

The project can be uniquely identified with no barriers regarding logistics. 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 any GHG emissions during the ten years renewable of the crediting period.

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 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:

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

Methane avoidance component:

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

AMS-III.H refers to:

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

AMS.I.D refers to:

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

For Greenfield project, the “Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories”, version 12.1 refers to:

- “Combined tool to identify the baseline scenario and demonstrate additionality” version 2.2

Both 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:

Methane avoidance component - AMS III.H (Version 13):

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 of the following options:</i> (i) Substitution of aerobic wastewater or sludge treatment systems with anaerobic systems with biogas recovery and combustion; (ii) Introduction of anaerobic sludge treatment system with biogas recovery and combustion to an existing wastewater treatment plant without sludge treatment; (iii) Introduction of biogas recovery and combustion to an existing sludge treatment system; (iv) Introduction of biogas recovery and combustion to an existing anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an onsite industrial plant; (v) Introduction of anaerobic wastewater treatment with biogas recovery	As demonstrated in Section 2.3, the wastewater from the three different processes would have been treated in open anaerobic lagoons in the absence of the project. These open lagoons have depth greater than 2 meters (minimum 4.5m), without aeration, and the ambient temperature on a monthly average basis being greater than 15 °C. For the dry starch production process, design wastewater generation rate is of 2,800 m³ per day and the COD concentration of this untreated wastewater of 17,725 mg/l (i.e. 17.7 kg/m³). For the sweetener process, the design wastewater generation rate is 320 m³ per day and the corresponding COD concentration of the wastewater is at 12,200 mg/l (or 12.2 kg/m³). Lastly, the ethanol production process generates 1,240 m³ of wastewater per day and the

and combustion, with or without anaerobic sludge treatment, to an untreated wastewater stream; (vi) Introduction of a sequential stage of wastewater treatment with biogas recovery and combustion, with or without sludge treatment, to an existing 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)	COD level of this wastewater has a design value of 50,000 mg/l (50 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). Thus the project activity refers to option (vi) described. The UASB, CL1, CL2 and CL3 in combined way attribute as a new addition in sequence before actual system.
The recovered biogas from the above measures may also be utilised for the following applications instead of combustion/flaring: (a) Thermal or electrical energy generation directly; or (b) Thermal or electrical energy generation after bottling of upgraded biogas; or (c) Thermal or electrical energy generation after upgrading and distribution: (i) Upgrading and injection of biogas into a natural gas distribution grid with no significant transmission constraints; or (ii) Upgrading and transportation of biogas via a dedicated piped network to a group of end users; or (d) Hydrogen production.	The project activity also involves the facility to capture biogas and further to utilise for heat and power generation. Hence, the project activity satisfies the criterion (a).
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.	The recovered biogas is used for heat generation as mentioned above. However, due to the complexity of the baseline and for conservativeness, energy generation component is not claimed for emission reductions in this project activity. The project considers only AMS.III.H.
If the recovered biogas is utilized for production of hydrogen (project activities covered under paragraph 2 (d)), that component of project activity shall use corresponding category AMS-III.O.	The recovered biogas is not utilized for production of hydrogen, thus this applicability condition is of no relevance.
In case of project activities covered under paragraph 2 (b) if bottles with upgraded biogas are sold outside the project boundary the end-use of the biogas shall be ensured via a contract between the bottled biogas vendor and the end-user. No emission reductions may be claimed from the displacement of fuels from the end use of bottled biogas in such situations. If however	The project activity does not involve an application of recovered biogas as per paragraph 2(b), thus this applicability criterion is of no relevance.

<i>the end use of the bottled biogas is included in the project boundary and is monitored during the crediting period CO2 emissions avoided by the displacement of the fuels is eligible under a corresponding Type I methodology, e.g., AMS-I.C.</i>	
<i>In case of project activities covered under paragraph 2 (c i) emission reductions from the displacement of the use of natural gas is eligible under this methodology, provided the geographical extent of the natural gas distribution grid is within the host country boundaries.</i>	The project activity does not involve an application of recovered biogas as per paragraph 2(c i), thus this applicability criterion is of no relevance.
<i>In case of project activities covered under paragraph 2 (c ii) emission reductions for the displacement of the use of fuels can be claimed following the provision in the corresponding Type I methodology, e.g., AMS-I.C.</i>	The project activity does not involve an application of recovered biogas as per paragraph 2(c ii), thus this applicability criterion is of no relevance.
<i>In case of project activities covered under paragraph 2 (b) and (c), this methodology is applicable if upgrade is done by one of the following technologies¹⁴ such that the methane content of the upgraded biogas is in accordance with relevant national regulations (where these exist) or, in the absence of national regulations, a minimum of 96% (by volume). These conditions are necessary to ensure that the recovered biogas is completely destroyed through combustion in an end use:</i> • <i>Pressure Swing Adsorption;</i> • <i>Absorption with/without water circulation;</i> <i>Absorption with water, with or without water recirculation (with or without recovery of methane emissions from discharge).</i>	The project activity does not involve an application of recovered biogas as per paragraph 2 (b) and (c), thus this applicability criterion is of no relevance.
<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>	Project combines with old facilities and new facilities. The new facilities comply with the requirements in the General Guidance for SSC methodologies concerning these topics.
<i>For project activities covered under paragraph 2 (b) and (c) additional guidance provided in annex 1 shall be followed for the</i>	The project activity does not involve an application of recovered biogas as per paragraph 2 (b) and (c), thus this

¹⁴ Please refer to annex 1 of approved methodology AM0053 / Version 01.1 regarding the description of these technologies.

<i>calculations in addition to the procedures in the relevant sections below.</i>	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 PDD.</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.

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

As per methodology AMS III.H the project boundary shall include:

“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”.

There are no physical units or processes removing GHG from the atmosphere (sink) nor physical units or components of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG removed from the atmosphere by a greenhouse gas sink or a GHG captured from a greenhouse gas source (reservoir) relevant in both the baseline- and project- activity. However, following the methodology AMS-III.H., 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 the table below:

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

	Source	Gas	Included	Justification
Baseline activity	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.
	Thermal energy generation	CO ₂	Excluded	Excluded for simplification. This is conservative.
		CH ₄	Excluded	Excluded for simplification. This is conservative
		N ₂ O	Excluded	Excluded for simplification. This is conservative
	Electricity	CO ₂	Included	Fossil fuel based grid electricity is displaced.

Project activity	generation	CH ₄	Excluded	Excluded for simplification. This is conservative.
		N ₂ O	Excluded	Excluded for simplification. This is conservative.
	Wastewater treatment systems	CH ₄	Included	The emissions from the wastewater treatment under the project activity are from: – Decomposition of the organic matter in the open anaerobic lagoons - Physical leakage from the bio-digester and covered lagoons - 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.

The definition of the system boundaries for calculation of project and baseline emissions is provided in the figure below:

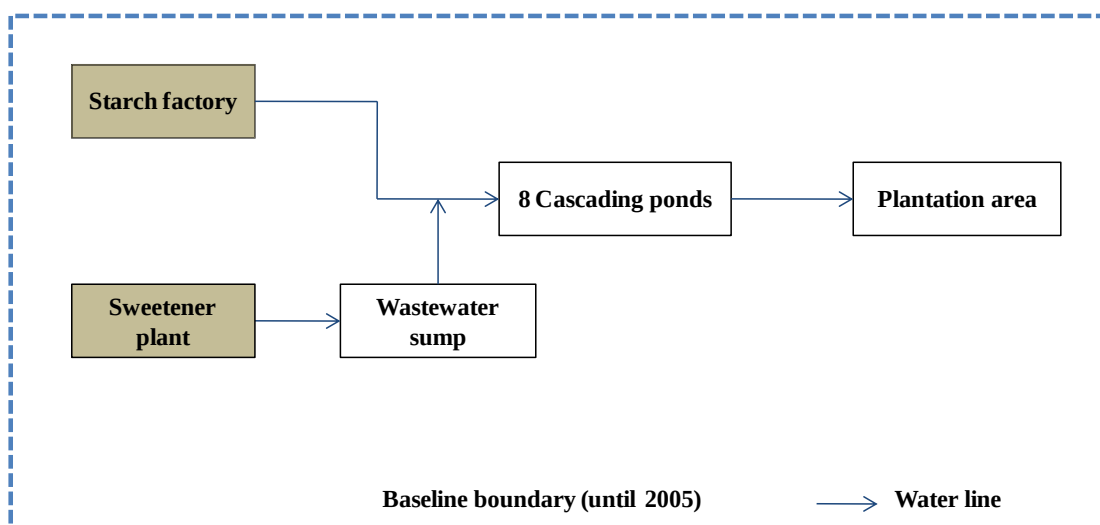


Figure 3: The baseline system boundary

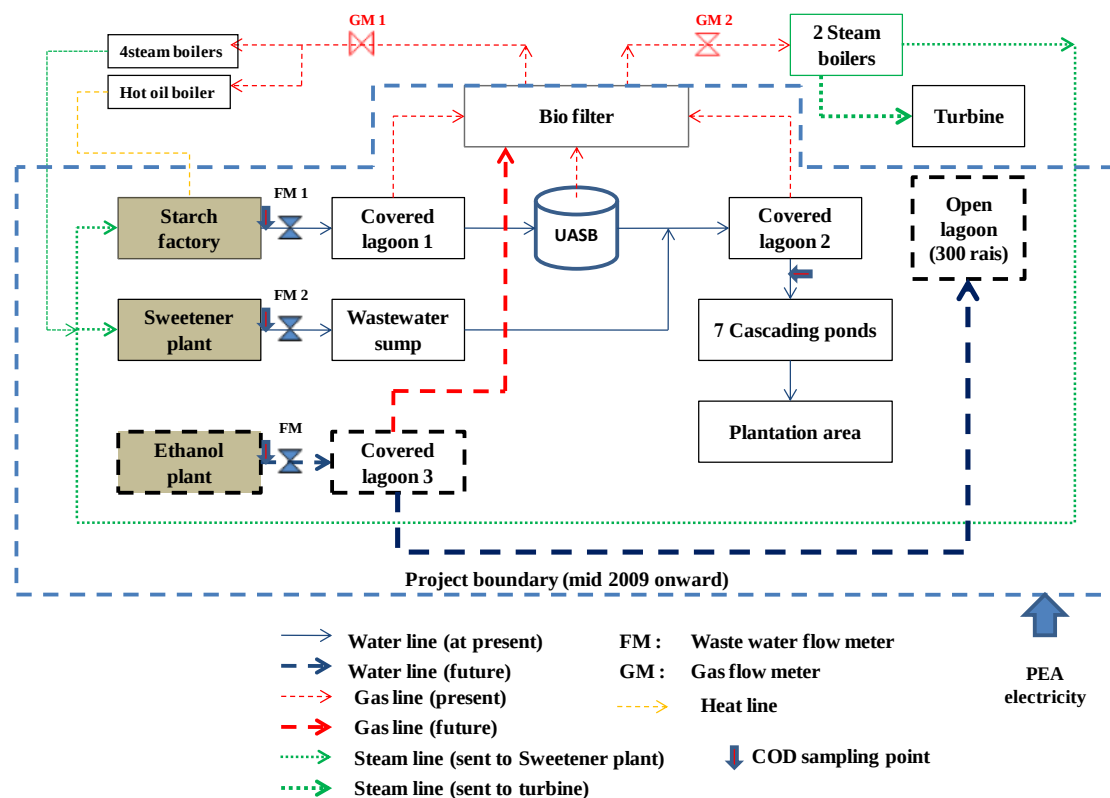


Figure 4: The project system boundary (after CL3 implementation)

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

Baseline for existing treatment facilities – for starch and sweetener plant

Open anaerobic lagoons without methane recovery represent the existing wastewater treatment system prior to project implementation (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 is defined as the existing anaerobic wastewater treatment system without biogas recovery.

The baseline scenario consists of 8 anaerobic lagoons being used to treat wastewater prior to project implementation. The lagoons' minimum depth is 4.5 m and they can all be considered as anaerobic lagoons according to methodology AMS III.H. It must also be noted that the baseline condition of the project as described is already sufficient in meeting all relevant regulations and legislations. . The following table provides the relevant details of the existing lagoons on site:

Table 5: Characteristics of the baseline open anaerobic lagoons at the starch facility

Lagoon no.	Depth	Volume	Retention time
	m	m ³	day
1	4.5	26,325	13
2	4.5	26,325	13
3	4.5	26,325	13

4	5.5	42,900	20
5	5.5	42,900	24
6	5.5	42,900	21
7	5.5	42,900	21
8	5.5	349,800	167
Total	-	600,375	292

Baseline for Greenfield project – Ethanol Plant:

For Greenfield projects, the determination of the baseline scenario has to be in line with the “**Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories**”.

The “Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories”, version 12.1, Paragraph 12, states that:

***Type II and III Greenfield projects (new facilities):** may use a Type II and Type III small-scale methodology provided that they can demonstrate that the most plausible baseline scenario for this project activity is the baseline provided in the respective Type II and III small-scale methodology. The demonstration should include the assessment of the alternatives of the project activity. For the purpose of the demonstration, project participants may apply the steps 1 to 3 of the latest version of “Combined tool to identify the baseline scenario and demonstrate additionality” to identify the baseline scenario. If the identified baseline scenario is the same as the baseline of the methodology, and it can be demonstrated that the implementation of the project as ‘the proposed project activity undertaken without being registered as CDM’, is not the common practice in the region, project participants can apply the methodology.*

Therefore, steps 1 to 3 of the “Combined tool to identify the baseline scenario and demonstrate additionality” version 2.2¹⁵ have been used to identify the baseline of the wastewater treatment system for the ethanol plant.

STEP 1: Identification of alternative scenarios

Step 1a. Define alternative scenarios to the proposed project activity

The main output or service of the project activity is the treatment of effluent water. The by-products of the project activity arising from the utilisation of biogas captured are the production of heat and electricity.

Therefore, the alternative scenarios that are available to the project participants and that provide outputs or services with comparable quality, properties and application areas as the proposed small-scale CDM project activity are:

Alternative (a): Open anaerobic lagoon based wastewater treatment system (lagoons exist for the other facilities)

Alternative (b): Methane recovery and utilization for heat and electricity generation (proposed project without emission reduction assistance)

Alternative (c): Aerobic wastewater treatment

Alternative (d): Direct discharge

¹⁵ http://cdm.unfccc.int/Reference/tools/ls/meth_tool02.pdf

Step 1b. Consistency with mandatory applicable laws and regulations

Alternatives (a), (b) and (c) are in compliance with current regulations in Thailand which allow the use of open lagoon systems as well as other wastewater treatment technologies so long as there is no discharge of wastewater from the ethanol plant to natural water resources¹⁶. There is no other regulatory requirement for the implementation of a specific wastewater treatment technology (such as whether to apply anaerobic digester or aerobic treatment system) to tapioca processing plants for effluent treatment. Thus it is clear that alternatives (a), (b) and (c) do not face any legal barriers, and is regulatory surpluses to any enforced legal framework.

In contrast, alternative (d) would violate the effluent discharge standards set by the laws and regulations in Thailand and cannot be considered as a baseline scenario; thus alternative (d) is excluded from further assessment.

STEP 2: Barrier analysis

Sub-step 2a. Identify barriers that would prevent the implementation of alternative scenarios

A complete list of realistic and credible barriers that may prevent the alternative scenarios to occur has been established in section 2.5 of the VCS PD.

Sub-step 2b. Eliminate alternative scenarios which are prevented by the identified barriers

As demonstrated in Section 2.5., Alternatives (b), (c) and (d) are prevented by at least one of the following implementation barriers: (1) technological barrier, (2) investment barrier and (3) institutional barriers. Therefore these alternatives are eliminated from further consideration. No barriers have been identified for Alternative (a). Therefore, according to “Combined tool to identify the baseline scenario and demonstrate additionality” version 2.2, Alternative (a) is identified as the baseline scenario.

STEP 3: Investment analysis

Since there is only one alternative remaining as an output of Step 2, Step 3 is not required.

Conclusion:

Following the different steps of the “Combined tool to identify the baseline scenario and demonstrate additionality”, it has been demonstrated that the wastewater of the second line would have been treated in an open anaerobic lagoon in the absence of the Project. Therefore, the project activity refers to case (vi) described in AMS.III.H and fulfils the applicability conditions of the respective project category:

(vi) Introduction of a sequential stage of wastewater treatment with methane recovery and combustion, with or without sludge treatment, to an existing wastewater treatment system without methane recovery (e.g. introduction of treatment in an anaerobic reactor with methane recovery as a sequential treatment step for the wastewater that is presently being treated in an anaerobic lagoon without methane recovery).

Moreover, it is demonstrated in section 2.5 (Step 3: Common practice) that the implementation of the project as “the proposed project activity undertaken without being registered as VCS” is not the common practice in the region. The methodology is thereby

¹⁶ 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.

applicable as per the Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories.

The existing lagoons system used before the implementation of the ethanol plant would have also received the wastewater from the expanded part, in the absence of the project activity. Indeed, after the introduction of the UASB reactor and covered lagoons for the starch and sweetener plants, the wastewater entering the lagoons has a very low COD content, as it is removed by the UASB reactor and covered lagoons; the lagoons have thus the capacity to treat additional wastewater flow. Therefore, the series of the eight existing deep anaerobic open lagoons is used as the baseline for both wastewater treatment systems, although after the operation of the ethanol plant there will be more anaerobic lagoons used. The efficiency of the baseline scenario for both phases is thus calculated based on the values from the measurement campaign.

This is conservative regarding the calculation of the emission reductions.

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):

According to the definition stated in the VCS Program Guidelines (section 2.2), the ‘additionality’ criteria requires 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 of the simplified modalities and procedures for small-scale CDM project activities¹⁷ is referred to in the applied small-scale CDM methodologies. In addition, as explained in Section 2.4, the steps 1 to 3 of the latest version of the “Combined tool to identify the baseline scenario and demonstrate additionality” have also to be applied in order to determine the baseline for the Greenfield component of the project. Given the fact that requirements of Attachment A to Appendix B of the Simplified Modalities of the simplified modalities and procedures for small-scale CDM project activities are fully consistent with Step 2 (Barrier Analysis) of the “Combined tool to identify the baseline scenario and demonstrate additionality”, this tool, including Step 4 (common practice analysis), is applied for demonstration of additionality.

STEP 1: Identification of alternative scenarios

Step 1a. Define alternative scenarios to the proposed project activity

In order to prove the assessment of additionality, alternative scenarios to the project activity have been identified for comparative assessment:

Alternatives	Plausible alternatives available to the project participant
Alternative (a)	Anaerobic open lagoon system without capture and utilization of biogas
Alternative (b)	New anaerobic wastewater treatment facilities with methane capture (proposed project undertaken as a VCS)
Alternative (c)	New aerobic wastewater treatment facilities

¹⁸ 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. For ethanol plant, the regulation does not permit discharge of wastewater.

Alternative (d) Direct discharge to nearby river
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Step 1b. Consistency with mandatory applicable laws and regulations

Alternatives (a), (b) and (c) are in compliance with current regulations in Thailand which allow the use of open lagoon systems as well as other wastewater treatment technologies so long as there is that meet effluent standards for the discharge of treated wastewater into the environment, or in the case of the ethanol plant there is no discharge of wastewater¹⁸. There is no other regulatory requirement for the implementation of a specific wastewater treatment technology (such as whether to apply anaerobic digester or aerobic treatment system) to tapioca processing plants for effluent treatment. Thus it is clear that alternatives (a), (b) and (c) do not face any legal barriers, and is regulatory surpluses to any enforced legal framework.

In contrast, alternative (d) would violate the effluent discharge standards set by the laws and regulations in Thailand and cannot be considered as a baseline scenario; thus alternative (d) is excluded from further assessment.

STEP 2: Barrier analysis

Sub-step 2a. Identify barriers that would prevent the implementation of alternative scenarios

Technical Barriers

The technological barrier is considered the main barrier for the implementation of this project activity. Open lagoons have been used extensively for treating wastewater from starch factories and ethanol plants in Thailand. The open lagoon system is considered as having low technical risk as it does not require any advanced technology and is easy to operate and maintain.

➤ Lack of skilled and trained manpower

Alternative (a) has 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 as it does not involve any advanced technology, is easy to operate and maintain, and does not need skilled manpower¹⁹. The related technology and the necessary human resource capacity are considered to be readily available in Thailand. 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 are covered), maintaining biochemical equilibrium within the digesters, and a detailed monitoring program (including equipment and material maintenance) to maintain system performance levels. Such requirements create 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 industry²⁰.

¹⁸ 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. For ethanol plant, the regulation does not permit discharge of wastewater.

¹⁹ Mara, D., 2003, Waste Stabilization Ponds: Time for Aggressive Marketing, <http://www.bvsde.paho.org/bvsacd/agua2003/mar.pdf>

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

Therefore, lack of skilled and qualified personnel poses a significant barrier to the success of the project. Additional investment in training of the operators and other personnel has to be provided by the project proponent (PP), particularly in the initial phase of the project. Occasional expert intervention is also required until in-house expertise in the process is developed. Lack of skilled and trained manpower may lead to increased mechanical breakdowns, decreased process efficiency, and inferior biogas quality and quantity, all adding financial burden on the PP. In the case of P.S.C, some conflicts between the technology provider and the PP during the construction period took a long time to resolve. The response from both organizations is provided in the following table. The major reason of conflict is found to be long delays in achieving construction milestones.

Table 6: the timeline of the action related to project implementation

Date		Number
14-Nov-02	BAU register as foundation	registration of foundation
1-Jan-03	contract with BAU	contract nr. PSC/01/2546
20-Feb-03	delivery plan for construction	letter 004/2546
3-Apr-03	reponse for first payment of 1500000 baht	letter. 010/2546
6-Sep-04	ask for second and third payment due to the delay of construction	letter 061/2547
18-Feb-05	PSC cancel the contract with development of biogas in wastewater treatment in Starch factory which the project proponents are PSC and BAU	letter from PSC on 18 Feb 2005
19-Apr-05	BAU response to the cacellation letter of PSC	Letter 140/2548

Alternative (c) is a well-established conventional practice for treatment of domestic and industrial wastewater. However, no previous experience exists with this type of technology in tapioca starch factories in Thailand. Largely due to commercial reasons, no operators are taking this option into their investment consideration as such installations consume great amounts of power. 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 high risk with limited performance guarantee. The process's success depends on the equilibrium among the various microbial species' activity and constant monitoring is required to ensure that the system remains in balance. Multiple variables 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 and frequently require a high level understanding of the biological system. Due to these sensitive parameters involved in operation of the project, system requires special care and keener observation. It can take significant amounts of 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; still most manufacturers prefer to retain wastewater from tapioca starch plant in open lagoons. This has been verified by a report from 2007 by the Energy Conservation and Renewable Energy Division and Energy Policy and Planning Office of Thailand²¹ (EPPO report). In fact,

²¹ 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

P.S.C Starch Products PLC is one of the first starch factories in Thailand implementing the UASB system.

In 2002, the time the PP considered the installation of the UASB system, only two other biogas reactors in Thai starch factories were in operation, as shown in below table from a technology provider. No Thai starch factories installed such systems until the PP decided to proceed in 2003. This 11-year gap clearly implies a technological barrier for alternative (b).

Table 7 : Amount of UASB plants in year 2002 as stated in one of the proposal provide to project proponent

Project name	Province	Origin of wastewater	Unit processes primary treatment	Flow (m3/day)	Plant capacity Kg COD/day	Year
1. Surathip (group)	11 provinces	Alcohol (Thin Stillage)	Acidification+UASB	600	45,000	1984
2.Thai Prasit Starch	Uthaitхани	Tapioca	UASB	1,440	38,340	1991
3.National starch and Chemical Thailand	Kalasin	Tapioca starch and modified starch	UASB	4,000	48,000	1992
4.Boon Rawd Brewery	Bangkok	Brewery	UASB	6,000	15,000	1994
5.Thai Amarit Brewery	Pathumthani	Brewery	UASB	1,600	4,000	1994
6.Serm Suk PLC. Co.Ltd.	Pathumthani	Soft Drinks	UASB	3,600	7,200	1997
7. Boon Rawd Brewery	Khon Khaen	Brewery	UASB	-	-	1997
8.President Bakery	Bangkok	Bakeries	UASB	300	450	1997
9.Super First Food	Samuthsakorn	Candy	UASB	30	180	1997
10.Thai Comercial Noodle	Bangkok	Noodle	UASB	40	40	1997
11.Thai Brewery	Ayuthaya	Brewery	UASB	4,000	14,000	1998
12.Shotiwat Frozen Co.,Ltd.	Songkla	Shrimp Frozen	UASB	1,000	2,100	1998
13.Thanakorn Paper Industry Co.,Ltd.	Pathumthani	waste paper	UASB	2,000	2,000	1998
14.B.S.A Product Co.,Ltd.	Samuthsakorn	Fish process	Acidification+UASB	250	600	1999
15.C.Y. Frozen Food Co.,Ltd.	Samuthsakorn	Shrimp Frozen	UASB	250	625	1999
16.Chalong Latex Industry Co.,Ltd	Songkla	Concentrate Latex	sulfate reduction+UASB	600	3,324	1999
17.C.P Retailing and Marketing Co.,Ltd.	Bangkok	Bakeries	Acidification+UASB	100	600	2000
18.Thai Union Frozen Product PLC.Co.,Ltd.	Samuthsakorn	Shrimp Frozen	UASB	1,000	1,500	2000
19. Tropica Canning Co.,Ltd.	Songkla	canned food	Acidification+UASB	2,400	18,000	2000
20.SiamChai International Food Co.Ltd	Ranong	Frozen and Surimi	UASB	2,400	3,000	2000
21.General Food Poultry (Thailand) Plc.Ltd.	Samutprkarn	Poultry	UASB	5,000	6,000	2000
22.Uni-President (Thailand) Ltd.	Nakornpathom	Fruit Juice	UASB	300	1,350	2000
23.Surapon Food Co.,Ltd.	Samuthsakorn	frozen seafood and dimsum	UASB	1,000	1,100	2001

Source: Papop's proposal presented to the PSC Production PLC. Co.Ltd. when PP decided to construct the UASB system for their wastewater treatment system on page6.

At the time of contract made with the technology provider in 2003, the designer of the UASB system for P.S.C. had worked mainly with swine farm wastewater only. The characteristics of these wastewaters are greatly different, shown in the table below.

source of wastewater	PH	COD	BOD	TKN	TSS
starch factory	3.4-6.5	5000-37000	2500-16000	230-500	7000-37000
Swine farm (more than 5000 pigs)	5.5-9	400	100	200	200

Source: 1. Promotion project of biogas from wastewater by UASB system, Worrasut T. and Wongchaisuwan S., in Thai

2. The study of wastewater from swine farm in Payao, Thailand, Art-ong B. and Lertsri J. in Thai.

Initially the project didn't make use of covered lagoons but the only the UASB system, which contributed to initial project failure after implementation. The engineer, being no specialist in biogas reactors, advised the PP to start and operate the project without further supervision, obviously strongly underestimating the complexity of operating a UASB system for starch factories. This shows how crucial support and assistance was still required through international contributors for transferring critical knowledge to industrial applications in Thailand.

Similarly, alternative (c) is also not a common option in Thailand. The aerobic systems generate huge amount of sludge and make the final handling of the sludge very expensive. These systems require very high power usage and are expensive in terms of Operation and maintenance in comparison to lagoon systems.

As well, similar technology risks are applicable to the aerobic systems due to common nature of microbial functioning.

Investment Barrier

Anaerobic open lagoons (alternative a) require little investment in technology apart from excavating the ponds and installing pipes and pumps. In fact, the practice is low cost and usually least cost in both capital and operation & maintenance cost^{22, 23}. Consequently, the majority of wastewater treatment systems in Thailand are open lagoons. Overall, there is no significant investment barrier and no associated investment risks. Anaerobic open lagoons are the prevalent wastewater system in Thailand and an adequate technology²⁴ that have been installed and operated for several decades. The Ministry of Industry, in cooperation with the Ministry of Natural Resources and Environment have elaborated and promoted guidelines for open lagoons anaerobic systems as economic solutions with resulting nutritive wastewater for irrigation²⁵. Moreover, the open lagoon treatment system requires no further investment because PP has already in place treatment facility. Therefore, it is reasonable to conclude that Alternative A does not 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*”²⁶. Therefore penetration of other advanced wastewater treatment technologies is very low in Thailand and biogas projects are considered as highly risky by the financiers. Hence, financing of biogas project in starch industry appears to be constraint²⁷. Due to high risks associated with such

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

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

²⁴ Wastewater Engineering: Treatment, Disposal, Reuse: Third Edition by George Tchobanoglous, Frank Burton, and Metcalf & Eddy (Paperback – 1991)

²⁵ GTZ, Department of Industrial Works (1997). Environment Management Guideline for the Palm Oil Industry. <http://www.elaw.org/assets/pdf/th.palm.oil.industry.guidelines.pdf> 6

²⁶ 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.

²⁷ 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.

kind of projects even, without subsidies, it is almost impossible to produce a bankable document for the loan proposal²⁸.

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)²⁹. At the early stage of construction, PSC Starch wastewater treatment also applied for this funding. BAU was acting as a representative for PSC Starch.

The application for fund or subsidy for project was coordinated by BAU with assistance from PSC. However with conflict in the construction milestones, the project proponent became apprehensive of fulfilling the conditions stipulated under fund allocation. The project owner decided to withdraw application for fund fearing even higher.

These state above show that PP had incentive to invest in the project because at first time, PP had the support from ENCON fund. But during the trouble over the construction, PP had terminated the contract with BAU and withdrew the application for the fund. Without the fund, the project activity is deemed unattractive from financial perspective.

Therefore, Alternative (b) faces an important investment barrier.

Due to high operation cost, starch production operators are not willing to take alternative (c) for investment consideration, while Alternative (d) is deemed a violation to national regulations.

Institutional Barriers

Although there are some slight discomforts to local community associated with odour from the 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.

Sub-step 2b. Eliminate alternative scenarios, which are prevented by the identified barriers

²⁸ Prasertsan, S. B. Sajjakulnukit (2006). Biomass and biogas energy in Thailand: Potential, opportunity and barriers. *Renewable Energy* 31:599–610.

²⁹ 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,

Alternatives (b), (c) and (d) are prevented by at least one barrier. Therefore these alternatives are eliminated from further consideration. No barriers have been identified for Alternative (a). Therefore, according to “Combined tool to identify the baseline scenario and demonstrate additionality” version 2.2, Alternative (a) is identified as the baseline scenario.

Given explanations above, it is clear that revenues from carbon credits alleviate the barriers outlined above by providing additional revenues to overcome the risks faced by the project activity prior to the investment decision.

STEP 3: Investment analysis

Since there is only one alternative remaining as an output of Step 2, Step 3 is not required.

STEP 4: Common Practice Analysis

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” projects³⁰, some background of the tapioca-based sweetener and the ethanol industries in Thailand must be given.

The common practice analysis has to be done for two separate wastewater treatment systems for different production lines, both tapioca-based sweetener-starch wastewater and ethanol wastewater.

Tapioca-based sweetener-starch procedure analysis

In demonstrating the market penetration rate of this project activity or “similar” projects³¹, some background into the relevant industry in Thailand must be given. At the time of drafting the PD an area of roughly 12,800³² km² is covered with tapioca cultivation in Thailand. Of some 85 native starch factories³³ only 10 produce sweet starch-based sweetener. Most of the wastewater management systems in these factories are based on open anaerobic lagoons³⁴, which require little investment, have low operation and maintenance costs, and fulfil the national regulations for wastewater discharge. Like in other starch plants, the discharged water comes mainly from the processing of raw tapioca to wet starch, which is then used in the process of making sweetener syrup.

Out of 10 factories countrywide 3 have installed anaerobic digesters. Although this number may appear large, operating such facilities cannot be considered common practice as verified below.

Table 8: the data related to common practice of starch and sweetener factories in one site.

Area of tapioca plantation in Thailand (km ²)	12,800
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³⁰ 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”.

³¹ 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”.

³² <http://www.thaitapiocastarch.org/crop.asp>

³³ <http://www.thaitapiocastarch.org/article05.asp>

³⁴ <http://www.thaitapiocastarch.org/article01.asp>

Native starch factory	75
Native starch factory + Sweetener	7
Native starch factory + Sweetener + Anaerobic digester	3

The GHG Protocol for Project Accounting states, ‘project type shall not be common practice in sector/region, compared with projects that have received no carbon revenue’ and ‘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’.

Before drawing a conclusion based on the market penetration rate of 30% alone, a closer look has to be taken into the market’s make-up. Two out of three closed anaerobic system projects mentioned have submitted an application to acquire environmental credit (either in the form of CER or VER) in order to ask for assistance for the financial burden of the investment of this costly set of technologies. This shows that the technology was unattractive before the possibility of requesting such support: only one starch producer decided to install the technology without assistance through the carbon market. Consequently, the project activity is not common practice under the above definition.

The two projects are Chao Khun Agro Biogas Energy Project³⁵ and Asia Fructose³⁶; the first being in the review request stage and the latter having shown its intent to register with CDM on their company website.

Tapioca based Ethanol analysis

As stated before, common practice refers to the predominant technologies or practices in a given market, determined by the degree to which those technologies or practices have penetrated the market.

Current regulations state that wastewater from an ethanol plant are not to be discharged outside factory grounds. Common practice among ethanol producers are open anaerobic lagoons to store the wastewater from the process while having a long retention time in the treatment system. The analysis will be performed only on the tapioca-based ethanol industry in Thailand’s Eastern Region.

As of 2009, there are 12 ethanol plants in the Eastern Region. Five of these are in the construction period and 7 received the necessary permission from the government. Only 4 out of 12 are planning on installing a biogas system, showing that the P.S.C. starch factory is one of the pioneering plants in this field with its biogas digester starting to operate beginning of 2010. This also demonstrates that the project activity is not common practice in this sector.

Table 9 : the amount of plants related to the common practice of ethanol

Ethanol plant in the eastern region	12
Received permission from government	7
Plan to install biogas system	4

Conclusion of the project test:

The proposed project activity is not implemented to respond to any laws or regulations. The project activity also faces several barriers and cannot be considered as a common practice. The carbon credits’ incentive helps to overcome these barriers. According to the Attachment

³⁵ <http://cdm.unfccc.int/Projects/DB/DNV-CUK1218616482.16/view>

³⁶ <http://www.asiafructose.com/about.htm>

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, thus the project is additional.

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 the proposed project activity for the methane avoidance component.

AMS-III.H refers to:

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

AMS.I.D refers to:

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

Both 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 the diagrams in section 2.3 for the location of the monitoring equipments at each phase. In circumstances where 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 end of 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 once every three years).

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

Parameters for which the values are fixed, throughout the crediting period:

Data / Parameter:	GWP_{CH_4}
Data unit:	-
Description:	Global warming potential of methane gas
Source of data used:	Based on AMS-III.H, version 13, default value
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:	$B_{0, ww}$
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 version 13
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 default value. Based on AMS III.H.
Any comment:	

Data / Parameter:	UF_{BL}
Data unit:	-
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 description of	Reference: FCCC/SBATA/2003/10/Add2, page 25. Based on AMS III.H.

measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	UF _{PJ}
Data unit:	-
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 :	Reference: FCCC/SBATA/2003/10/Add2, page 25. Based on AMS III.H.
Any comment:	

Data / Parameter:	MCF _{ww, treatment, BL, lagoon}
Data unit:	Fraction
Description:	Methane correction factor for baseline anaerobic wastewater treatment systems
Source of data used:	Table III.H.1 from AMS III.H, version 13 methodology
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 4.5 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,k}
Data unit:	Fraction
Description:	Methane correction factor for the project wastewater treatment system <i>k</i> equipped with biogas recovery
Source of data used:	Table III.H.1 from AMS III.H, version 13 methodology
Value applied:	MCF _{ww, treatment, PJ,UASB} = 0.8 MCF _{ww, treatment, PJ,CL1} = 0.8 MCF _{ww, treatment, PJ,CL2} = 0.8 MCF _{ww, treatment, PJ,CL3} = 0.8
Justification of the choice of data or description of measurement methods and procedures actually applied :	All MCF values have been chosen in accordance with table III.H.1 from methodology AMS III.H., version 13. The project wastewater treatment system equipped with biogas recovery consists of a UASB system and covered lagoons, therefore MCF value is chosen as 0.8.
Any comment:	

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

Data / Parameter:	MCF _{ww, PJ,discharge}
Data unit:	Fraction
Description:	Methane correction factor based on discharge pathway in the project situation
Source of data used:	Table III.H.1 from AMS III.H, version 13 methodology
Value applied:	0.8
Justification of the choice of data or description of measurement methods and procedures actually applied :	The wastewater coming out of the covered lagoon CL3 will be discharged into a series of new anaerobic lagoons. A value of 0.8 is chosen for conservativeness.
Any comment:	

Data / Parameter:	CFE _{ww}
Data unit:	
Description:	Capture and utilization/combustion/flare efficiency of the methane recovery and combustion/utilization equipment in the wastewater treatment
Source of data used:	IPCC
Value applied:	0.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value is used here. Based on AMS III.H., applicable for equation(s) (5) in the methodology.
Any comment:	

Data / Parameter:	$\eta_{BL,starch}$
Data unit:	%
Description:	COD removal efficiency of baseline wastewater treatment system for the starch and sweetener plants

Source of data used:	calculated																																																																			
Value of data applied for the purpose of calculating expected emission reductions:	98.61%																																																																			
Justification of the choice of data or description of measurement methods and procedures actually applied :	The COD removal efficiency is based on monitored historical COD values for baseline system before implementation of project activity. <table><tr><th>Date</th><th>COD_{in} (outlet) (mg/l)</th><th>COD_{out} (Pond 8) (mg/l)</th><th>%COD removal</th></tr><tr><td>Sep_2003</td><td>11570</td><td></td><td></td></tr><tr><td>Jan_2004</td><td></td><td>120</td><td></td></tr><tr><td>Feb_2004</td><td>16410</td><td>370</td><td>97.75%</td></tr><tr><td>Mar_2004</td><td>13790</td><td>135</td><td>99.02%</td></tr><tr><td>Apr_2004</td><td>14835</td><td>230</td><td>98.45%</td></tr><tr><td>May_2004</td><td>17430</td><td>280</td><td>98.39%</td></tr><tr><td>Jun_2004</td><td>15410</td><td>245</td><td>98.41%</td></tr><tr><td>Aug_2004</td><td>13420</td><td>155</td><td>98.85%</td></tr><tr><td>Sep_2004</td><td>15080</td><td>210</td><td>98.61%</td></tr><tr><td>Oct_2004</td><td></td><td>145</td><td></td></tr><tr><td>Nov_2004</td><td>18605</td><td>258</td><td>98.61%</td></tr><tr><td>Dec_2004</td><td></td><td>145</td><td></td></tr><tr><td>Jan_2005</td><td>16475</td><td>105</td><td>99.36%</td></tr><tr><td>Mar_2005</td><td></td><td>74</td><td></td></tr><tr><td>Average</td><td>15303</td><td>190</td><td>98.61%</td></tr></table>				Date	COD _{in} (outlet) (mg/l)	COD _{out} (Pond 8) (mg/l)	%COD removal	Sep_2003	11570			Jan_2004		120		Feb_2004	16410	370	97.75%	Mar_2004	13790	135	99.02%	Apr_2004	14835	230	98.45%	May_2004	17430	280	98.39%	Jun_2004	15410	245	98.41%	Aug_2004	13420	155	98.85%	Sep_2004	15080	210	98.61%	Oct_2004		145		Nov_2004	18605	258	98.61%	Dec_2004		145		Jan_2005	16475	105	99.36%	Mar_2005		74		Average	15303	190	98.61%
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Any comment:	-																																																																			

Data / Parameter:	$\eta_{BL,ethanol}$
Data unit:	%
Description:	COD removal efficiency of baseline wastewater treatment system for the ethanol plant
Source of data used:	calculated
Value of data applied for the purpose of calculating expected emission reductions:	87.76%
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 open lagoons system multiply by 0.89
Any comment:	-

Data / Parameter:	FE
Data unit:	%
Description:	Flare efficiency
Source of data	Tool to determine project emissions from flaring gases

used:	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:	P _{el}
Data unit:	kW
Description:	Total electrical capacity of the equipments installed in the project activity
Source of data used:	Plant data
Value applied:	209.2 kW
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	-

Data / Parameter:	EF _y
Data unit:	tCO ₂ /MWh
Description:	CO ₂ emission factor of the grid
Source of data used:	“The calculation of emission factor for an electricity system in Thailand 2007”, DEDE. ³⁷
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:	

The following parameters are part of the monitoring plan and shall be monitored during crediting period:

Data / Parameter:	Q _{y, ww, starch}
Data unit:	m ³
Description:	Volume of wastewater treated in year y from the starch plant
Source of data to be	Measured – Volumetric flow meters

³⁷ http://www2.dede.go.th/cdm/520126_GridEmission2007.pdf

used:	
Value of data applied for the purpose of calculating expected emission reductions:	630,000 m ³ (based on design value and average 75% operation of starch mill)
Description of measurement methods and procedures to be applied:	• Monitoring: Volumetric flow meters. • Data type: Records in both hard files (logsheets) and soft files. • Frequency: Continuous measurements • Recording: Cumulative readings are recorded daily. • Archiving policy: The data shall be stored and available up to two years after the end of the crediting period. • Responsibility: The designated employee from the wastewater treatment system division will be responsible for reading the data from meter and then recording will be done in both hard and soft files. The plant manager is responsible for data check and transfer of soft files to carbon consultant. • Calibration frequency: Generally once every three years. • Accuracy: The volumetric flow meters with +/- 1% are installed to monitor the overall flow of treated wastewater. Please note that continuous measurement is made and cumulative readings are recorded daily.
QA/QC procedures to be applied:	Periodic calibrations (Once in three years) for wastewater flow meter are ensured via an external agency. This calibration is usually undertaken to ensure data accuracy. In case the flow meter value is not available for a particular day, the same shall be estimated in a conservative manner.
Any comment:	

Data / Parameter:	$Q_{y, \text{ww, sweetener}}$
Data unit:	m ³
Description:	Volume of wastewater treated in year y from the sweetener plant
Source of data to be used:	Measured – Volumetric flow meters
Value of data applied for the purpose of calculating expected emission reductions:	72,000 m ³ (based on design value and 75% operation performance)
Description of measurement methods and procedures to be applied:	• Monitoring: Volumetric flow meters. • Data type: Records in both hard files (logsheets) and soft files. • Frequency: Continuous measurements • Recording: Cumulative readings are recorded daily. • Archiving policy: The data shall be stored and available up to two years after the end of the crediting period. • Responsibility: The designated employee from the wastewater treatment system division will be responsible for reading the data from meter and then

	recording will be done in both hard and soft files. The plant manager is responsible for data check and transfer of soft files to carbon consultant. • Calibration frequency: Generally once every three years. • Accuracy: The volumetric flow meters with +/- 1% are installed to monitor the overall flow of treated wastewater. Please note that continuous measurement is made and cumulative readings are recorded daily.
QA/QC procedures to be applied:	Periodic calibrations (Once in three years) for wastewater flow meter are ensured via an external agency. This calibration is usually undertaken to ensure data accuracy. In case the flow meter value is not available for a particular day, the same shall be estimated in a conservative manner.
Any comment:	

Data / Parameter:	$Q_{y, ww, Ethanol}$
Data unit:	m^3
Description:	Volume of wastewater treated in year y from the ethanol plant
Source of data to be used:	Measured – Volumetric flow meters
Value of data applied for the purpose of calculating expected emission reductions:	279,000 m ³ (based on technology proposal and)
Description of measurement methods and procedures to be applied:	• Monitoring: Volumetric flow meters. • Data type: Records in both hard files (logsheets) and soft files. • Frequency: Continuous measurements • Recording: Cumulative readings are recorded daily. • Archiving policy: The data shall be stored and available up to two years after the end of the crediting period. • Responsibility: The designated employee from the wastewater treatment system division will be responsible for reading the data from meter and then recording will be done in both hard and soft files. The plant manager is responsible for data check and transfer of soft files to carbon consultant. • Calibration frequency: Generally once every three years. • Accuracy: The volumetric flow meters with +/- 1% are installed to monitor the overall flow of treated wastewater. Please note that continuous measurement is made and cumulative readings are recorded daily.
QA/QC procedures to be applied:	Periodic calibrations (Once in three years) for wastewater flow meter are ensured via an external agency. This calibration is usually undertaken to ensure data accuracy. In case the flow meter value is not available for a particular day, the same shall be estimated in a

	conservative manner.
Any comment:	

Data / Parameter:	COD _{y, ww, untreated, starch}
Data unit:	mg/l
Description:	COD of wastewater from starch plant
Source of data to be used:	Measured – Colorimetric analysis.
Value of data applied for the purpose of calculating expected emission reductions:	17,725 mg/l
Description of measurement methods and procedures to be applied:	• Monitoring: Colorimetric method in the on-site laboratory of the treatment plant. Sample will be taken from the outlet of wastewater from starch plant before entering CL1 • Data type: Records in both hard and soft files. • Frequency: Daily basis • Recording: Daily records. • Archiving policy: The data shall be stored and available up to two years after the end of the crediting period. • Responsibility: The results will be logged by the operator in the plant operation report. The plant manager is responsible for data check and transfer of soft files to carbon consultant. • Calibration frequency: Generally once every three years. • Accuracy: The colorimetric method is well documented and well accepted by national and international standards (e.g. US Environmental Protection Agency – USEPA).
QA/QC procedures to be applied:	In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation. The colorimetric method is well documented and well accepted by both national and international standards (e.g. approve by United States Environmental Protection Agency – USEPA)..
Any comment:	

Data / Parameter:	COD _{y, ww, untreated, sweetener}
Data unit:	mg/l
Description:	COD of wastewater from sweetener plant
Source of data to be used:	Measured – Colorimetric analysis.
Value of data applied for the purpose of calculating expected emission reductions:	12,200 mg/l
Description of measurement methods	• Monitoring: Colorimetric method in the on-site laboratory of the treatment plant. Sample will be taken

and procedures to be applied:	from outlet of the sweetener plant from the sump before entering CL2. • Data type: Records in both hard and soft files. • Frequency: Daily basis • Recording: Daily records. • Archiving policy: The data shall be stored and available up to two years after the end of the crediting period. • Responsibility: The results will be logged by the operator in the plant operation report. The plant manager is responsible for data check and transfer of soft files to carbon consultant. • Calibration frequency: Generally once every three years. • Accuracy: The colorimetric method is well documented and well accepted by national and international standards (e.g. US Environmental Protection Agency – USEPA).
QA/QC procedures to be applied:	In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation. The colorimetric method is well documented and well accepted by both national and international standards (e.g. approve by United States Environmental Protection Agency – USEPA)..
Any comment:	

Data / Parameter:	COD _{y, ww, untreated, Ethanol}
Data unit:	mg/l
Description:	COD of wastewater from Ethanol plant
Source of data to be used:	Measured – Colorimetric analysis.
Value of data applied for the purpose of calculating expected emission reductions:	50,000 mg/l
Description of measurement methods and procedures to be applied:	• Monitoring: Colorimetric method in the on-site laboratory of the treatment plant. Sample will be taken from outlet of the sweetener plant from the sump before entering CL3. • Data type: Records in both hard and soft files. • Frequency: Daily basis • Recording: Daily records. • Archiving policy: The data shall be stored and available up to two years after the end of the crediting period. • Responsibility: The results will be logged by the operator in the plant operation report. The plant manager is responsible for data check and transfer of soft files to carbon consultant. • Calibration frequency: Generally once every three years.

	• Accuracy: The colorimetric method is well documented and well accepted by national and international standards (e.g. US Environmental Protection Agency – USEPA).
QA/QC procedures to be applied:	In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation. The colorimetric method is well documented and well accepted by both national and international standards (e.g. approve by United States Environmental Protection Agency – USEPA).
Any comment:	

Data / Parameter:	COD _{y, ww,treated, CL2}
Data unit:	mg/l
Description:	COD of water exiting the covered lagoon 2 treatment process
Source of data to be used:	Measured – Colorimetric analysis.
Value of data applied for the purpose of calculating expected emission reductions:	1073 mg/l
Description of measurement methods and procedures to be applied:	• Monitoring: Colorimetric method in the on-site laboratory of the treatment plant. Sample will be taken from outlet of CL2 before entering open anaerobic lagoons. • Data type: Records in both hard and soft files. • Frequency: Daily basis • Recording: Daily records. • Archiving policy: The data shall be stored and available up to two years after the end of the crediting period. • Responsibility: The results will be logged by the operator in the plant operation report. The plant manager is responsible for data check and transfer of soft files to carbon consultant. • Calibration frequency: Generally once every three years. • Accuracy: The colorimetric method is well documented and well accepted by national and international standards (e.g. US Environmental Protection Agency – USEPA).
QA/QC procedures to be applied:	In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation. The colorimetric method is well documented and well accepted by both national and international standards (e.g. approve by United States Environmental Protection Agency – USEPA)..
Any comment:	

Data / Parameter:	COD _{y, ww, treated, CL3}
Data unit:	mg/l
Description:	COD of water exiting the covered lagoon 2 treatment process
Source of data to be used:	Measured – Colorimetric analysis.
Value of data applied for the purpose of calculating expected emission reductions:	15000 mg/l
Description of measurement methods and procedures to be applied:	• Monitoring: Colorimetric method in the on-site laboratory of the treatment plant. Sample will be taken from outlet of CL3 before entering open anaerobic lagoons. • Data type: Records in both hard and soft files. • Frequency: Daily basis • Recording: Daily records. • Archiving policy: The data shall be stored and available up to two years after the end of the crediting period. • Responsibility: The results will be logged by the operator in the plant operation report. The plant manager is responsible for data check and transfer of soft files to carbon consultant. • Calibration frequency: Generally once every three years. • Accuracy: The colorimetric method is well documented and well accepted by national and international standards (e.g. US Environmental Protection Agency – USEPA).
QA/QC procedures to be applied:	In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation. The colorimetric method is well documented and well accepted by both national and international standards (e.g. approve by United States Environmental Protection Agency – USEPA).
Any comment:	

Data / Parameter:	W _{CH}
Data unit:	%
Description:	Methane content in biogas
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions:	Not applicable for ex-ante calculation.
Description of measurement methods and procedures to be applied:	• Monitoring: Online methane analyser (to be installed). • Data type: Records in both hard and soft files. • Frequency: Continuous measurements. • Recording: Daily records.

	• Archiving policy: The data shall be stored electronically and available up to two years after the end of the crediting period. • Responsibility: The results will be logged by the operator in the plant operation report. The plant manager is responsible for data check and transfer of soft files to carbon consultant. • Calibration frequency: Generally once every three years (during off-season). Accuracy: Uncertainty of +/- 2% of the reading.
QA/QC procedures to be applied:	Periodic calibrations (generally once in three year) for methane analyzer are ensured via an external agency according to national or international standard. This can be verified by the DOE during the verification process. This calibration is usually undertaken in off-season to ensure data accuracy and sufficiency in operation days.
Any comment:	

Data / Parameter:	BG _{combusted}
Data unit:	Nm ³
Description:	Amount of biogas combusted for gainful use in the year y
Source of data to be used:	Measured – Gas flow meter
Value of data applied for the purpose of calculating expected emission reductions	Not applicable for ex-ante calculation
Description of measurement methods and procedures to be applied:	Measurements of volume of biogas sent to boilers shall be done continuously using gas flow meters. The gas flow meters are installed and values recorded regularly by skilled employees. . In recording this parameter, plant's operators shall first manually archive the monitored data onto log sheets then transfer to the computer for electronic storage. The archive shall be done on a daily basis.
QA/QC procedures to be applied:	The gas flow meter shall be subjected to periodic calibration according to the equipment's specifications and applicable industrial standards.
Any comment:	There are two gas flow meters GM1 and GM2.

Data / Parameter:	EC _y
Data unit:	MWh
Description:	Electricity consumption by waste water treatment system and biogas 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 in section B.5	2,016 MWh
Description of measurement methods and procedures to be	Calculation based on maximum rated consumption is conducted in a conservative manner (as per paragraph 35 in AMS III. H., version 13).

applied:	
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 8,760 hours per year, the QA/QC aspect has already been assured.
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 factory manager as well as the head of the biogas plant. 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 factory manager dealing with data processing and transfer, head of the biogas plant, as well as the biogas staffs working in the day and night shift. Figure 5 outlines the structure of operational and management of the project activity.

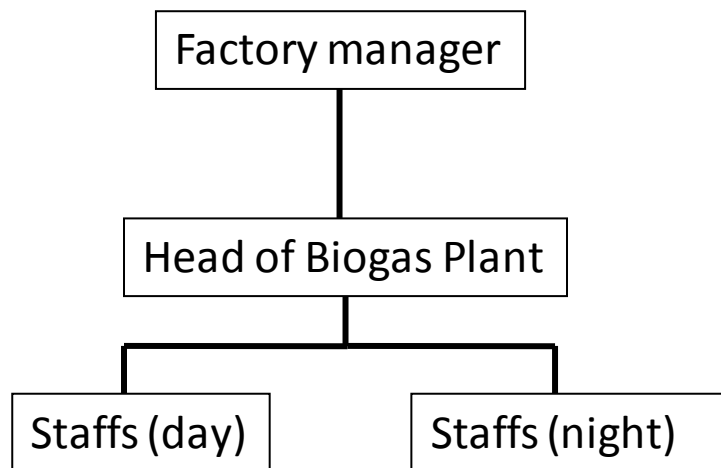


Figure 5: Organisation chart showing the persons involved in the project activity

- 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.

Ex-ante estimations of emission reduction:

Baseline emissions

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

- (i) Emissions on account of electricity or fossil fuel used ($BE_{power,y}$);
- (ii) Methane emissions from baseline wastewater treatment systems ($BE_{ww,treatment,y}$);
- (iii) Methane emissions from baseline sludge treatment systems ($BE_{s,treatment,y}$);
- (iv) 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 ($BE_{ww,discharge,y}$);
- (v) 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).

$$BE_{power,y} = (BE_{elec,y} + BE_{heat,y})$$

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.

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

Equation 3

Where:

Parameter	Details
$Q_{ww,i,y}$	Volume of wastewater treated in baseline wastewater treatment system i in year y (m^3) There are three different flows: $Q_{ww,y,starch}$, $Q_{ww,y,sweetener}$, $Q_{ww,y,ethanol}$
$COD_{removed,i,y}$	Chemical oxygen demand removed by baseline treatment system i in year y ($tonnes/m^3$) measured as the difference between inflow COD and the outflow COD in system i. - For the wastewater coming out of the starch plant: $COD_{removed,i,y,starch} = COD_{ww,untreated,y,starch} * \eta_{BL,starch}$ - For the wastewater coming out of the sweetener plant: $COD_{removed,i,y,sweetener} = COD_{ww,untreated,y,sweetener} * \eta_{BL,sweetener}$ - For the wastewater coming out of the ethanol plant: $COD_{removed,i,y,ethanol} = COD_{ww,untreated,y,ethanol} * \eta_{BL,ethanol}$
$MCF_{ww,treatment,BL,i}$	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; i= lagoons
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC lower value for domestic wastewater of 0.21 kg CH_4 /kg COD) ³⁸
UF_{BL}	Model correction factor to account for model uncertainties (0.94) ³⁹
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 is neglected from baseline emissions.

Although the recovered biogas is used for heat and steam generation in boilers, which were using fuel oil prior the project implementation, for easiness and conservativeness, the project proponents decided not to claim emission reductions from this component.

³⁸ The IPCC default value of 0.25 kg CH_4 /kg COD was corrected to take into account the uncertainties. Project activities may use the default value of 0.6 kg CH_4 /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.

³⁹ Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

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 ($PE_{biomass, y}$).

$$PE_y = \left\{ \begin{array}{l} PE_{power, y} + PE_{ww, treatment, y} + PE_{s, treatment, y} + PE_{ww, discharge, y} + PE_{s, final, y} + \\ PE_{fugitive, y} + PE_{biomass, y} + PE_{flaring, y} \end{array} \right\} \quad \text{Equation 4}$$

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 paragraphs 26 and 19 of AMS III.H. as determined per the procedures described in AMS-I.D. The energy consumption shall include all equipment/devices in the baseline wastewater and sludge treatment facility. The following formula is used:

$$PE_{power, y} = EF_y * EC_y \quad \text{Equation 5}$$

Where:

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

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

$$PE_{Power,y} = \frac{\sum P_{el} * 110\% * 8,760 * EF_y}{1000} \quad \text{Equation 6}$$

Where:

Parameter	Details
P _{el}	Total electrical capacity of the equipments installed in the project activity (kW) – for reference, 43 kW will be used for this project.
EF _y	Thailand National Grid emission factor (tCO _{2e} /MWh)

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

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.

$$PE_{ww,treatment,y} = Q_{ww,y} * COD_{removed,PJ,lagoon,y} * MCF_{ww,treatment,PJ,lagoon} * B_{o,ww} * UF_{PJ} * GWP_{CH4} \quad \text{Equation 7}$$

Where:

Parameter	Details
Q _{ww,k,y}	Volume of wastewater treated in project wastewater treatment system k in year y (m ³)
COD _{removed, PJ, lagoon,y}	Chemical oxygen demand removed by project secondary wastewater treatment system in year y (tonnes/m ³), calculated as the COD in the effluent of the covered lagoon 2 (CL2) times the efficiency of the baseline system.
B _{o,ww}	Methane producing capacity of the wastewater (IPCC default value of 0.21 kg CH ₄ /kg COD)
MCF _{ww, treatment, PJ, lagoon}	Methane correction factor for project wastewater treatment system without biogas recovery
UF _{PJ}	Model correction factor to account for model uncertainties (1.06)
GWP _{CH4}	Global Warming Potential for methane (value of 21 is used)
k	Wastewater treatment systems affected by the project activity, and not equipped with biogas recovery; k= lagoon

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

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 from the starch and sweetener plants will be discharge in existing open lagoons and there will be no discharge to river, sea or lake.

The wastewater coming from the ethanol plant will be treated in the covered lagoon 3 and then discharged into another serie of open lagoons. For conservativeness, we assume that all the COD will be degraded in these lagoons and that the MCF is equal to 0.8.

Therefore these project emissions are calculated as:

$$PE_{ww, discharge, y} = Q_{ww, y} * GWP_{CH_4} * B_{o, ww} * UF_{PJ} * COD_{ww, discharge, PJ, y} * MCF_{ww, PJ, discharge}$$

Equation 8

Where:

Parameter	Details
$Q_{ww, y}$	Volume of wastewater treated in project wastewater treatment system k in year y (m^3). This is the flow coming out of the ethanol plant going into the CL3.
$COD_{ww, discharge, PJ, y}$	Chemical oxygen demand of the treated wastewater discharged in the project situation (tonnes/ m^3). This is the outlet of the covered lagoon 3 (CL3).
$B_{o, ww}$	Methane producing capacity of the wastewater (IPCC default value of 0.21 kg CH_4 /kg COD)
$MCF_{ww, PJ, discharge}$	Methane correction factor based on discharge pathway in the project situation (0.8).
UF_{PJ}	Model correction factor to account for model uncertainties (1.06)
GWP_{CH_4}	Global Warming Potential for methane (value of 21 is used)

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 used as soil application onsite. 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 9

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

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

Where:

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

Note that:

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

Where:

Parameter	Details
$COD_{removed,PJ,k,y}$	The chemical oxygen demand removed ⁴⁰ by the treatment system k of the project activity equipped with biogas recovery in the year y (tonnes/m ³) calculated as : For k= CL1: $COD_{removed,PJ,CL1,y} = COD_{ww,untreated,y,starch} - COD_{out,PJ,CL1,y}$ For k= UASB: $COD_{removed,PJ,UASB,y} = COD_{out,PJ,CL1,y} - COD_{out,PJ,UASB,y}$ For k= CL2: $COD_{removed,PJ,CL2,y} = COD_{int,PJ,CL2,y} - COD_{out,PJ,CL2,y}$ For k= CL3: $COD_{removed,PJ,CL3,y} = COD_{ww,untreated,y,ethanol} - COD_{out,PJ,CL3,y}$
$MCF_{ww,treatment,PJ,UASB}$	Methane correction factor for the project wastewater treatment system equipped with biogas recovery equipment (UASB) (MCF values as per table III.H.1)
UF_{PJ}	Model correction factor to account for model uncertainties (1.06)
k	Anaerobic wastewater treatment system equipped with biogas recovery. k= CL1, UASB, CL2, CL3

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

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

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

No biogas will be flared, since the capacity of the 6 steam boilers and of the hot oil boiler is higher than the maximum generation capacity of the wastewater treatment plant.

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

⁴⁰ Difference of inflow COD and the outflow COD

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.

Emission Reduction (ER_y):

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

$$ER_{y,ex-ante} = BE_{y,ex-ante} - (PE_{y,ex-ante} + LE_{y,ex-ante}) \quad \text{Equation 12}$$

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)

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;

$$ER_{y,ex post} = \min((BE_{y,ex post} - PE_{y,ex post} - LE_{y,ex post}), (MD_y - PE_{power,y} - PE_{biomass,y} - LE_{y,ex post})) \quad \text{Equation 13}$$

Where:

Parameter	Details
$ER_{y,ex post}$	Emission reductions achieved by the project activity based on monitored values for year y (tCO ₂ e)
$BE_{y,ex post}$	Baseline emissions calculated as per paragraph ex-post monitored values
$PE_{y,ex post}$	Project emissions calculated as per paragraph ex-post 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:

$$MD_y = BG_{burnt,y} * w_{CH4,y} * D_{CH4} * FE * GWP_{CH4} \quad \text{Equation 14}$$

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”⁴¹.

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
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:

- Emissions from wastewater treatment systems affected by the project activity in year “y” (BE_{ww, treatment, y})

⁴¹ <http://cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKEUHEF5LB07QICT1P>

Baseline emissions starch factory

BE _{ww, treatment, y}

Operation capacity of starch plant	75%	
Waste water generation per day	2800	m ³
No. of Operation Days	300	days
Wastewater vloume	630000	m3/year
Efficiency of Lagoon system (starch and sweetener plants)	98.61%	
COD _{in}	17725	mg/l
COD _{out}	247	mg/l
COD _{removed}	0.0175	ton/m3
MCF _{ww, treatment, BL,lagoon}	0.8	
BE _{ww,treatment,starch,y}	36,516	tCO2e

Baseline emission sweetener

BE _{ww, treatment, y}

Operation capacity of starch plant	75%	
Waste water generation per day	320	m ³
No. of Operation Days	300	days
Wastewater vloume	72000	m3/year
Efficiency of Lagoon system (starch and sweetener plants)	98.61%	
COD _{in}	12200	mg/l
COD _{out}	170	mg/l
COD _{removed}	0.012	ton/m3
MCF _{ww, treatment, BL,lagoon}	0.8	
BE _{ww,treatment,sweetner,y}	2,872	tCO2e

Baseline emission ethanol plant

BE _{ww, treatment, y}

Operation capacity of ethanol plant	75%	
Waste water generation per day	1240	m ³
No. of Operation Days	300	days
Wastewater vloume	279000	m3/year
Efficiency of Lagoon system (ethanol plant)	87.76%	
COD _{in}	50000	mg/l
COD _{out}	6121	mg/l
COD _{removed}	0.0439	ton/m3
MCF _{ww, treatment, BL,lagoon}	0.8	
BE _{ww,treatment,ethanol,y}	40,599	tCO2e

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

- Emissions from electricity consumption in the year “y” ($PE_{power,y}$)

PE_{power, y}

Rated Power P_{el}	209.2	kW
yearly power consumption EC_y	2016	MWh
grid emission EF_y	0.5057	tCO ₂ /MWh
PE_{y, power}	1019	tCO₂e

- **Emissions in treated wastewater in year “y” ($PE_{ww, treatment, y}$)**

PE_{ww, treatment, y, lagoons}

COD _{in, lagoon, PJ}	1073	mg/l
COD _{out, lagoon, PJ}	0	mg/l
COD _{removed, lagoon, PJ}	0.0011	ton/m ³
Annual wastewater generation	702000	m ³
MCF _{ww, treatment, PJ, lagoon}	0.8	
PE_{y, ww, treatment}	2817	t CO₂

- **Emission from inefficiency of the project activity without biogas recovery in year “y” ($PE_{ww, discharge, y}$)**

PE_{ww, discharge, CL3}

COD _{in, lagoon, PJ}	15000	mg/l
COD _{out, lagoon, PJ}	0	mg/l
COD _{removed, lagoon, PJ}	0.0150	ton/m ³
Annual wastewater generation	279000	m ³
MCF _{ww, treatment, PJ, lagoon}	0.8	
PE_{y, ww, treatment}	15651	t CO₂

- Emissions from methane emission on account of inefficiencies in *Capture systems* in the year “y” ($PE_{fugitive,y}$)

$PE_{fugitive,ww,CL1,y}$

Annual wastewater generation $Q_{ww,y}$	630000	m3/year
Efficiency CL 1	70%	
COD_{in}	17725	mg/l
COD_{out}	5317	mg/l
$COD_{removed}$	0.0124	ton/m3
$MCF_{ww, treatment, PJ,CL1}$	0.8	
$PE_{fugitive,ww,CL1,y}$	2923	t CO2

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

Annual wastewater generation $Q_{ww,y}$	630000	m3/year
Efficiency UASB	70%	
COD_{in}	5317	mg/l
COD_{out}	1595	mg/l
$COD_{removed}$	0.0037	ton/m3
$MCF_{ww, treatment, PJ,UASB}$	0.8	
$PE_{fugitive,ww,UASB,y}$	877	t CO2

$PE_{fugitive,ww,CL2,y}$

Annual wastewater generation $Q_{ww,y}$	702,000	m3/year
Efficiency CL2	60%	
COD_{in}	2683	mg/l
COD_{out}	1073	mg/l
$COD_{removed}$	0.0016	ton/m3
$MCF_{ww, treatment, PJ,UASB}$	0.8	
$PE_{fugitive,ww,CL2,y}$	423	t CO2

$PE_{fugitive,ww,CL3,y}$

Annual wastewater generation $Q_{ww,y}$	279,000	m3/year
Efficiency CL3	70%	
COD_{in}	50000	mg/l
COD_{out}	15000	mg/l
$COD_{removed}$	0.0350	ton/m3
$MCF_{ww, treatment, PJ,CL3}$	0.8	
$PE_{fugitive,ww,CL3,y}$	3652	t CO2

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

A complete Excel data sheet summarizing all ER calculations has been provided to the DOE. The results are summarized below:

Years	2009 (1st Dec - 31st Dec)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019 (1st jan - 30th Nov)
Baseline emission	6,666	79,986	79,986	79,986	79,986	79,986	79,986	79,986	79,986	79,986	73,321
Baseline emission from electricity		-	-	-	-	-	-	-	-	-	-
Baseline emission of wastewater treatment	6,666	79,986	79,986	79,986	79,986	79,986	79,986	79,986	79,986	79,986	73,321
Baseline emission of sludge treatment		-	-	-	-	-	-	-	-	-	-
Baseline emission from degradable organic carbon in treated wastewater discharged		-	-	-	-	-	-	-	-	-	-
Baseline methane emission from anaerobic decay of the final sludge		-	-	-	-	-	-	-	-	-	-
Years	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Project emission	3,584	43,012	43,012	43,012	43,012	43,012	43,012	43,012	43,012	43,012	39,428
CO ₂ emission from electricity consumption $PE_{power,y}$	85	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	934
Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery	1,539	18,468	18,468	18,468	18,468	18,468	18,468	18,468	18,468	18,468	16,929
Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery	-	-	-	-	-	-	-	-	-	-	-
Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in	1,304	15,651	15,651	15,651	15,651	15,651	15,651	15,651	15,651	15,651	14,346
Methane emissions from anaerobic decay of the final sludge $PE_{s,final,y}$	-	-	-	-	-	-	-	-	-	-	-
Methane fugitive emissions on account of inefficiencies in capture system $PE_{fugitive,y}$	656	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,218
project emissions due to incomplete flaring											-
Methane emissions due to incomplete flaring			-	-	-	-	-	-	-	-	-
Emission reduction	3,081	36,973	36,973	36,973	36,973	36,973	36,973	36,973	36,973	36,973	33,892

5 Environmental Impact:

The project, being a renewable energy biogas based thermal project, does not fall under the purview of the Environmental Impact Assessment (EIA) notification of the Ministry of Natural Resources and Environment (MONRE). The Government of Thailand with the approval of National Environment Board (NEB) has the power to specify notification for the type and size of projects or activities requiring EIA, which is currently regulated by Section 46 of the Enhancement and Conservation of Nation from the National Environmental Quality Act 1992. However, the expected environmental impact of the project activity was considered as a part of the feasibility study. According to the results of the feasibility study it is expected that the project activity will improve both water and air quality.

By adopting the anaerobic wastewater treatment system, which uses more advanced technology than the existing system, it is expected that the project activity will improve water quality. No wastewater is discharged to the river, and treated wastewater can and will be used for irrigation or in other processes. At the same time, the anaerobic wastewater treatment system will be equipped with a biogas collection/utilization system. By collecting and utilizing biogas, to which odour emissions in the vicinity of the project site are directly attributable, the project activity will clearly improve local air quality.

There will be no additional sludge generation by the Project activity. Sludge generated during the wastewater treatment process will be treated by land application.

In conclusion, the Project will result in a higher quality of wastewater treatment and a high standard of technology for pollution control (i.e. noise pollution, odour nuisance and air pollution) during the project construction and commissioning.

6 Stakeholders' comments:

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

Invitation procedure

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

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

Place and date of the meetings

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

Meeting Participants on December 9, 2008

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

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

20 participants have followed the invitation and attended the meeting.

Language

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

Meeting procedures

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

Meeting documents and protocols

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

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

Compilation of comments received:

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

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

Short description:

The proposed project is implemented at P.S.C. Starch Products PLC.; a starch plant with a total production capacity of 200 t of native starch per day, 400 m³ per day of sweetener products and expected ethanol of 1600 m³ per day, generating an average of 350,000 m³, 240,000 m³ and 380000 m³ per year respectively.

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

A diagram summarising the technology installed is provided below:

Environmental impacts:

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

Contribution to sustainable development:

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

7 Schedule:

Date	Event	Comment
24 th June 2002	Operation start of the starch plant	Operation permit
January 2003	Construction start of UASB wastewater treatment system	Contract with technology provider, BAU
25 th April 2005	Feeding wastewater into UASB	Commissioning report from contractor
28 th April 2005	Date of initiating the project. First date biogas is sent to boiler is considered as project start date,	Commissioning report from contractor
12 th June 2006	First covered lagoon for starch factory becomes operational	Commissioning report from contractor
1 st March 2007	Second covered lagoon for sweetener becomes operational	Commissioning Report from contractor
October 2009	Operation start of the ethanol plant	Commissioning Report
January 2010	Third covered lagoon in operation	Expected ⁴²
28 th April 2020	Date of terminating the project	Estimate based on operational lifetime 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 project has an expected operational lifetime of 15 years.

The crediting period of the project is of 10 years (December 1st 2009 to November 30th 2019).

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:

⁴² The operation start date of the third cover lagoon was delayed compared with the initial schedule.

8.1 Proof of Title:

Documents assessing the ownership of the wastewater treatment plant from P.S.C. Starch PCL will be provided to the DOE during the validation.

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

CL	Covered lagoon
DNA	Designated National Authorities
DOE	Designated Operational Entities
EPPO	Energy Policy and Planning Office
EIA	Environmental Impact Assessment
GLS	Gas-liquid-solid
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
MONRE	Ministry of Natural Resources and Environment
NEB	National Environmental Board
UASB	Upflow Anaerobic Sludge Blanket
VER	Voluntary Emission Reduction
VFA	Volatite Fatty Acid
VCS	Voluntary Carbon Standard