

SD BIOSUPPLY WASTEWATER TREATMENT AND BIOGAS UTILIZATION PROJECT

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PROJECT DETAILS

1.1 Summary Description of the Project

The proposed project has been implemented at Somdej Flour Mill Co. Ltd since 18th August 2005. The starch plant has a total production capacity of 300 tonnes of native starch per day. The project activity entails the installation of an anaerobic wastewater treatment facility, based on Upflow Anaerobic Sludge Blanket (UASB) biogas reactor technology at the existing starch plant, replacing the open anaerobic lagoon based system. The UASB system generates and recovers biogas for energy generation purposes, avoiding methane emissions to the atmosphere. The methane captured by biogas system is consumed partially in the hot oil boilers for thermal utilization in starch drying process. This activity leads reduction of CO₂ emission by replacing fossil fuel consumption in the starch manufacturing process. Any surplus of biogas consumption is flared in the open flare system. The project activity is located in Karasin province, northeast of Thailand.

Prior to implementation of the project activity, the wastewater of the starch plant the plant was treated in 8 cascading open anaerobic lagoons, with a retention time of more than a year. The minimum depth of these ponds is more than 2.0 m from the water surface. The average atmospheric temperature in the region is 28 degree Celsius. These conditions result in anaerobic environment within the ponds, resulting in methane generation from the organic content of the wastewater. Meanwhile, the energy supplied in the starch drying process was produced by heavy fuel oil (HFO) consuming in two hot oil boilers of starch factory. The consumption of HFO as fossil fuel is considered as a baseline thermal component of the project.

The project was registered as a VCS project since 06/05/2010. The first crediting period was considered from 28/03/2006 to 27/03/2016. This project is being re-validated under requirements of the Voluntary Carbon Standard, Version 3. This project document is developed for the purpose of renewable of a second crediting period. In this proposed second period, an estimate of annual average GHG emission reductions is 51,316 tCO₂/year. The total GHG emission reduction during this crediting period is 513,156 tCO₂ in 10 years. This is a second crediting period of the project.

1.2 Sectoral Scope and Project Type

The sectoral scope and type of the project is according to CDM project standard for project activities, version 01 as follows:

Methane destruction component:

Category III.H: Methane Recovery in Wastewater Treatment

Type of GHG emissions mitigation action: Destruction of methane emission

Sectoral Scope: 13 Waste Handling and Disposal

Thermal energy production component:

Category I.C: Thermal energy production with or without electricity

Type of GHG emissions mitigation action: Displacement of more-GHG-intensive thermal energy production

Sectoral Scope: 1 Energy Industries

The project is not a grouped project and not an AFOLU project.

1.3 Project Proponent

Organization name	SD Biosupply Co., Ltd (Project owner: Responsible for implementation and operation of the project activity)
Contact person	Mr. Sivaroj Suralertrungsri
Title	Managing Director
Address	113 Soi Chokchaijonjamrern, Rama III Road, Bangpongpan, Yannawa, Bangkok 10120, Thailand
Telephone	+66 2 683 1900-7
Email	-

1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon Asset Management Ltd. (Project developer: Responsible for development of emission reduction through the Voluntary Carbon Standard)
Contact person	Mr. Marco Hirsbrunner
Title	Managing director
Address	Technoparkstrasse 1, Zurich 8005 Switzerland
Telephone	+41 43 501 35 50
Email	registration@southpolecarbon.com

1.5 Project Start Date

The project start date was defined on 16/09/2005 based on the date when emission reductions began. As per VCS standard, the start date of crediting period is defined as 28/03/2006.

1.6 Project Crediting Period

The project activity has been operated since 2005.

The first crediting period of ten years was from 28/03/2006 - 27/03/2016. This PD is being developed for the second crediting period which will be starting from 28/03/2016. After the proposed second 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.

Crediting period start date: 28/03/2016

Crediting period end date: 27/03/2027

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	x
Large project	

Year	Estimated GHG emission reductions or removals (tCO ₂ e)
2016	21,381
2017	51,316
2018	51,316
2019	51,316
2020	51,316
2021	51,316
2022	51,316
2023	51,316
2024	51,316
2025	51,316
2026	29,934
Total estimated ERs	513,156
Total number of crediting years	10
Average annual ERs	51,316

1.8 Description of the Project Activity

The project activity is implemented closed to the starch factory in order to treat the wastewater generated by starch production process. The starch plant has an installed capacity of 300 tonnes of native starch per day, generating wastewater up to 3,000 m³ per day¹. The propose project activity involves the installation of UASB digesters for recovering biogas and utilised them as a fuel for thermal generation in the starch factory. In the absence of project, the wastewater from starch factory would have been continued treating in the existing anaerobic open lagoons nearby the biogas system. The determination of baseline scenario is explained in the section 2.4.

Technical description of project

The UASB system is a methanogenic digester, which uses an anaerobic process whilst forming a blanket of granular sludge, which is suspended in the tank. The wastewater is entered to the UASB digesters at the base of the system and is supplied through the blanket where it is degraded by anaerobic microorganisms contained in the sludge. With an average inlet COD of 22,972 mg/l and a COD removal efficiency of around 90%, the production of biogas is expected at 18,000 m³ per day (with the methane percentage being around 65%). The treated wastewater is supplied to the existing anaerobic lagoons and reused it in the starch factory.

The biogas is produced as a by-product of the wastewater treatment in the UASB digester and captured in the biogas storage. In addition, the biogas is utilised for thermal generation in the starch factory. Two thermal oil boilers with capacity of 7.27 MW_{th} consume biogas for heat generation for starch drying process. In the case of emergencies or surplus, biogas is flared by opened flaring system.

1.9 Project Location

The project site is located on the site of the SD Starch factory, located at address: 99 Moo 10, Somdej-Khuchinarai Road, Kambong sub-district, Huai Phueng district, Kalasin, approx. 580 km from Bangkok. The project coordinates are 16° 40'40.20"N and 103° 48' 19.67"E as shown in Figure 2.

¹ This is based on the design value of biogas recovery system.

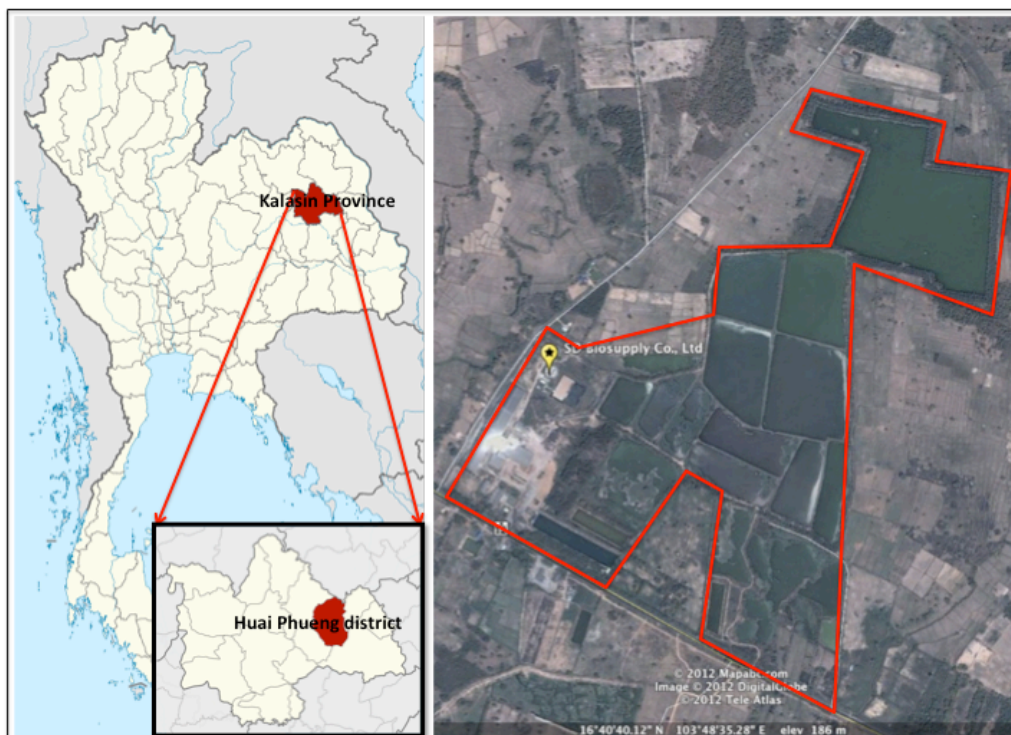


Figure 1: Project location and boundaries

1.10 Conditions Prior to Project Initiation

The baseline scenario is the same as the condition of existing prior to the project initiation. Please refer to section 2.4 baseline scenario for more details.

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

The proposed project activity is in compliance with all local laws and regulations from the local government section and the Ministry of Industry², Thailand as follows.

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

Moreover, the project activity needs to get acceptance from the local stakeholders since any negative comments from stakeholders can affect the operation permit approval from the

² Notification of Ministry of Industry, Industrial Effluent Standards, B.E. 2560. The maximum permissible COD content of wastewater discharge is 120 mg/L.

Department of Industrial Works (DIW). A valid operational permit shall ensure that all the regulations prescribed by local and national authorities are met and complied to.

1.12 Ownership and Other Programs

1.12.1 Project Ownership

The project activity is own by SD Biosupply Co., Ltd. The project participant has the evidence of the ownership from the respective start date of project activity. The evidence of the right of use is referred to the operation license of the company.

1.12.2 Emissions Trading Programs and Other Binding Limits

The section is not applicable. The project is not applied with other mechanism or programs.

1.12.3 Other Forms of Environmental Credit

The project does not seek for any other GHG programs.

1.12.4 Participation under Other GHG Programs

The project is not registered, or is seeking registration under any other GHG programs.

1.12.5 Projects Rejected by Other GHG Programs

The project is not rejected by any other GHG programs.

1.13 Additional Information Relevant to the Project

Eligibility Criteria

The project activity is not a grouped project. This section is not applicable.

Leakage Management

This is not applicable.

Commercially Sensitive Information

None of information is excluded.

Sustainable Development

The proposed project activity has been assessed in line with the sustainable development per as

1. National Resource and Environmental Dimension

- The project activity reduces GHG emission through the avoidance of methane emission from the existing open lagoon.

- The project activity captures biogas from the anaerobic wastewater treatment of starch factory. The biogas recovered is used for energy generation purpose; thereby the bad odor is reduced. The ambient air quality is improved accordingly.
- The project activity reduces GHG emission, other air pollutant emissions such as oxides of nitrogen, oxides of sulphur, carbon monoxide and particulates through reducing the combustion of fossil fuels.
- The project activity reduces the carbon intensity of the Thai national grid by reducing the emission of GHGs.
- The treated wastewater is recycled for internal consumption in the starch factory.

2. Social Dimension

The training program is provided to local employees of the project annually in order to enhance work skills.

3. Development/ Transfer of Technology

The project involves the use of some imported components and hence the transfer of technology from outside the country which provides an opportunity to promote and disseminate the successful application and integration of technologies for replication across Thailand.

4. Economic Dimension

- The project activity leads to the utilization of renewable energy and contributes thereby to energy security and savings in expenditure on imported fuel.
- The project activity increases the employment opportunities for the local people by setting up an industrial unit in the area.
- The project activity contributed to the employment of local people both in the skilled and semi-skilled category during the construction phase.

Further Information

This is not applicable.

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

Baseline & Monitoring Methodology for the project activity is defined:

- AMS III.H: Methane Recovery in Wastewater Treatment, version 18
- AMS I.C: Thermal energy for user with or without electricity, version 20

Tool referenced in the applied methodologies:

- Tool to calculate project or leakage CO₂ emissions from fossil combustion
- Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation
- Project emission from flaring

2.2 Applicability of Methodology

AMS III.H and I.C are applicable to the project activity that aims to implement recovery of biogas resulting from anaerobic decay of organic matter in wastewaters and displacement of more-GHG intensive thermal energy production, respectively. The biogas captured is utilised for thermal generation. The justifications of project eligibility are conducted through methane destruction component for AMS III H and thermal energy production component for AMS I.C. The project activity fulfils the applicability criteria of methodologies as shown in Tables below.

Methane destruction component: (AMS III.H)

In absence of project activity, the wastewater from the starch production would have been treated in existing open lagoons. The project activity also involves the installation of biogas recovery system called UASB system in the wastewater treatment system. Therefore the project complies with the methodology scope option (f):

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

The below table provides a justification of the project activity on application criteria of AMS.III.H.

Table 1: Applicability criteria for AMS III-H

Applicability criteria		Justification
3.	In cases where baseline system is anaerobic lagoon the methodology is applicable if: (a) The lagoons are ponds with a depth greater than two meters, without aeration. The value for depth is obtained from engineering design documents, or through direct measurement, or by dividing the surface area by the total volume. If the lagoon filling level varies seasonally, the average of the highest and lowest levels may be	In the absence of project activity, the wastewater was treated in the anaerobic open lagoon system. There are eight existing lagoons without aeration system. The average depth of lagoon is 3.06 m. The ambient temperature at the project site in Kalasin province is higher than 15°C on a monthly average basis. Also, no sludge has been removed from the baseline anaerobic lagoons since the date of starch factory operation. Therefore, the project activity is applicable under this

Table 1: Applicability criteria for AMS III-H

Applicability criteria		Justification
	taken; (b) Ambient temperature above 15°C, at least during part of the year, on a monthly average basis; (c) The minimum interval between two consecutive sludge removal events shall be 30 days.	criteria.
4	The recovered biogas from the above measures may also be utilised for the following applications instead of combustion/flaring: (a) Thermal or mechanical,³ electrical energy generation directly; (b) Thermal or mechanical, electrical energy generation after bottling of upgraded biogas, in this case additional guidance provided in the appendix shall be followed; or (c) Thermal or mechanical, electrical energy generation after upgrading and distribution, in this case additional guidance provided in the appendix shall be followed: (i) Upgrading and injection of biogas into a natural gas distribution grid with no significant transmission constraints; (ii) Upgrading and transportation of biogas via a dedicated piped network to a group of end users; or (iii) Upgrading and transportation of biogas (e.g. by trucks) to distribution points for end users; (d) Hydrogen production; (e) Use as fuel in transportation applications after upgrading.	The project activity satisfies the condition (a). The recovered biogas from the project activity will be utilised for thermal generation. The thermal energy will be generated using biogas in the thermal oil boilers. The thermal energy will be utilised in the starch drying process in the starch factory.
5	If the recovered biogas is used for project activities covered under paragraph 4(a), that component of the project activity can use a corresponding methodology under Type I.	The recovered biogas will be used as per the paragraph 3(a) above. The methodologies AMS I.C will be used for the thermal component.
6	For project activities covered under paragraph 4(b), if bottles with upgraded biogas are sold outside the project boundary, the end-use of the biogas shall be ensured via a contract between the bottled biogas vendor and the end-user. No emission reductions may be claimed from the displacement of fuels from the end use of bottled biogas in such situations. If, however, the end use of the bottled biogas is included	The project activity satisfies paragraph 3 (a) as mentioned above. The biogas generated is not bottled but will be utilised as fuel in thermal oil boiler for thermal energy generation. Therefore, this condition is not relevant to the project activity.

³ For example combusted in a prime mover such as an engine coupled to a machine such as grinding machine.

Table 1: Applicability criteria for AMS III-H

Applicability criteria		Justification
	in the project boundary and is monitored during the crediting period CO ₂ emissions avoided by the displacement of fossil fuel can be claimed under the corresponding Type I methodology, e.g. “AMS-I.C.: Thermal energy production with or without electricity”.	
7	For project activities covered under paragraph 4(c)(i), emission reductions from the displacement of the use of natural gas are eligible under this methodology, provided the geographical extent of the natural gas distribution grid is within the host country boundaries.	The project activity satisfies paragraph 3 (a) as mentioned above. The biogas generated is not bottled but will be utilised as fuel in thermal oil boiler for thermal energy generation. Therefore, this condition is not relevant to the project activity.
8	For project activities covered under paragraph 4(c)(ii), emission reductions for the displacement of the use of fuels can be claimed following the provision in the corresponding Type I methodology, e.g. AMS-I.C.	The project activity satisfies paragraph 3 (a) as mentioned above. Therefore, this condition is not relevant to the project activity.
9	In particular, for the case of paragraph 4(b) and (c)(iii), the physical leakage during storage and transportation of upgraded biogas, as well as the emissions from fossil fuel consumed by vehicles for transporting biogas shall be considered. Relevant procedures in paragraph 18 of the appendix of “AMS-III.H.: Methane recovery in wastewater treatment” shall be followed in this regard.	The project activity satisfies paragraph 3 (a) as mentioned above. Therefore, this condition is not relevant to the project activity.
10	For project activities covered under paragraph 4(b) and (c), this methodology is applicable if the upgraded methane content of the biogas is in accordance with relevant national regulations (where these exist) or, in the absence of national regulations, a minimum of 96 per cent (by volume).	The project activity satisfies paragraph 3 (a) as mentioned above. Therefore, this condition is not relevant to the project activity.
11	If the recovered is utilized for the production of hydrogen (project activities covered under paragraph 3(d)), that component of the project activity shall use the corresponding methodology “AMS-III.O.: Hydrogen production using methane extracted from biogas”.	The project activity satisfies paragraph 3 (a) as mentioned above. Therefore, this condition is not relevant to the project activity.
12	If the recovered biogas is used for project activities covered under paragraph 4(e), that component of the project activity shall use corresponding methodology “AMS-III.AQ.: Introduction of Bio-CNG in transportation applications”.	The project activity satisfies paragraph 3 (a) as mentioned above. Therefore, this condition is not relevant to the project activity.
13	New facilities (Greenfield projects) and project activities involving a change of equipment resulting in a capacity addition of	Given the fact that the starch factory itself was constructed and started operation in parallel to the development of the project

Table 1: Applicability criteria for AMS III-H

Applicability criteria		Justification
	the wastewater or sludge treatment system compared to the designed capacity of the baseline treatment system are only eligible to apply this methodology if they comply with the relevant requirements in the “General guidelines for SSC CDM methodologies”. In addition the requirements for demonstrating the remaining lifetime of the equipment replaced, as described in the general guidelines shall be followed.	activity, the project activity is considered a Greenfield project. The “General guidelines to SSC CDM methodologies” is complied and the details are given in section B.4.
14	The location of the wastewater treatment plant as well as the source generating the wastewater shall be uniquely defined and described in the PDD.	The location of the wastewater treatment plant has been clearly given in section 1.8. The starch factory located at the same location is the source of wastewater generation.
15	Measures are limited to those that result in aggregate emissions reductions of less than or equal to 60 kt CO ₂ equivalent annually from all Type III components of the project activity.	The emission reductions to be achieved by the project activity from methane avoidance component (type III) are estimated at 51,316 tCO ₂ per year, which is lower than 60 ktCO ₂ e per year.

Thermal energy production component: (AMS.I.C)

The biogas generated in the project activity will be utilised for thermal generation in the starch factory. The biogas fuel as renewable energy will be replaced fossil fuel consumption like HFO in the thermal oil boilers of the starch factory. Therefore the project complies with the scope of AMS.I.C that *“the methodology comprises renewable energy technologies supply users i.e. residential, industrial or commercial facilities with thermal energy that displaces fossil fuel use. These units include technologies such as solar thermal water heaters and dryers, solar cookers, energy derived from renewable biomass and other technologies that provide thermal energy that displaces fossil fuel.”*

Table 2: Applicability criteria for AMS I-C

Applicability criteria		Justification
3	Biomass-based cogeneration and trigeneration systems are included in this category.	The project involved with recovering of biogas from wastewater treatment system in order to utilised it for thermal generation. This condition is not relevant to the project activity.
4	Emission reductions from a biomass cogeneration or trigeneration system can accrue from one of the following activities: (a) Electricity supply to a grid; (b) Electricity and/or thermal energy production for on-site consumption or for consumption by other facilities; (c) Combination of (a) and (b).	As mentioned above, this condition is not relevant to the project activity.
5	Project activities that seek to retrofit or modify	The project will utilise the captured

Table 2: Applicability criteria for AMS I-C

Applicability criteria		Justification
	an existing facility for renewable energy generation are included in this category.	biogas in two hot oil boilers of the starch factory. The hot oil boilers have existed facility prior implementing project activity. This is applicable to project activity.
6	In the case of new facilities (Greenfield projects) and project activities involving capacity additions the relevant requirements related to determination of baseline scenario provided in the "General guidelines for SSC CDM methodologies" for Type-II and Type-III Greenfield/capacity expansion project activities also apply.	The project is not a greenfield project. In the absence of the project, the hot oil boiler system of starch factory consumed heavy fuel oil (HFO) for generating heat that supplied to the starch drying process. In the project, the biogas will be replaced the fossil fuel in the existing facilities of starch factory.
7	The total installed/rated thermal energy generation capacity of the project equipment is equal to or less than 45 MW thermal ⁴ (see paragraph 9 for the applicable limits for cogeneration and trigeneration project activities).	The thermal generation capacity of the thermal oil boiler is 7.268 MW _{th} which is less than 45 MW thermal as per the applicability criteria.
8	For co-fired systems, the total installed thermal energy generation capacity of the project equipment, when using both fossil and renewable fuel, shall not exceed 45 MW thermal (see paragraph 9 for the applicable limits for cogeneration project activities).	Thermal oil boiler is a dual fuel fired boiler. The total installed thermal energy generation capacity is 7.268 MW _{th} which is less than 45MW thermal.
9	The following capacity limits apply for biomass cogeneration and trigeneration units: (a) If the emission reductions of the project activity are on account of thermal and electrical energy production, the total installed thermal and electrical energy generation capacity of the project equipment shall not exceed 45 MW thermal. For the purpose of calculating the capacity limit the conversion factor of 1:3 shall be used for converting electrical energy to thermal energy (i.e. for renewable energy project activities, the installed capacity of 15 MW(e) is equivalent to 45 MW thermal output of the equipment or the plant); (b) If the emission reductions of the project activity are solely on account of thermal energy production (i.e. no emission reductions accrue from the electricity component), the total installed thermal energy production capacity of the project equipment shall not exceed 45 MW thermal; (c) If the emission reductions of the project	As mentioned in justification of applicability para 3, this condition is not relevant to the project.

⁴ Thermal energy generation capacity shall be manufacturer's rated thermal energy output, or if that rating is not available the capacity shall be determined by taking the difference between enthalpy of total output (for example steam or hot air or chilled water in kcal/kg or kcal/m³) leaving the project equipment and the total enthalpy of input (for example feed water or air in kcal/kg or kcal/m³) entering the project equipment. For boilers, condensate return (if any) must be incorporated into enthalpy of the feed.

Table 2: Applicability criteria for AMS I-C

Applicability criteria		Justification
	activity are solely on account of electrical energy production (i.e. no emission reductions accrue from the thermal energy component), the total installed electrical energy generation capacity of the project equipment shall not exceed 15 MW.	
10	The capacity limits specified in paragraphs 7 to 9 above apply to both new facilities and retrofit projects. In the case of project activities that involve the addition of renewable energy units at an existing renewable energy facility, the total capacity of the units added by the project shall comply with capacity limits specified in the paragraphs 7 to 9, and shall be physically distinct ⁵ from the existing units.	The project does not involve with any addition of renewable energy units at an existing renewable energy facility.
11	If solid biomass fuel (e.g. briquette) is used, it shall be demonstrated that it has been produced using solely renewable biomass and all project or leakage emissions associated with its production shall be taken into account in the emissions reduction calculation.	The project does not use solid biomass. This is not relevant to project activity.
12	Where the project participant is not the producer of the processed solid biomass fuel, the project participant and the producer are bound by a contract that shall enable the project participant to monitor the source of the renewable biomass to account for any emissions associated with solid biomass fuel production. Such a contract shall also ensure that there is no double-counting of emission reductions.	The project does not use solid biomass. This is not relevant to project activity.
13	If electricity and/or thermal energy produced by the project activity is delivered to a third party i.e. another facility or facilities within the project boundary, a contract between the supplier and consumer(s) of the energy will have to be entered into that ensures there is no double-counting of emission reductions.	The project activity will not deliver directly the heat to the starch factory. However, the biogas which will be generated from the methane avoidance component of the project will be delivered which will be combusted in the boiler in the starch factory. The contract between supplier (SD Biosupply Co., Ltd.) and consumer (Somdej Flour Mill Co., Ltd.) is available which clearly states that only the supplier can claim emission reductions.
14	If the project activity recovers and utilizes biogas for producing electricity and/or thermal energy and applies this methodology on a standalone basis i.e. without using a Type III component of a SSC methodology, any incremental emissions occurring due to the implementation of the project activity (e.g.	The project activity recovers and utilises biogas for both power and heat generation. However, AMS-I.C is not used on a standalone basis but used with AMS-III.H. All project or leakage emissions are taken into account.

⁵ Physically distinct units are those that are capable of producing thermal/electrical energy without the operation of existing units, and that do not directly affect the mechanical, thermal, or electrical characteristics of the existing facility. For example, the addition of a steam turbine to an existing combustion turbine to create a combined cycle unit would not be considered "physically distinct".

Table 2: Applicability criteria for AMS I-C

Applicability criteria		Justification
	physical leakage of the anaerobic digester, emissions due to inefficiency of the flaring), shall be taken into account either as project or leakage emissions as per relevant procedures in the tool “Emissions from solid waste disposal sites” and/or “Project emissions from flaring”. In the event that the biomass fuel (solid/liquid/gas) is sourced from an existing CDM project, then the emissions associated with the production of the fuel shall be accounted with that project.	
15	If project equipment contains refrigerants, then the refrigerant used in the project case shall have no ozone depleting potential (ODP).	The project does not involve any refrigerants. This is not relevant to the project.
16	Charcoal based biomass energy generation project activities are eligible to apply the methodology only if the charcoal is produced from renewable biomass sources-provided: (a) Charcoal is produced in kilns equipped with methane recovery and destruction facility; or (b) If charcoal is produced in kilns not equipped with a methane recovery and destruction facility, methane emissions from the production of charcoal shall be considered. These emissions shall be calculated as per the procedures defined in the approved methodology “AMS-III.K: Avoidance of methane release from charcoal production by shifting from traditional open-ended methods to mechanized charcoaling process”. Alternatively, conservative emission factor values from peer reviewed literature or from a registered CDM project activity can be used, provided that it can be demonstrated that the parameters from these are comparable e.g. source of biomass, characteristics of biomass such as moisture, carbon content, type of kiln, operating conditions such as ambient temperature.	The project does not involve any charcoal based biomass energy generation. This is not relevant to the project.
17	In cases where the project activity utilizes biomass, sourced from dedicated plantations, applicability conditions prescribed in the tool “Project emissions from cultivation of biomass” shall apply.	The project does not utilize any biomass. This is not relevant to the project activity.

2.3 Project Boundary

The project boundary covers the requirement of AMS III.H and AMS.I.C as following justification;

As per the AMS III.H. version 18, the project boundary shall respectively include the following:

paragraph 20, *“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”.*

As per paragraph 21 of the methodology, implementation of the project activity at a wastewater and/or sludge treatment system will affect certain sections of the treatment systems while others may remain unaffected. As the project activity is implemented next to the existing starch factory. The wastewater from the starch factory was treated in the open anaerobic lagoons. In the project, the wastewater will be first treated in the biogas system before being fed to the open lagoons. The COD levels entering the open lagoons in the project activity will be much lower than those in the baseline scenario. The resulting methane emissions will be considered under the project emissions. Furthermore, the electricity consumption in the baseline and project wastewater treatment system will also be affected. These emission sources are also dealt separately in the baseline and project emission calculations. In the project activity, the pre-treatment process unit, the biogas system and the subsequence open lagoon system (post treatment) including the utilisation of effluent are covered within the boundary. The exclusion of sections or the components of the treatment system affected by project activity are taken into account for ex ante GHG calculation and further justified in the section 2.4.

As per the AMS I.C. version 20, the project boundary shall respectively include the following:

Project boundary		Included?
a)	All plants generating power and/or heat located at the project site, whether fired with biomass, fossil fuels or a combination of both;	Yes, the thermal oil boiler which will be using biogas to generate heat is included in the project boundary.
b)	All power plants connected physically to the electricity system (grid) that the project plant is connected to;	Not relevant, but grid is included in the project boundary in the context of AMS-I.D for the electricity component of the project activity.
c)	Industrial, commercial or residential facility, or facilities, consuming energy generated by the system and the processes or equipment affected by the project activity;	Yes, the starch drying process consuming heat supplied by the thermal boiler is included in the project boundary.
d)	The processing plant of biomass residues, for project activities using solid biomass fuel (e.g. briquette), unless all associated emissions are accounted for as leakage emissions;	Not relevant as the project activity does not involve processing of biomass residues.
e)	The transportation itineraries, if the biomass is transported over distances greater than 200 kilometres, unless all associated emissions are accounted for as leakage emissions;	Not relevant as project activity utilises biogas which is generated next to the starch factory and transported using pipelines.
f)	The site of the anaerobic digester in the case of project activity that recovers and utilizes biogas for power/heat production and applies this methodology on a stand alone basis i.e. without using a Type III component of a SSC methodology.	Yes, the site of anaerobic digester is already included in the context of AMS-III.H

The GHG gases considered in the analysis are given in the following table:

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

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

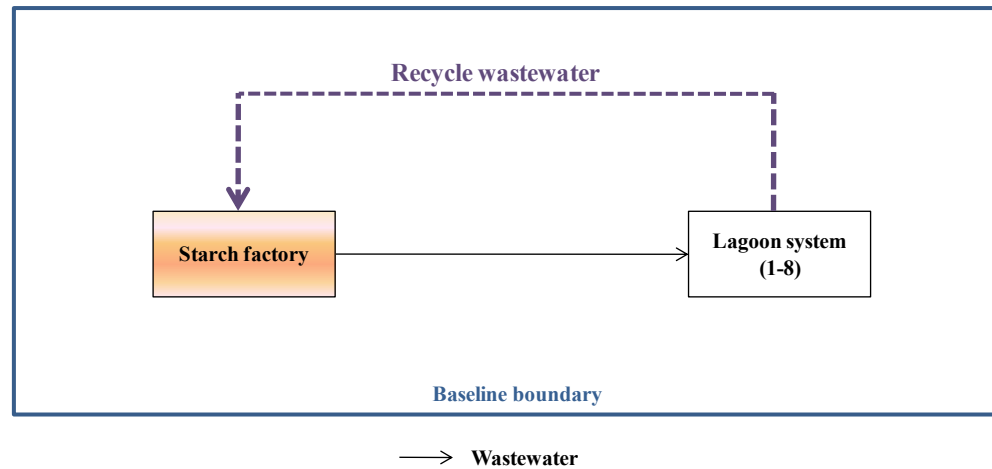


Figure 2: The baseline system boundary

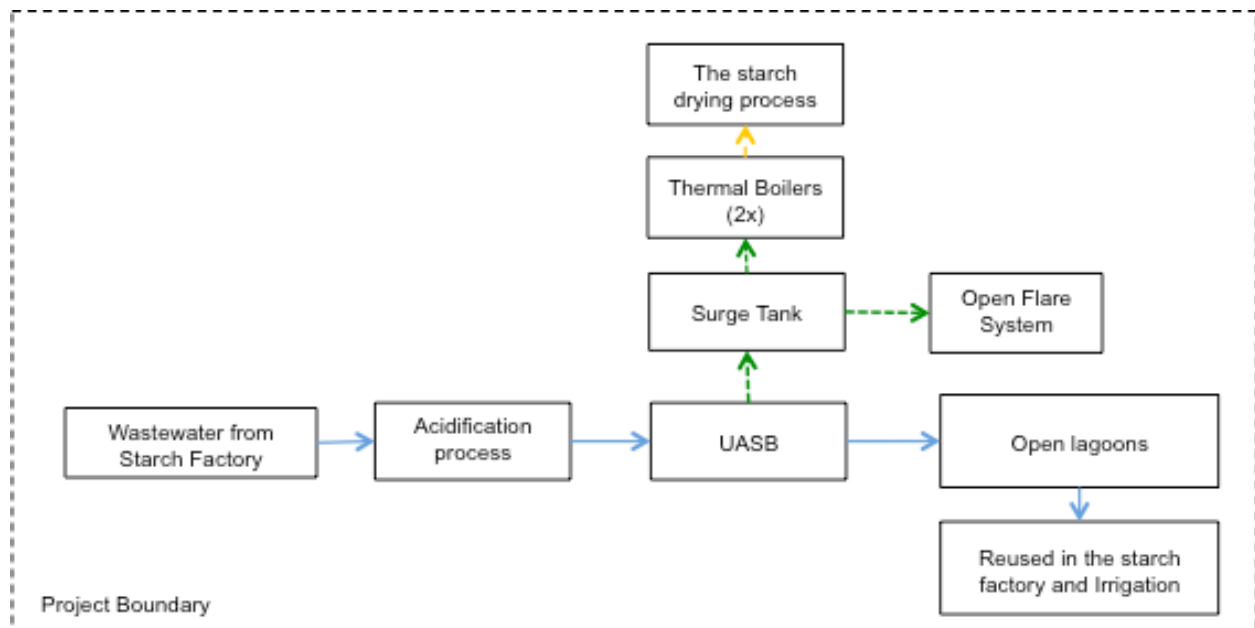


Figure 3: The current boundary of project system

2.4 Baseline Scenario

Validity of baseline scenario

With the references to the VCS standard (version 3), section 3.8.5 “Renewal of Project Crediting Period”, the followings have been assessed with the respect to the validation of the original baseline for methane avoidance component (AMS III.H) and thermal generation component (AMS.I.C).

As per paragraph (1) of the same section, there is no change in the project activity in terms of capacity or location. In line with the section 4.6.3 of VCS standard, version 3.7, the regular surplus for the project has been demonstrated in the section 1.11 of this PD. The project description is updated accordingly. The additionality as mentioned in section 2.5 of this PD has been assessed in the former PD. A full reassessment of additionality is not required.

Demonstration of the validity of baseline scenario

The demonstration of the validity of the original baseline scenario as per section 3.8.3 VCS standard, paragraph 2 is provided as following;

Assessment as per VCS standard	Justification
(a) The validity of the original baseline scenario shall be assessed. Such assessment shall include an evaluation of the impact of new relevant national and/or sectoral policies and circumstances on the validity of the baseline scenario.	The project is inline with all local laws and regulation in Thailand. The operation license issued by provincial department of industry has been renewed and valid. The regulation on the limitation of discharge wastewater is still applicable and controlled by the Department of Industrial Work, Ministry of Industry, Thailand ⁶ . There is no regulation in the Thailand that requires the management of biogas from industrial site. Therefore, there is no impact to the original baseline of project activity.
(b) Where it is determined that the original baseline is still valid, the GHG emissions associated with the original baseline scenario shall be reassessed using the latest version of the CDM Tool to assess the validity of the original/current baseline and to update the baseline at the renewable of a crediting period.	The assessment is provided as table 4 and 5 below.
(c) Where it is determined that the original baseline scenario is no longer valid, the current baseline scenario shall be established in accordance with the VCS rules.	According to table 4 and 5, the original baseline scenario is still valid. This section is not applicable.
(d) The project description, containing updated information with respect to the baseline, the estimated GHG emission reductions or removals and the monitoring plan, shall be submitted for validation.	The project description is updated and revised according to the latest approved version of AMS III.H and AMS I.C including the relevant tools to the applied methodologies.

Methane destruction component:

According to Paragraph 2 (f) of AMS III.H version 18, the baseline scenario to the project activity is defined as follows:

“Introduction of a sequential stage of wastewater treatment with biogas recovery and combustion, with or 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 aerobic lagoon without methane recovery).”

⁶ https://www.jetro.go.jp/ext_images/thailand/pdf/MOIEffluentStandards2560.pdf

“In absence of the project activity, the wastewater would have been treated in anaerobic open lagoons. The project involves the installation of a new stage in the wastewater system; the wastewater is treated sequentially in a sump tank, then treated in the biogas reactor with methane recovery and it’s utilization for electricity generation, without sludge separation, and finally treated by the existing series of anaerobic open lagoons.”

The baseline scenario consists of 8 anaerobic lagoons⁷, which were used to treat wastewater prior to project implementation. The lagoons had an average depth of 3.0 m.

Table 3: Characteristics of the baseline open anaerobic lagoons at the starch facility

Lagoons	Area (m ²)	Depth (m)	Volume (m3)
Anaerobic – no.1	10,280	3.5	35,980
Anaerobic – no.2	14,636	3.5	51,226
Anaerobic – no.3	15,188	3.5	53,158
Anaerobic – no.4	20,912	3.5	73,192
Anaerobic – no.5	21,924	3.0	65,772
Anaerobic – no.6	16,184	3.0	48,552
Anaerobic – no.7	26,624	2.5	66,560
Anaerobic – no.8	48,764	2.0	97,528
Average:		3.06	

The existing lagoons, which would have been used in the absence of project activity, are in line with the applicability conditions of AMS.III H version 18 as justified in the table 1 above.

The assessment of original baseline using “Tool to assess the validity of the original/current baseline and to update the baseline at the renewal of a crediting period, version 3.0.1” as following table;

Table 4: the validity of original baseline for methane avoidance component	
Assessment as per CDM tool	Justification
Step 1: Assess the validity of the current baseline for the next crediting period	
Step 1.1: Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies	The same justification is provided in the section 2.4. The current baseline of project activity is the existing open lagoon system. In the absence of project activity, the starch factory would have used existing open lagoon system for treating untreated effluent from the production process. The treated effluent from open lagoons would not be discharged out of the factory. By using this baseline system, it still complies with relevant mandatory national and/or sectoral policies ⁸ .
Step 1.2: Assess the impact of circumstances	There is no change in the circumstance that would impact the continuation of existing open lagoon system as a baseline scenario of the project.

⁷ The open lagoon depth (cross section drawing) is provided

⁸ https://www.jetro.go.jp/ext_images/thailand/pdf/MOIEffluentStandards2560.pdf

Table 4: the validity of original baseline for methane avoidance component	
Assessment as per CDM tool	Justification
Step 1.3: Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested.	The identified baseline scenario at the validation of this project was the continuation of the use of existing anaerobic open lagoons without any investment. This system requires extremely limited operation and maintenance due to the self-regulatory nature of the systems. Hence, lagoons are a very cost-effective solution, do not require advanced technology and are easy to operate and maintain ⁹ . The technical lifetime of baseline system exceeds the crediting period for which renewal is requested.
Step 1.4: Assessment of the validity of the data and parameters	All data and parameters that were determined at the start of the crediting period are updated accordingly. Also, following updates are undertaken; (a) All updated IPCC defaults are applied in this crediting period; e.g GWP_{CH_4}, $B_{0,ww}$ (b) Emission factor of electricity system (EF_y) is also updated.
Outcome: the justification in step 1 demonstrates that the current baseline scenario for methane avoidance component is still valid for subsequent crediting period. Therefore, all relevant data and parameters can be used for the renewed crediting period.	
Step 2: Update the current baseline and the data and parameters	As per the outcome of step 1, this step is not applicable due to the current baseline emission is still valid.

Thermal generation component:

In absence of the project activity, the project would use fossil fuel oil in boiler to produce thermal energy. According to AMS.I.C version 20, baseline emissions are calculated as per paragraph 33 of the methodology. Please refer to section 4.1 for further details.

During the years 2002, 2003 & 2004, the HFO consumption in starch drying process can be summarized as follows:

Year	Average HFO consumption L/kg of dry starch	HFO Consumption in litres
2002	0.0338	2,187,940
2003	0.0345	2,303,060
2004	0.0375	2,111,970

The project activity will result in a partial replacement of the HFO requirements of the starch plant. Please see Section 4.1 for the estimation of the expected fuel replacement by the project activity. The ex-ante estimation of the baseline emissions for the thermal energy component is based on

⁹ Cinara, 2004 "Waste stabilization ponds for wastewater treatment, International Water and Sanitation Centre" <http://www.irc.nl/page/8237>

the historical consumption of fuel oil per tonne of dry starch production i.e. specific fuel oil consumption is used to ex ante baseline emissions.

The assessment of original baseline using “Tool to assess the validity of the original/current baseline and to update the baseline at the renewal of a crediting period, version 3.0.1” as following table;

Table 5: the validity of original baseline for thermal energy production component	
Assessment as per CDM tool	Justification
Step 1: Assess the validity of the current baseline for the next crediting period	
Step 1.1: Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies	The project complies the national policies as the justification is provided in the previous section.
Step 1.2: Assess the impact of circumstances	There is no change in the circumstance that would impact the continuation of HFO consumption in the thermal oil boilers as a baseline scenario of the project.
Step 1.3: Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested.	The thermal oil boiler system of the project has a technical lifetime of 20 years since the starting date of operation.
Step 1.4: Assessment of the validity of the data and parameters	All data and parameters that were determined at the start of the crediting period are updated accordingly.
Outcome: the justification provided in step 1 demonstrates that the current baseline scenario for thermal energy production component is still valid for subsequent crediting period. Therefore, all data and parameters can be used for the renewed crediting period.	
Step 2: Update the current baseline and the data and parameters	As per the outcome of step 1, it found that the baseline emission is still valid. Therefore, this step is not applicable.

2.5 Additionality

For projects renewing the crediting period, no re-assessment of additionality is required according to paragraph 3.8.5 of VCS standard v3.6. The additionality was assessed in the former registered PD. In addition, the original baseline scenario is valid as per the justification provided in section 2.4. The demonstration of regulatory surplus is provided below.

Regulatory surplus

The project activity is in compliance with current law in Thailand, which allows the use of open lagoon systems and other waste treatment technologies that meet effluent standards for the discharge of treated wastewater into the environment. The law and regulations is described in section 1.11. There is no other regulatory requirement for the implementation of a specific wastewater treatment technology such as anaerobic digester or aerobic treatment system to starch factory.

2.6 Methodology Deviations

Determination of EG_{thermal}

Formula that is deviated from the applied methodology is described below;

As per paragraph 33, AMS I.C version 20, for steam/heat produced using fossil fuels, the baseline emissions are calculated as;

$$BE_{\text{thermal, CO}_2, y} = (EG_{\text{thermal, y}} / \eta_{\text{BL, thermal}}) \times EF_{\text{FF, CO}_2}$$

As per the measurement requirement of monitoring parameter $EG_{\text{thermal, y}}$, heat generation is determined as the difference of the enthalpy of the hot fluid or thermal fluid generated by the heat generation equipment and the sum of the enthalpies of the feed-fluid. The respective enthalpies should be determined based on the mass (or volume) flows and the temperatures.

Deviated approach or formula / Deviated approach in this monitoring period:

The project proponent is not able to conduct the measurement of temperature (in and out) and the flow of the thermal fluid as per the applied methodology. Therefore, the deviated approach is introduced as following. The monitoring parameter of $EG_{\text{thermal, y}}$ can be estimated based production historical data and actual fuel energy input. By considering historical data, the estimation is considered from heat requirements per tonne of starch prior the implementation of project activity. The approach estimates the thermal energy delivered by the project activity based on historical fuel oil consumption and starch production for the given year. The conservative approach is ensured by comparing the total energy delivered by the fuels burnt in the project activity and thermal energy estimate based on historical fuel oil consumption values. The conservativeness of the historical data: the historical data of Somdej Flour Mill Co., Ltd is available for 3 years (2002-2004) on starch production and heavy oil consumption as follows:

Year	Dry starch (tonne)	Heavy oil (litre)	Litre of HFO/tonne of dry starch
2002	64,830	2,187,940	33.8
2003	66,347	2,303,060	34.7
2004	57,837	2,111,970	36.5
Average			35.0

Based on the historical data, the project has considered the most conservative average specific energy consumption during 2002-2004, which is 33.8 litre of HFO/tonne of dry starch in year 2002.

The calculation formula is determined as following:

$$EG_{\text{thermal, y}} = \min (EG_{\text{thermal, historical}}, EG_{\text{thermal, energy input}})$$

Historical production approach:

$$EG_{\text{thermal, historical}} = Q_{\text{starch}} \times q_{\text{HFO, starch}} \times D_{\text{HFO}} \times NCV_{\text{HFO}}$$

Where:

Parameter	Details
$EG_{\text{thermal, historical}}$	Net quantity of thermal energy supplied by the project during year y (TJ)
Q_{starch}	Quantity of starch production in year y (tonne)
$q_{\text{HFO, starch}}$	Specific energy consumption (HFO/tonne)
D_{HFO}	Density of HFO (tonne/litter)
NCV_{HFO}	NCV of fossil fuel (HFO) used in the process (0.0404 TJ/tonne)

Fuel energy input approach:

$$EG_{\text{thermal, energy input}} = BG_{\text{combusted, y}} \times w_{\text{CH}_4} \times D_{\text{CH}_4} \times NCV_{\text{CH}_4}$$

Where:

Parameter	Details
$EG_{\text{thermal, energy input}}$	Net quantity of thermal energy supplied by the project during year y (TJ)
$BG_{\text{combusted, y}}$	Amount of biogas sent to boiler in year y (Nm^3)
w_{CH_4}	Methane content in the biogas in the year y (%)
D_{CH_4}	Density of methane at normal condition (tonne/ Nm^3)
NCV_{CH_4}	NCV of methane (TJ/tonne)

Justification for deviation:

When compared to the industrial research as per published data at Thai Tapioca Starch Association website¹⁰, the average of 33.6 litre of HFO/ tonne of dry starch (range: 25.9-39.4) is found. The lowest historical data of 33.8 l/t is considered, as it is the most conservative and precise value based on the applied technology and equipment at Somdej starch plant. By the way, the value assumed in project activity is still in the suggested range and close to the average value of 33.6 litre of HFO/ tonne of dry starch.

3 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

The determination of baseline for the project activity is anaerobic open lagoons without methane recovery system and consumption of heavy fuel oil for heat generation at the starch plant. Emission reduction calculation are considered into two components; (a) methane destruction in comply with to AMS III.H version 18, and (b) thermal energy production component according to AMS I.C, version 20.

3.1 Baseline Emissions

(a) Methane destruction component (AMS.III.H)

According to the paragraph 27 of AMS III.H, baseline emissions for the systems affected by the project activity may consist of:

- Emissions on account of electricity or fossil fuel used ($BE_{\text{power, y}}$);
- Methane emissions from baseline wastewater treatment systems ($BE_{\text{ww, treatment, y}}$);

¹⁰ Source: <http://www.thaitapiocastarch.org/article05.asp>

- c) Methane emissions from baseline sludge treatment systems ($BE_{s,treatment,y}$);
- d) 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 ($BE_{ww,discharge,y}$);
- e) Methane emissions from the decay of the final sludge generated by the baseline treatment systems ($BE_{s,final,y}$).

Baseline emissions (BE_y)

The baseline emissions are calculated as follows.

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

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). If the sludge is controlled combusted, disposed in a landfill with biogas recovery, or used for soil application in the baseline scenario, this term shall be neglected.

Baseline emissions of the wastewater treatment systems affected by the project activity ($BE_{ww,treatment,y}$):

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 29 of AMS III.H version 18. The following equation is used.

$$BE_{ww,treatment,y} = \sum_i Q_{ww,i,y} * COD_{inflow,i,y} * \eta_{COD,BL,i} * MCF_{ww,treatment,BL,i} * B_{o,ww} * UF_{BL} * GWP_{CH4} \quad (2)$$

Where,

Parameter	Details
$BE_{ww,treatment,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO ₂ e)
$Q_{ww,i,y}$	Volume of wastewater treated in baseline wastewater treatment system i in year y (m ³)
$COD_{inflow,i,y}$	Chemical oxygen demand of the wastewater inflow to the baseline

	treatment system i in year y . Average value may be used through sampling with the confidence/precision level 90/10 (t/m^3).
$\eta_{\text{COD, BL}, i}$	COD removal efficiency of the baseline treatment system i
$\text{MCF}_{\text{, ww, treatment, BL}, i}$	Methane correction factor for the baseline anaerobic wastewater treatment i (MCF values as per table III.H.2)
i	Index for baseline wastewater treatment system
$B_{\text{o, ww}}$	Methane producing capacity of the wastewater (IPCC lower value for domestic wastewater of $0.25 \text{ kg CH}_4/\text{kg COD}$) ¹¹
U_{BL}	Model correction factor to account for model uncertainties (0.89) ¹²
GWP_{CH_4}	Global Warming Potential for methane (value of 25)

The parameter $\eta_{\text{COD, BL}, i}$ is based on the historical COD measurement of the baseline system prior implementation of project activity. The measurement campaign of 11 days were conducted in order to determine the COD removal efficiency. This is in line with paragraph 39 (b) of AMS. III-H.

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

The only electricity consumption devices used in the baseline wastewater treatment systems are pumps for pumping the wastewater from the starch factory into the open anaerobic lagoons. There is no consumption of fossil fuels for the operation of the baseline system. Please note that consumption of fossil fuels for heat generation at the starch plant are considered in the emission reduction component as per AMS.I.C.

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

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

Baseline emission from wastewater discharge ($BE_{\text{ww, discharge}, y}$)

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

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

Baseline emissions of the sludge treatment systems affected by the project ($BE_{\text{s, treatment}, y}$)

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

Baseline emissions from final sludge disposal ($BE_{\text{s, final}, y}$)

¹¹ The IPCC default value of $0.25 \text{ kg CH}_4/\text{kg COD}$ was corrected to take into account the uncertainties. Project activities may use the default value of $0.6 \text{ kg CH}_4/\text{kg BOD}$, in case the parameter $\text{BOD}_{5,20}$ 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 $\text{BOD}_{5,20}$, i.e., the estimation of BOD values based on COD measurements is not allowed.

¹² Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

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

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

(b) Thermal energy production component AMS.I.C:

As per paragraph 33 of AMS I.C, for steam/heat produced using fossil fuels the baseline emissions are calculated as follows:

$$BE_{thermal, CO_2, y} = (EG_{thermal, y} / \eta_{BL, thermal}) * EF_{FF, CO_2} \quad (3)$$

Where:

Parameter	Details
$BE_{thermal, CO_2, y}$	the baseline emissions from steam/heat displaced by the project activity during the year y in tCO_2e
$EG_{thermal, y}$	the net quantity of steam/heat supplied by the project activity during the year y in TJ.
EF_{FF, CO_2}	the CO_2 emission factor per unit of energy of the fuel that would have been used in the baseline plant in (tCO_2/TJ), obtained from reliable local or national data if available, otherwise, IPCC default emission factors are used.
$\eta_{BL, thermal}$	the efficiency of the plant using fossil fuel that would have been used in the absence of the project activity

The baseline emissions for ex-ante estimations are based on historical specific consumption of fossil fuel oil per tonne of starch. The future expected starch production is used to estimate the baseline emissions for ex ante purpose. In case of ex-post calculations, the amount of energy delivered by the dual fuel fired boiler is used to estimate the baseline emissions. This is based on the methodology deviation provided in section 2.6.

3.2 Project Emissions

(a) Methane destruction component: (AMS III.H)

As per the paragraph 41 of AMS III.H, Project activity emissions from the systems affected by the project activity are:

- CO_2 emissions from electricity and fuel used by the project activities ($PE_{power, y}$);
- Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{ww, treatment, y}$);
- Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{s, treatment, y}$);
- Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater ($PE_{ww discharge y}$);
- Methane emissions from the decay of the final sludge generated by the project activity treatment systems ($PE_{s, final, y}$);

- f) Methane fugitive emissions on account of inefficiencies in capture systems ($PE_{fugitive, y}$);
g) Methane emissions due to incomplete flaring ($PE_{flaring, y}$);
h) Methane emissions from biomass stored under anaerobic conditions which does not take place in the baseline situation ($PE_{biomass, y}$).

$$PE_{y, y} = \{PE_{power, y} + PE_{ww, treatment} + PE_{s, treatment} + PE_{ww discharge, y} + PE_{s, final, y} + PE_{fugitive, y} + PE_{biomass, y} + PE_{flaring, y}\} \quad (4)$$

Where,

Parameter	Details
PE_y	Project emissions in 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 the project situation (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 the project situation (tCO ₂ e)
$PE_{ww, discharge, y}$	Methane emissions from degradable organic carbon in treated wastewater in year y (tCO ₂ e)
$PE_{s, final, y}$	Methane emissions from anaerobic decay of the final sludge produced in year y (tCO ₂ e)
$PE_{fugitive, y}$	Methane emissions from biogas release in capture systems in year y (tCO ₂ e)
$PE_{biomass, y}$	Methane emissions from biomass stored under anaerobic conditions (tCO ₂ e)
$PE_{flaring, y}$	Methane emissions due to incomplete flaring in year y (tCO ₂ e)

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

As per paragraph 41, these emissions shall be calculated using “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”. The energy consumption data of all equipment/devices is required in the project activity wastewater and sludge treatment systems and systems for biogas recovery and flaring/gainful use.

$$PE_{Power, y} = EC_{PJ, j, y} * EF_{EF, j, y} * (1 + TDL_{j, y}) \quad (5)$$

Where,

Parameter	Details
$PE_{y, power}$	Emissions from electricity consumption in the year y (tCO ₂ e)
EC_y	Electricity from the grid consumed by the project activity (wastewater treatment, biogas recovery and biogas utilisation/flaring systems) (MWh)
$TDL_{j, y}$	Average technical transmission and distribution losses for providing electricity to source j in year y
EF_y	Thailand National Grid emission factor (tCO ₂ e/MWh)

The project activity consumes power from the national grid system. As per the tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”, version 02, the emission factor ($EF_{EF, j, y}$) is based on the option A1: calculate the combined margin emission factor of the applicable electricity system, using the procedures in the latest approved version of the “Tool to calculate the emission factor an electricity system”

($EF_{EL,j,k,l,y} = EF_{grid,CM,y}$). In this crediting period, the emission factor of the project is referred to the published value announced by Thai DNA. This is inline with paragraph 17 of Tool 7 version 05, EB87 Annex 9.

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

Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation are calculated as per equation 2 of paragraph 29 in AMS.III.H using an uncertainty factor of 1.06. The following equation is used.

$$PE_{ww,treatment,y} = \sum (Q_{ww,y} * \eta_{PJ,k,y} * MCF_{ww,treatment,PJ,k} * B_{o,ww} * UF_{PJ} * GWP_{CH4}) \quad (6)$$

Where,

Parameter	Details
$PE_{ww,treatment,y}$	Emissions from degradable organic carbon in treated wastewater in year y (tCO ₂ e)
$Q_{ww,k,y}$	Volume of wastewater treated in project activity (m ³)
$\eta_{COD,PJ,k,y}$	COD removal efficiency of the project wastewater treatment system k in year y (t/m ³) measured based on inflow COD and outflow COD in system k
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for the project wastewater treatment system k (MCF values as per table 2 in AMS III.H. version 18)
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC lower value for domestic wastewater of 0.25 kg CH ₄ /kg COD) ¹³
UF_{PJ}	Model correction factor to account for model uncertainties (1.12)
GWP_{CH4}	Global warming potential for methane (value of 25)

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

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

Methane emissions from degradable organic carbon in treated wastewater ($PE_{ww,discharge,y}$)

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

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

A relatively small amount of final sludge will be removed from the digester. The project proponent will apply final sludge for field application as fertilizer and the final disposal of the

¹³ The IPCC default value of 0.25 kg CH₄/kg COD was corrected to take into account the uncertainties. Project activities may use the default value of 0.6 kg CH₄/kg BOD, in case the parameter BOD_{5,20} is used to determine the organic content of the wastewater. In this case, baseline and project emissions calculations shall use BOD instead of COD in the formulas, and the monitoring of the project activity shall be based in direct measurements of BOD_{5,20}, i.e., the estimation of BOD values based on COD measurements is not allowed.

sludge shall be monitored during the crediting period. Therefore as suggested by the AMS III.H, the emission from anaerobic decay from the final sludge produced can be omitted.

Methane emissions from biogas release in capture systems ($PE_{fugitive, y}$)

Project activity emissions from methane release in capture systems are determined as per paragraph 42 of AMS III.H as given below.

$$PE_{fugitive, y} = PE_{fugitive, ww, y} + PE_{fugitive, s, y} \quad (7)$$

Where,

Parameter	Details
$PE_{fugitive, y}$	Methane emissions from methane release in capture and utilization/combustion/flare systems in year y (tCO ₂ e)
$PE_{fugitive, ww, y}$	Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year y (tCO ₂ e)
$PE_{y, fugitive, s}$	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y (tCO ₂ e)

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

These emissions are calculated as follows;

$$PE_{fugitive, ww, y} = (1 - CEF_{ww}) * MEP_{ww, treatment, y} * GWP_{CH4} \quad (8)$$

Where,

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

$$MEP_{ww, treatment, y} = Q_{ww, y} * B_{o, ww} * UF_{PJ} * \sum_k COD_{removed, PJ, k, y} * MCF_{ww, treatment, PJ, k} \quad (9)$$

Where,

Parameter	Details
$Q_{ww, y}$	Volume of wastewater treated in project wastewater treatment system k in year y (m ³ /year)
$B_{o, ww}$	Methane producing capacity of the wastewater
UF_{PJ}	Model correction factor to account for model uncertainties (1.12)
$COD_{removed, PJ, k, y}$	The chemical oxygen demand removed by the treatment system k of the project activity equipped with biogas recovery in the year y (tonnes/m ³)
$MCF_{ww, treatment, PJ, k}$	Methane correction factor for the project wastewater treatment system k equipped with biogas recovery equipment (MCF values as per table III.H.2)

b. **Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y ($PE_{y, \text{fugitive}, s}$) :**

Sludge will be used only for land application, therefore no sludge treatment envisaged in the project activity. Therefore emission from sludge treatment is not taken into consideration.

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

Methane emissions due to incomplete flaring in year y are calculated as per the the ex-post emission reduction shall be calculated as per methodological tool “Project emissions from flaring”.

Steps 1 to 3 of the “Project emissions from flaring” (hereafter the flaring tool) are used to determine the project emissions from flaring of the residual gas stream. The calculation procedures provided the determination of the project emissions from flaring the residual gas ($PE_{\text{flaring}, y}$) based on the flare efficiency ($\eta_{\text{flaring}, m}$) and the mass flow of methane to flare ($F_{\text{CH}_4, \text{RG}, m}$). The project emissions calculation procedure is given in the following steps:

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

This step determines the mass flow of methane ($F_{\text{CH}_4, \text{RG}, m}$) as kg unit in the residue gaseous stream in the minute “m” as per the guidance given in the “Tool to determine the mass flow of a green house gas in a gaseous stream”.

$F_{\text{CH}_4, \text{RG}, m}$, which is measured as the mass flow during minute m , shall then be used to determine the mass of methane in kilograms fed to the flare in minute m ($F_{\text{CH}_4, \text{RG}, m}$). $F_{\text{CH}_4, \text{RG}, m}$ shall be determined on a dry basis. Therefore, the measurement option A as per the table 1 of the tool is selected in order to determine the volume flow and the volumetric fraction of the residue gaseous stream on the dry basis. The temperature of the gaseous stream is less than 60 deg C at the flow measurement point. Therefore as per Option A (b), the gaseous stream is considered dry.

$F_{\text{CH}_4, m}$ is determined as following equation;

$$F_{\text{CH}_4, \text{RG}, m} = V_{t, \text{db}} * v_{\text{CH}_4, m, \text{db}} * \rho_{\text{CH}_4, m} \quad (10)$$

Where:

Parameter	Details
$F_{\text{CH}_4, \text{RG}, m}$	Mass flow of greenhouse gas CH ₄ in the residual gaseous stream in the minute m
$V_{t, \text{db}}$	Volumetric flow of the residual gaseous stream in minute m on dry basis (Nm ³)
$v_{\text{CH}_4, m, \text{db}}$	Volumetric fraction of the greenhouse gas CH ₄ in the gaseous stream in minute m on dry basis (%).
$\rho_{\text{CH}_4, m}$	Density of greenhouse gas CH ₄ in the gaseous stream in minute m (0.716 kg/m ³) at reference conditions

Density of methane ($\rho_{\text{CH}_4, m}$) is determined at the normal condition in line with below equation. The measurement of biogas flow will be conducted in normalized unit (Nm³).

$$\rho_{i,t} = \frac{P_t \times MM_i}{R_u \times T_t} \quad (11)$$

Where:

Parameters	Details
$\rho_{CH_4,m}$	Density of greenhouse gas (CH ₄) in the gaseous stream in minute <i>m</i>
P_t	Absolute pressure of the gaseous stream in time interval <i>t</i> (Pa)
MM_{CH_4}	Molecular mass of CH ₄ (kg/kmol)
R_u	Universal ideal gases constant (Pa.m ³ /kmol.K)
T_i	Temperature of the gaseous stream in time interval <i>t</i> (K)

Step 2: Determination of flaring efficiency

The flare efficiency depends on the efficiency of combustion in the flare and the time that the flare is operating. For this project activity, the open flare is used for flaring the residual gas stream. In the case of open flares, the flare efficiency in the minute *m* ($\eta_{flare,m}$) is 50% when the flame is detected in the minute *m* (Flare _{*m*}), otherwise $\eta_{flare,m}$ is 0%. This is complied with the flaring tool.

Step 3: Calculation of project emission from flaring

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

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

Where:

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

Methane emissions from biomass stored under anaerobic conditions which does not take place in the baseline situation ($PE_{biomass,y}$).

Biomass storage is not envisaged in the project activity. Therefore methane emissions from biomass stored under anaerobic conditions are not taken into consideration.

(b) Thermal energy production (AMS.I.C):

According to paragraph 66 of AMS-I.C, CO₂ emissions from on-site consumption of fossil fuels due to the project activity shall be calculated using the latest version of “Tool to calculate project

or leakage CO₂ emissions from fossil fuel combustion". As per paragraph 6 of the tool, the formula is determined as below.

$$PE_{FC,j,y} = \sum FC_{HFO,y} * COEF_{i,y} \quad (13)$$

Parameter	Details
PE _{FC,y}	Project emissions due to combustion of fossil fuel in year y (tCO ₂ e)
FC _{HFO,y}	Amount of fossil used in the boiler in ton/yr
COEF _{i,y}	CO ₂ emission coefficient of fuel type i in year y (tCO ₂ /mass or volume unit)

In comply with paragraph 7, the option B is selected for determination of COEF_{i,y}. The calculation is based following fomula;

$$COEF_{i,y} = NCV_{HFO} * EF_{HFO,CO2} \quad (14)$$

Parameter	Details
NCV _{HFO}	NCV of fossil fuel used in the process (0.0404 TJ/tonne)
EF _{HFO,CO2}	Emission factor of Heavy fuel oil as per IPCC (77.4 tCO ₂ /TJ)

By considering equation (13) and (14), parameter PE_{FC,j,y} can be determined as following:

$$PE_{FC,j,y} = \sum FC_{HFO,y} * NCV_{HFO} * EF_{HFO,CO2} \quad (15)$$

The ex-ante estimation of project emissions is based on the expected fuel oil quantity that would be utilized in the project activity after partial replacement of fuel oil by biogas. For ex-post estimations, the fossil fuel consumption at the project site shall be monitored for estimation of project emissions.

3.3 Leakage

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

3.4 Net GHG Emission Reductions and Removals

I – Emission Reduction

As per the paragraph 29 of AMS III.H and paragraph 28 of AMS I.C, emission reduction is 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;

$$ER_{y, ex-ante} = BE_{y, ex-ante} - (PE_{y, ex-ante} + LE_{y, ex-ante}) \quad (16)$$

Where,

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

$$ER_{y, ex-post} = \min(BE_{y, ex-post} - PE_{y, ex-post} - LE_{y, ex-post}, (MD_y - PE_{power, y} - LE_{y, ex-post})) \quad (17)$$

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 <i>ex post</i> monitored values
$PE_{y, ex-post}$	Project emissions calculated as per paragraph <i>ex post</i> monitored values
MD_y	Methane captured and destroyed/gainfully used by the project activity in the year y

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

$$MD_y = BG_{burnt, y} * W_{CH_4, y} * D_{CH_4} * FE * GWP_{CH_4} \quad (18)$$

Where:

Parameter	Details
$BG_{burnt, y}$	Biogas flared/combusted in year y (m ³)
W_{CH_4}	Methane content in the biogas in the year y (mass fraction)
D_{CH_4}	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)

II – The ex-ante calculation

II.1 Baseline Emission (BE_y)

The ex-ate estimation of the baseline emission can be given as:

$$BE_y = BE_{CH_4, y} + BE_{thermal, CO_2, y}$$

Where:

$$BE_{CH4,y} = BE_{ww,treatment,y}$$

$$BE_{thermal, CO2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{FF,CO2}$$

The following section gives details of ex-ante estimation of baseline emissions:

Methodology: AMS III H (Methane destruction component)		
Formula:		
$BE_{ww,treatment,y} = \sum_i Q_{ww,i,y} * COD_{inflow,i,y} * \eta_{COD,BL,i} * MCF_{ww,treatment,BL,i} * B_{o,ww} * UF_{BL} * GWP_{CH4}$		
$Q_{y,ww}$	707,405 m3	Based on the data assumptions made by technology provider and historical data
$COD_{inflow,i,y}$	0.02297t/m3	Based on the measurement campaign of the baseline system prior implementation of project activity. Please refer to Appendix.
$\eta_{COD,BL,i}$	87.62%	Please refer to Annex3.
$B_{o,ww}$	0.25kg CH ₄ /kg COD	Default value as per AMS III.H
$MCF_{ww,treatment,BL,i}$	0.8	Default value as per AMS III.H
GWP_{CH4}	25	Default value as per IPCC
UF_{BL}	0.89	Default value as per AMS III.H
Calculation: $BE_{CH4,y} = BE_{ww,treatment,y} = 63,364 \text{ tCO}_2$		
Methodology: AMS I.C. (Thermal energy production component)		
Formula:		
$BE_{thermal, CO2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{FF,CO2}$		
$EG_{thermal,y} =$	113 TJ	Based on the biogas supplied to thermal oil boilers and the historical data of HFO consumption. Detailed calculations are provided in the calculation spreadsheet ¹⁴ .
$EF_{FF,CO2} =$	77.40 tCO ₂ /TJ	For fuel oil – 2006 IPCC.
$\eta_{BL,thermal} =$	100%	Default value
Calculation: $BE_{thermal, CO2,y} = 8,753 \text{ tCO}_2\text{e}$		

II.2 Project Emission (PEy)

As per the above section, the ex-ante estimation of the project emissions can be given as :

Methane destruction component:

¹⁴ During actual project operation, the parameter will be calculated based on the temperature (in and out) from the thermal oil boiler and the amount of thermic fluid circulated. These are included in the monitoring section.

$$PE_{\text{methane destruction}, y} = PE_{\text{power}, y} + PE_{\text{ww, treatment}} + PE_{\text{fugitive}, y} + PE_{\text{flaring}, y}$$

Thermal energy production component:

$$PE_{FC,j,y} = \sum FC_{HFO,y} * COEF_{i,y}$$

Therefore, the ex-ante estimation of PE_y as following fomula;

$$PE_y = PE_{\text{methane destruction}, y} + PE_{FC,j,y}$$

The emissions if any from the fossil fuel used in the boiler (AMS.I.C) will be accounted during ex-post. Therefore, the project emissions are only from the methane destruction component of the project activity as given in the equation above.

The following section gives details of ex – ante estimation of project emissions:

Methodology: AMS III.H (Methane destruction component)		
Emission from electricity consumption		
Formula: $PE_{\text{Power}, y} = EC_{PJ, j, y} * EF_{EF, j, y} * (1 + TDL_{j, y})$		
$EC_{PJ, j, y} =$	596 MWh	Power rating based on the list given by technology provider.
$EF_{EF, j, y} =$	0.5637 tCO ₂ /MWh	Public information by Thai DNA
$TDL_{j, y} =$	6.07%	World bank database (Thailand 2014)
Calculation: $PE_{\text{Power}, y} = 357 \text{ tCO}_2\text{e}$ (detailed ex-ante calculation given the calculation sheet)		
Emissions in wastewater treatment system without biogas recovery		
Formula: $PE_{\text{ww, treatment}, y} = \sum (Q_{\text{ww}, y} * \eta_{\text{COD}, PJ, k, y} * MCF_{\text{ww, treatment}, PJ, k}) * B_{o, \text{ww}} * UF_{PJ} * GWP_{\text{CH}_4}$		
$Q_{\text{ww}, k, y} =$	707,405 m3	Based on the initial assumptions made by the technology provider
$\eta_{\text{COD}, PJ, k, y} =$	0.0028 t/m3	Based on the initial assumptions made by the technology provider
$B_{o, \text{ww}} =$	0.25 kg CH ₄ /kg COD	Default value as per AMS III.H.
$MCF_{\text{ww, treatment}, i} =$	0.8	Default value as per AMS III.H.
$GWP_{\text{CH}_4} =$	25	Default value as per AMS III.H
UF_{PJ}	1.12	Default value as per AMS III.H
Calculation: $PE_{\text{ww, treatment}, y} = 11,263 \text{ tCO}_2\text{e}$		
Fugitive emissions in wastewater treatment system with biogas recovery		
Formula: $PE_{\text{fugitive ww}, y} = (1 - CEF_{\text{ww}}) * MEP_{\text{ww, treatment}, y} * GWP_{\text{CH}_4}$		
CEF_{ww}	0.9	Default value as per AMS III.H

MEP _{ww, treatment,y}	3,276 tCH ₄ /year	Detailed calculations are available in the calculation sheet.
Calculation: PE _{fugitive ww, y} = 8,190 tCO ₂ e		
Methane emissions due to incomplete flaring		
Formula: $PE_{flare,y} = GWP_{CH_4} * \sum_{m=1}^{525600} F_{CH_4,RG,m} * (1 - \eta_{flare,m}) * 10^{-3}$		
Calculation: PE _{flare,y} is possible to estimate the amount of biogas which will be flared as this would happen only in the case of emergencies or surplus. For ex-ante calculation, the value of biogas flared is zero. Using default flare efficiency as 50%, methane content in biogas as 65%, GWP of methane as 25 and methane density as 0.716kg/m ³ , project emissions from flaring are given as PE _{flare,y} = 0 tCO ₂ e.		
Methodology: AMS I.C (Thermal energy production component)		
Emission from on-site consumption of fossil fuels due to the project activity		
Formula: PE _{FC,j,y} = Σ FC _{HFO, y} * NCV _{HFO} * EF _{HFO,CO2}		
FC _{HFO, y} =	317 ton	For ex-ante quantity of fuel oil combusted in the thermal oil boiler is based on the assumption of historical data and plant data.
NCV _{HFO,y} =	0.0404 TJ/ton	IPCC value
EF _{CO2,k,y} =	77.40 tCO ₂ /TJ	IPCC value
Calculation: PE _{FC, y} = 992 tCO ₂ e (detailed calculation given the calculation sheet)		

III.3 Emission Reduction Summary

To summarise ex-ante baseline and project emissions are given as follows:

As per equation 20, total baseline emissions are given as:

BE_y = 68,746 tCO₂/year

As per equation 21, the total project emissions are given as:

PE_y = 18,955 tCO₂/year

Therefore, the ex-ante estimates on emissions reductions are given as:

ER_y = 49,791 tCO₂/year

Table of ex-ante calculation summary

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
1	30,049	8,667	0	21,381
2	72,117	20,801	0	51,316
3	72,117	20,801	0	51,316
4	72,117	20,801	0	51,316
5	72,117	20,801	0	51,316
6	72,117	20,801	0	51,316
7	72,117	20,801	0	51,316
8	72,117	20,801	0	51,316
9	72,117	20,801	0	51,316
10	72,117	20,801	0	51,316
10	42,068	12,134	0	29,934
TOTAL	679,102	195,880	0	513,156

4 MONITORING

4.1 Data and Parameters Available at Validation

Data / Parameter	GWP _{CH₄}
Data unit	tCO ₂ e/tCH ₄
Description	Global Warming Potential for Methane
Source of data	AMS III.H V12
Value applied	25
Justification of choice of data or description of measurement methods	Default value as per IPCC

and procedures applied	
Purpose of Data	Calculation of baseline emission and project emissions
Comments	Global Warming Potential value of methane valid for the commitment period (Fourth Assessment Report: AR4)

Data / Parameter	$B_{o,ww}$
Data unit	kg CH ₄ /kg COD
Description	Methane producing capacity of the wastewater
Source of data	AMS III.H V18
Value applied	0.25
Justification of choice of data or description of measurement methods and procedures applied	IPCC defaults value
Purpose of Data	Calculation of baseline emission and project emissions
Comments	-

Data / Parameter	UF_{BL}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS III.H V18
Value applied	0.89
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of baseline emission
Comments	-

Data / Parameter	UF_{PJ}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS III.H V18
Value applied	1.12

Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	$MCF_{ww,treatment,BL,i}$
Data unit	Fraction
Description	Methane correction factor for baseline wastewater treatment systems i
Source of data	AMS III.H V18, Table III.H 2
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of baseline emission
Comments	-

Data / Parameter	$MCF_{ww,treatment,PJ,k}$
Data unit	Fraction
Description	Methane correction factor for project wastewater treatment systems k
Source of data	AMS III.H V18, Table III.H 2
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emission
Comments	-

Data / Parameter	COD removal efficiency-baseline
Data unit	%
Description	Chemical oxygen demand removal efficiency of baseline treatment

	system
Source of data	Historical data of baseline lagoons based on colorimetric analysis
Value applied	87.62%
Justification of choice of data or description of measurement methods and procedures applied	The removal efficiency is based on a measurement campaign. The efficiency was 98.45% that must be multiplied with 0.89 for a conservative estimation as per AMS III.H. The resulting COD removal efficiency factor of the baseline system is thus 87.62%.
Purpose of Data	Calculation of baseline emission
Comments	-

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

Data / Parameter	EF_y
Data unit	tCO ₂ /MWh
Description	CO ₂ emission factor for grid power
Source of data	Thai DNA ¹⁵
Value applied	0.5637
Justification of choice of data or description of measurement methods and procedures applied	The value is based on the official public data.
Purpose of Data	Calculation of baseline emission and project emission
Comments	-

¹⁵http://ghgreduction.tgo.or.th/t-ver/index.php?option=com_jdownloads&task=download.send&id=55&catid=12&m=0&Itemid=180

Data / Parameter	D_{CH_4}
Data unit	kg/m ³
Description	Density of methane at normal condition (T=273.15 K, p=101.325 kPa) of the biogas in the year y
Source of data	Tool to determine project emissions from flaring gases containing methane.
Value applied	0.716
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emission
Comments	-

Data / Parameter	$\eta_{BL,thermal}$
Data unit	%
Description	Efficiency of the boiler using fossil fuel that would have been used in the absence of the project activity.
Source of data	AMS I.C V.20
Value applied	100
Justification of choice of data or description of measurement methods and procedures applied	Default values, 100% is the most conservative choice as per AMS I.C.
Purpose of Data	Calculation of baseline emission
Comments	-

4.2 Data and Parameters Monitored

Data / Parameter	$Q_{ww,y}$
Data unit	m^3
Description	Volume of wastewater treated in year y
Source of data	Plant data
Description of measurement methods and procedures to be applied	Measurement is undertaken using flow meter
Frequency of monitoring/recording	Monitored continuously (at least hourly measurements are undertaken, if less, confidence/precision level of 90/10 shall be attained)
Value applied	707,405
Monitoring equipment	The flow meter for wastewater measurement is applied.
QA/QC procedures to be applied	The meter shall be calibrated annually or as per the manufacturer's recommendations to maintain the measuring accuracy. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager.
Purpose of data	• Calculation of baseline emission • Calculation of project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	$COD_{ww,untreated,y}$
Data unit	$tCOD/m^3$
Description	The chemical oxygen demand of the wastewater before and after the treatment system affected by the project activity
Source of data	Plant data
Description of measurement methods and procedures to be applied	The COD content is analyzed using a colorimetric method in the on-site laboratory of project. The results shall be logged in the plant operation report on a daily basis. The COD analysis will be conducted according to national or international standards. COD is measured through representative sampling.
Frequency of monitoring/recording	The monitoring will be conducted on daily basis. Samples and measurement shall ensure a 90/10 confidence/precision level.
Value applied	0.02297
Monitoring equipment	The equipment of COD analysis will be in line with the requirement of national or international standards. The results will

	be logged in the plant operation report on a daily basis.
QA/QC procedures to be applied	The analysis method shall be well documented and well accepted either by national or international standards. The relevant equipment shall be calibrated annually or as per manufacturer's recommendations to maintain the measuring accuracy. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager.
Purpose of data	Calculation of baseline emission
Calculation method	Not applicable
Comments	-

Data / Parameter	COD _{ww,treated,y}
Data unit	tCOD/m3
Description	The chemical oxygen demand of the wastewater after the treatment system affected by the project activity
Source of data	Plant data
Description of measurement methods and procedures to be applied	This can be referred to description of parameter COD _{ww,untreated,y}
Frequency of monitoring/recording	This can be referred to description of parameter COD _{ww,untreated,y}
Value applied	0.0207
Monitoring equipment	Same as parameter COD _{ww,untreated,y}
QA/QC procedures to be applied	Same as parameter COD _{ww,untreated,y}
Purpose of data	Calculation of project emissions
Calculation method	Same as parameter COD _{ww,untreated,y}
Comments	Same as parameter COD _{ww,untreated,y}

Data / Parameter	S _{final,PJ,y}
Data unit	ton
Description	Amount of dry matter in the sludge
Source of data	Plant data
Description of measurement methods	The project proponent does not envisage the generation of any sludge during the crediting period. Whenever sludge is removed

and procedures to be applied	from the reactor the practice of final disposal shall be monitored by keeping written evidence of the amount of sludge removed and its application. Measurement of the total quantity of sludge on a wet basis will be conducted. The volume (m^3) and density or direct weighting may be used to determine the sludge amount (wet basis). Representative samples (ensuring 90/10 confidence level) will be taken to determine moisture content to calculate the total sludge amount on dry basis.
Frequency of monitoring/recording	Whenever the sludge is removed, the quantity shall be recorded and documented.
Value applied	0 It is expected that a small amount of sludge would be generated.
Monitoring equipment	Using weighbridge before end use.
QA/QC procedures to be applied	The measurement equipment shall be calibrated at least once every three years based on relevant national or international standards.
Purpose of data	Calculation of project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	$BG_{burnt,y}$
Data unit	m^3
Description	Biogas volume in year y
Source of data	Plant data
Description of measurement methods and procedures to be applied	In all cases, the amount of biogas recovered, fuelled, flared or otherwise utilized shall be monitored ex post, using continuous flow meters. If the biogas stream flared and fuelled (or utilized) are monitored separately, the two fractions can be added together to determine the total biogas recovered, without the need to monitor the recovered biogas before the separation.
Frequency of monitoring/recording	The measurement monitoring will be conducted continuously. At least hourly measurements are undertaken, if less, confidence/precision level of 90/10 shall be attended. The monitored data will be recorded into the log sheet on daily basis.
Value applied	4,860,000
Monitoring equipment	The biogas shall be monitored using continuous flow meter. The volumetric flow meters have been automatically measured temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm^3).
QA/QC procedures to be	The flow meter shall be subject to periodic calibration according to

applied	the equipment's specifications and applicable industrial standards.
Purpose of data	• Calculation of baseline emissions • Calculation of project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	W_{CH_4}
Data unit	%
Description	Methane content in the biogas in the year y
Source of data	Plant data
Description of measurement methods and procedures to be applied	The fraction of methane in the biogas shall be measured with a continuous analyzer, or alternatively, with periodic measurement ensuring a 90/10 confidence/precision level. The methane content measurement shall be carried out close to a location in the system where a biogas flow measurement takes place.
Frequency of monitoring/recording	Daily basis
Value applied	65%
Monitoring equipment	The methane fraction shall be measured using continuous gas analyzer. In case the continuous gas analyzer is not available (or not functioning), a portable gas analyzer shall be used to monitor the methane content. The measurement using portable gas analyzer will ensure 90/10 confidence/precision level.
QA/QC procedures to be applied	The monitoring equipment shall be calibrated as recommended by the manufacturer. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager.
Purpose of data	Calculation of baseline emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	$BG_{combusted,y}$
Data unit	Nm^3
Description	Amount of biogas sent to boiler in year y
Source of data	Plant data
Description of	The biogas sent to boiler is monitored by using the continuous

measurement methods and procedures to be applied	flow meter directly.
Frequency of monitoring/recording	The measurement monitoring will be conducted continuously. At least hourly measurements are undertaken, if less, confidence/precision level of 90/10 shall be attended. The monitored data will be recorded into the log sheet on daily basis.
Value applied	4,860,000
Monitoring equipment	The biogas shall be monitored using continuous flow meter. The volumetric flow meters have been automatically measured temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm ³).
QA/QC procedures to be applied	The flow meter shall be subject to periodic calibration according to the equipment's specifications and applicable industrial standards.
Purpose of data	Calculation of baseline emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	$V_{RG,h}$
Data unit	Nm ³
Description	Volumetric flow of the residual gas on dry basis at reference conditions in the minute m
Source of data	Plant records
Description of measurement methods and procedures to be applied	The biogas produced is monitored using the continuous flow meter directly.
Frequency of monitoring/recording	The measurement monitoring will be conducted continuously. At least hourly measurements are undertaken, if less, confidence/precision level of 90/10 shall be attended. The monitored data will be recorded into the log sheet on daily basis.
Value applied	0 (for ex-ante calculation)
Monitoring equipment	The gas flow meters with an accepted level of accuracy has been installed and integrated with the SCADA system (Supervisory Control And Data Acquisition system) at the plant, providing continuous measurements of the total biogas volume produced by the UASB system. Volumetric flow meters has been automatically measured temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm ³).
QA/QC procedures to be	The flow meter shall be subject to periodic calibration according to

applied	the equipment's specifications and applicable industrial standards.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	$FC_{HFO,y}$
Data unit	Liters/y
Description	Quantity of fuel type i (HFO) combusted in process j during the year y
Source of data	Plant data, onsite measurement
Description of measurement methods and procedures to be applied	The fuel oil consumption is monitored using the fuel oil meter directly.
Frequency of monitoring/recording	Continuous monitoring. The monitored data will be recorded into the log sheet on daily basis.
Value applied	319
Monitoring equipment	A proper record of all the fossil fuel consumed shall be maintained at the project site.
QA/QC procedures to be applied	The meter shall be calibrated at least once in two years or as per the manufacturer's recommendations to maintain the measuring accuracy. The metered fuel consumption quantity should also be cross-checked with available purchase invoices.
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$EF_{FF,HFO}$
Data unit	tCO ₂ /TJ
Description	Emission factor of fossil fuel replaced-residual fuel oil
Source of data	IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23
Value applied	77.4
Justification of choice of data or description of measurement methods and procedures applied	Default value

Purpose of Data	This parameter was used to calculate the baseline emissions from the use of the fossil fuel that would be used in the baseline scenario.
Comments	-

Data / Parameter	NCV _{HFO}
Data unit	TJ/tonne
Description	Weighted average net calorific value of fuel type i (HFO) in year y
Source of data	IPCC 2006, Volume 2: Energy, Table 1.2.
Value applied	0.0404
Justification of choice of data or description of measurement methods and procedures applied	IPCC default value
Purpose of Data	Calculation of baseline emission
Comments	-

Data / Parameter	EG _{thermal,y}
Data unit	TJ/year
Description	Net quantity of thermal energy supplied by the project activity during the year y
Source of data	Plant records
Description of measurement methods and procedures to be applied	The thermal oil flow rate and the temperature difference of the thermal oil before and after the boiler shall be monitored. In case the monitoring equipment is not available, the methodology deviation approach is applied. The approach estimates the thermal energy delivered by the project activity based on historical fuel oil consumption and starch production for the given year. The conservative approach is ensured by comparing the total energy delivered by the fuels burnt in the project activity and thermal energy estimate based on historical fuel oil consumption values. Therefore, the amount of dry starch and quantity of biogas utilised are the monitored parameters in order to determine the thermal energy required in the project activity.
Frequency of monitoring/recording	Continuous monitoring, aggregated annually
Value applied	113
Monitoring equipment	The monitoring equipment is referred to monitoring parameter BG _{combusted} , and Q _{starch} . The value applied is based on the

	calculation as per the deviation approach.
QA/QC procedures to be applied	This section is referred to parameter BG _{combusted} , and Q _{starch} .
Purpose of data	Calculation of baseline emissions.
Calculation method	Calculation method is based on the measurement of historical production data and energy input. The deviation approach is provided in section 2.6.
Comments	-

Data / Parameter	EC _y
Data unit	MWh/year
Description	Quantity of electricity consumed by the project electricity consumption source j in year y
Source of data	Monthly joint meter readings
Description of measurement methods and procedures to be applied	Electricity consumption shall be monitored continuously by an import electricity meter of the PEA. The reading will be based on monthly meter reading reports.
Frequency of monitoring/recording	Continuous monitoring by electricity meter of the PEA.
Value applied	599
Monitoring equipment	The monitoring will be done by the import power meter.
QA/QC procedures to be applied	The electricity meter will be under the ownership of the PEA. The PP will follow the calibration schedule of PEA.
Purpose of data	Calculation of project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	TDL _{j,y}
Data unit	-
Description	Average technical transmission and distribution losses for providing electricity to source j in year y
Source of data	World bank database (Thailand 2014) This is annual average value based on the most recent data available within the host country
Description of	-

measurement methods and procedures to be applied	
Frequency of monitoring/recording	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Value applied	6.07%
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	Flame _m
Data unit	Flame on or Flame off
Description	Flame detection of flare in the minute m
Source of data	Plant data
Description of measurement methods and procedures to be applied	Measure using a fixed installation optical flame detector: Ultra Violet detector or Infra Red or both
Frequency of monitoring/recording	Once per minute. Detection of flare recorded as minute that the flare was on, otherwise recorded as a minute that the flame was off.
Value applied	Assume as zero for ex-ante calculation
Monitoring equipment	Flame detector
QA/QC procedures to be applied	Equipment shall be maintained and calibrated in accordance with manufacturer's recommendations
Purpose of data	Calculation of project emissions
Calculation method	Not applicable
Comments	-

Data / Parameter	$\eta_{\text{Flare-h}}$
Data unit	%
Description	Flare efficiency in the minute m
Source of data	Default value for open flares as per tool "project emission from

	flaring”
Description of measurement methods and procedures to be applied	The flare efficiency of 50% in the minute m is applied when the flare is detected in the minute m ($Flame_m$). If these conditions are not met, 0% default value should be used for this period.
Frequency of monitoring/recording	Continuous measurement
Value applied	50% default factor for an open flare
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	Not applicable
Comments	-

4.3 Monitoring Plan

1. Monitoring Management

The details on monitoring approaches used in qualifying and reporting GHG emissions and/or removals relevant for the project and baseline scenario shall be elaborated in section 4.1 and 4.3. Data acquisition for the gas and wastewater flow meters is executed through the process control unit of the biogas plant and the plant operations software. Lab data is fed into the operations software through a manual data entry user interface. The biogas plant is operated by four operators (working in 3 shifts a day) who also collect data under the supervision of the assistant plant manager who is in charge of filing and processing data and report directly to biogas plant manager. All biogas plant staffs are trained by the Papop Company prior to full commissioning of biogas plant. Figure 3 outlines the structure of operational and management of the project activity.

2. Quality Assurance and Quality Control

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

3. On-site Procedures

The operations software creates daily logs of plant performance which are printed out and recorded electronically for periodic download onsite or remote transfer for further processing. Procedures for Calibration of Equipment. The biogas plant operators carry out calibration according to international standards.

4. Data Storage and Filing – Electric Workbook

All relevant data is stored electronically in excel sheets. The monitoring records shall be archived for a period of crediting period + 2 years.

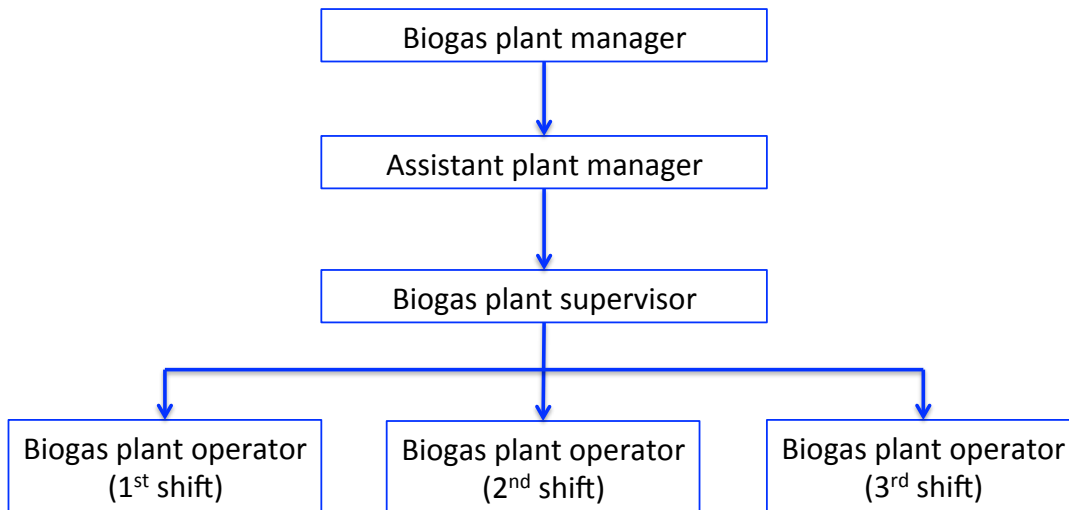


Figure 3: The structure of operational and management of the project activity

5 SAFEGUARDS

5.1 No Net Harm

There is no negative environmental and socio-economic impact. The project is a renewable energy biogas based thermal generation activity. In line with the operation license issued by the department of industrial work, the project follows the local regulation in order to maintain and prevent the environmental impact.

5.2 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 (MORE). The government of Thailand with 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.

5.3 Local Stakeholder Consultation

Invitation procedure

The Stakeholder Consultation has been conducted by the project owner SD Biosupply Co., Ltd. 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 mean about the meetings, place and date of the meetings. The stakeholder consultation was held at communities around the starch plant on 22/07/2008. Thus, all participants were able to examine the location where the proposed project will take place.

Meeting Participants

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

1. Local residents
2. Local government representatives
3. Delegates from political parties
4. Local entrepreneurs
5. Employees

There were 18 participants attended this meeting.

Language

Documentation and meeting was held in Thai (local language).

Meetings agenda

- 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 various meetings, 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 to 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.

In all, no adverse reaction/ comments/ clarifications have been sought/ received during the Stakeholder Consultation process. The project participants did not recognize any need to make changes to the project design or monitoring plan.

5.4 Public Comments

The revised PD is being re-validated in order to renewable the second crediting period of the project. The revised PD is not listed for public comment period. This section is not applicable.

APPENDIX X: HISTORICAL DATA**COD Measurement Campaign**

Baseline Wastewater Treatment System Measurement Campaign

Reference: Historical Data (atleast 10 days)

Date	CODin(#1)	CODout(#8)	%COD removal (%)
28/08/2004	20260	243	98.80%
11/09/2004	25975	519	98.00%
12/09/2004	27875	306	98.90%
13/09/2004	23800	209	99.12%
14/09/2004	23900	239	99.00%
15/09/2004	24160	375	98.45%
16/09/2004	19660	420	97.86%
17/09/2004	20320	540	97.34%
25/09/2004	20660	433	97.90%
26/09/2004	21160	277	98.69%
01/10/2004	24920	271	98.91%
Average (mg COD/l)	22,971.82	348.36	98.45%
Average (TCOD/m³)	0.02297	0.00035	
COD removal efficiency in Baseline		98.45%	
Conservative Factor (AMS.III.H)		0.89	
Conservative COD removal efficiency in Baseline		87.62%	