



**Verified Carbon
Standard**

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



Document Prepared by South Pole Carbon Asset Management Ltd.

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Prepared By	South Pole Carbon Asset Management Ltd.
Contact	Technoparkstrasse 1, 8005, Zurich, Switzerland, Tel: +41 43 501 35 50 Email: registration@southpole.com Website: www.southpole.com

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1 PROJECT DETAILS

1.1 Summary Description of the Project

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

This starch factory has a mean daily production capacity of 175 tonnes of dried starch, generating 2,000 m³ of wastewater per operational day¹. Under the previous system, wastewater released from the starch plant was treated in cascading open anaerobic lagoons. With the depth of these ponds being greater than 2 m from the water surface, and the mean temperature of the area being in the region of 28°C², there is a suitable anaerobic environment within the ponds, with the anaerobic bacteria, that breakdown the organic compounds in the wastewater³. This consequently lead to methane generation from the organic content (characterised by chemical oxygen demand or COD) of the wastewater.

The project activity involves the installation of two anaerobic covered lagoon facilities (converted from two existing open lagoons) to complement the existing anaerobic open lagoon based system. The two covered lagoon digesters, together, are designed with volumetric capacity of around 177,375 m³ of wastewater⁴. The COD removal efficiency of such system is typically at 80% and its retention time is estimated at around 90 days. The wastewater after two anaerobic covered lagoons will continue to flow to a series of remaining 9 open lagoons. The implementing system enables recovery of biogas that would have been released into the atmosphere and utilise it for thermal and electricity generation. In the case of thermal energy generation, the captured biogas will be co-fired in existing heat generating devices for the process of drying the wet starch (displacing fuel oil under the previous system). In addition, the power produced by this captured biogas will not only facilitate the electricity requirement of the plant, it may also be fed to national grid under the pending power purchase agreement with the Provincial Electricity Authority (PEA). Excess biogas (if any) will then be flared in an open flare system.

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

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

² <http://www.e-report.energy.go.th/weather.html>

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

⁴ Refer to drawing of covered lagoons

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

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

The proposed project activity is expected to reduce 19,318 tCO₂e annually and total of 193,189 tCO₂e during 10 years of the second crediting period.

1.2 Sectoral Scope and Project Type

The project activity involves recovery of fugitive methane emissions using anaerobic covered lagoon system and utilization of biogas as fuel to generate heat and electricity.

The project has electricity and thermal generation capacity less than 15 MW_{el} and 45 MW_{th}, and generate emission reductions less than 60 ktCO₂e per year. The type/category of the project is thus according to Appendix B, Simplified Modalities and Procedures for Small-Scale CDM Project Activities, as follows:

Methane avoidance component:

Type III:	Other Project Activities
Category III.H:	Methane Recovery in Wastewater Treatment
Sectoral Scope 13:	Waste Handling and Disposal
Version	19

Thermal energy generation component:

Type I:	Renewable energy projects
Category I.C:	Thermal energy for the user with or without electricity
Sectoral Scope 1:	Energy Industries

Version: 21

Electricity energy generation component:

Type I: Renewable energy projects
Category I.D: Grid connected renewable electricity generation
Sectoral Scope 1: Energy industries (renewable /non-renewable sources)
Version: 18

The project is not AFOLU project and a grouped project.

1.3 Project Eligibility

According to paragraph 3.1.9 of the VCS Standard, the registered project does not need to adhere to the new requirements

The project activity involves the implementation of anaerobic wastewater treatment system and utilization of biogas captured for electricity and thermal energy generation.

1.4 Project Design

The project has been designed to include a single installation of an activity as per the project description in section 1.1 and project location in section 1.12.

Eligibility Criteria

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

1.5 Project Proponent

Organization name	Kean Charoen Co.,Ltd.
Contact person	Mr. Ung Mengchua
Title	Managing Director
Address	1004/201 Soi Watchannai, Ratchadapisek Rd, Bangpongpan, Yannawa, 10120
Telephone	+66 2 294 5315-6, 294 5646
Email	sales@thaitapiocastarch.com

1.6 Other Entities Involved in the Project

Organization name	South Pole Carbon Asset Management Ltd.
Role in the project	Project developer for development of emission reductions through the Voluntary Carbon Standard
Contact person	Renat Heuberger
Title	CEO
Address	Technoparkstrasse 1, Zurich, Switzerland, 8005
Telephone	+41 43 501 35 50
Email	registration@southpole.com

1.7 Ownership

The project ownership can be verified through the following evidence.

- Operation license
- Service agreement or Emission Reductions Purchasing Agreement

1.8 Project Start Date

The project activity began on 02-October-2006. This is the date that the biogas began to be utilized in the hot oil boiler.

1.9 Project Crediting Period

The second crediting period is from 15-July-2019 to 14-July-2029, which is 10 years period.

1.10 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)
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Year 2019 (15-July-2019 to 31-December-2019)	10,464
Year 2020	19,319
Year 2021	19,319
Year 2022	19,319
Year 2023	19,319
Year 2024	19,319
Year 2025	19,319
Year 2026	19,319
Year 2027	19,319
Year 2028	19,319
Year 2029 (01-January-2029 to 14-July-2029)	8,854
Total estimated ERs	193,189
Total number of crediting years	10
Average annual ERs	19,318

1.11 Description of the Project Activity

Before the implementation of the project, the wastewater is treated by an open lagoon system, consisting of 11 anaerobic lagoons⁵. This mode of treatment is the prevalent practice in this kind of industry, particularly where there is a relative abundance of land.

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

- Avoidance of fugitive methane emissions to the atmosphere;
- Avoidance of carbon dioxide emissions from replacement of fossil fuel with biogas in thermal generation system and;

⁵ All the baseline lagoons have depth greater than 2 m, thus with the ambient temperature being above 15 °C they can all be regarded as anaerobic lagoons.

- Avoidance of carbon dioxide emissions through displacement of fossil-based electricity from national grid.

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

Technology description

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

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

Anaerobic treatment

The effluent from the starch processing plant flows into two covered lagoons through an influent distribution system at the bottom of the reactor. In these methane reactors, organic compounds in wastewater are transformed mainly into biogas by anaerobic bacteria in the system. Using a typical anaerobic biodegradability value of raw tapioca wastewater of 80%, the production of biogas is estimated to be 12,009 m³ per day (with methane percentage being at 55%⁶). This represents the expected level of activity.

Biogas handling

The captured biogas will be routed to the combination boilers for the generation of thermal energy necessary for the starch drying process. Note that the two boilers together have a total capacity 10.23 MW_{thermal} (4.07 + 6.16). Later, a gas-based power generation facility has been installed with the total capacity at 1,904 kW_e (952 x 2). Excess biogas, if any, will then be sent to high temperature open flares to destroy methane gas as it is produced. The flaring system will be used only in the case of emergency.

Secondary treatment and final wastewater

The wastewater will continue to flow from the covered anaerobic section to a series of 9 open lagoons. After the whole treatment process, the COD concentration of the wastewater will be very low and it is recycled back for further utilisation at the starch factory⁷. It must be mentioned that there is no wastewater discharge outside the factory at all. The method of final discharge remains

⁶ Average methane content of biogas has a broad range of 55-80%; a lower value of 55% is chosen for the calculation of this project to demonstrate conservative principle. <http://www.oregon.gov/ENERGY/RENEW/Biomass/biogas.shtml>

⁷ Either for washing cassava roots or use for irrigation purpose of internal farmlands.

the same before and after the project activity. A relatively small amount of sludge will be removed infrequently and will be treated aerobically by land application⁸.

Table 1: Secondary treatment and final wastewater

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

Table 2: List of baseline and project components

Component	Brief description
Lagoon System	The 11 lagoons were commissioned along with the operation start date of starch plant in 1988. The approximate retention time of the open lagoon system is around 200 days. For the project implementation, the two open lagoons were converted to two covered lagoons. The remaining 9 open lagoons continues to be used as a secondary wastewater treatment system under the project activity.
Covered lagoons	Two covered lagoons were converted from existing open lagoons. Typically, the COD removal efficiency of this system is around 80%. The hydraulic retention time is approximately at 90 days. The covered lagoon system started operation in October 2006, first month of biogas usage.
Boiler	There are two dual-fired boilers with thermal capacity with a capacity of 4.07 and 6.16 MW _{th} respectively. The first boiler with a capacity of 4.07 MW _{th} shall not be part of the project activity in line with the previous crediting period. The second boiler, which previously capacity of 3.78 MW _{th} was replaced by the new one with capacity 6.16 MW _{th} in year 2020. It is important to mention that there is no change

⁸ The sludge will be used for fertiliser purpose.

	in starch or wastewater treatment system capacity ⁹ . The old second boiler (3.78 MW _{th}) when using biogas as fuel often delivered unstable performance, thus, the PO decided to replace with the new boiler.
Gas engines	There are two electricity generation sets; the first set (no.1 st and 2 nd) with 2 generators capacity of 952 kW _e each. The second generator set (no.3 rd and 4 th) with 2 generators capacity of 450 kW _e each are not included in this project boundary.
Flare	Open flare system is available at the plant. This is an automatic flare system that will operate when pressure is higher than 3 mbar. There is also a flame arrester to ensure the safe operation of the flare system.
Auxiliary drives	Total capacity of the auxiliary drives amount to 458 kW; the same can be referred in the GHG calculation sheet as well as in the document submitted during validation.

Table 3: List of equipment included in project boundary

⁹ The evidence has been submitted to the VVB during validation process.

No.	Tag	Description	Motor (HP)
1	ST1	Stirrer - NaoH Tank	3
2	ST2	Stirrer - Mixing tank	3
3	ST3	Stirrer - Pump sump	20
4	Bi1	WW Feed pump	40
5	Bi2	WW Feed pump	40
6	Bi3	WW recycle pump	25
7	Bi4	Sludge recycle pump 1	15
8	Bi5	Sludge recycle pump 2	15
9	Bi6	Reuse water pump	75
10	Bi7	Reuse water pump	40
11	Bi8	Reuse water pump	40
12	OG	Oxygen pumpfor Bio-scrubber	0.25
13	SP	Super pump for gas washer	1
14	FL	Flare	0.25
15	CH 1	Chiller No. 1	12.68
16	CH 2	Chiller No. 2	12.68
17	CH 3	Chiller No. 3	12.68
18	CH 4	Chiller No. 4	12.68
19	CH 5	Chiller No. 5	12.68
20	CLP1	Water pump - CT1	15
21	CLP2	Water pump - CT2	15
22	CLP3	Water pump - CT3	15
23	FBC1	Fan Blower of Cooling Tower 1	5
24	FBC2	Fan Blower of Cooling Tower 2	5
25	FB1	Fan Blower No. 1	0.5
26	FB2	Fan Blower No. 2	0.5
27	FB3	Fan Blower No. 3	1
28	FB4	Fan Blower No. 4	1
29	BA1	Blower air No. 1	5
30	BA2	Blower air No. 2	5
31	BL 1	Gas Blower No. 1	30
32	BL 2	Gas Blower No. 2	30
33	BL 3	Gas Blower No. 3	30
34	BL 4	Gas Blower No. 4	30
35	BL 5	Gas Blower No. 5	30
36	BP1	Spray pump	7.5
37	BP2	Spray pump	7.5
Total - HP			614
Total - kW			458

1.12 Project Location

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

Project's address: 261 Moo 4, Huanakhum, Kranuan, Khonkaen, 40170, Thailand

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



Figure 1: The starch plant location



Figure 2: Project activity boundaries

1.13 Conditions Prior to Project Initiation

Methane avoidance component:

Prior to project initiation, the wastewater from the tapioca processing plant was treated in the cascade of 11 open lagoons (with retention time of around 200 days). The open lagoon system, which has been modified to integrate a closed anaerobic lagoon system, is still in use as secondary treatment of the tapioca raw effluent.

Electricity generation component:

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

Thermal generation component:

Fuel oil was solely used for thermal generation in hot oil boiler. The same boiler is used for combustion of methane in the project scenario.

More details of the baseline scenario can be found in section 3.4.

1.14 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 Industry, Thailand as following.

Laws and regulations	Control on	Demonstration of the compliance
Regulation on the limitation of discharge wastewater	Limit on COD of 120 mg/L of wastewater from starch factory that can be discharge out of the factory	This project did not discharge wastewater outside of the factory, instead the wastewater is used for the washing process or in the plantation area

1.15 Participation under Other GHG Programs

1.15.1 Projects Registered (or seeking registration) under Other GHG Program(s)

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

1.15.2 Projects Rejected by Other GHG Programs

As described in section 1.15.1, the project has not been rejected by any other GHG programs.

1.16 Other Forms of Credit

1.16.1 Emissions Trading Programs and Other Binding Limits

The project does not reduce GHG emissions from activities that are included in an emissions trading program or any other mechanism that includes GHG allowance trading.

1.16.2 Other Forms of Environmental Credit

The project has not sought or received another form of GHG-related environmental credit, including renewable energy certificates.

1.17 Additional Information Relevant to the Project

Leakage Management

This is not applicable.

Commercially Sensitive Information

The project has no commercially sensitive information included in the public version of the project description. Thus, this is not applicable.

Sustainable Development

Legislative:

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

Technical:

The covered lagoon biogas reactor system is implemented for reusing biogas as fuel for heat and electricity generation. As compared to the baseline scenario, the installed wastewater treatment system consists of a highly efficient process for wastewater treatment, which brings about the promotion of new technology in Thailand with replication options.

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

Economic:

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

Sectoral:

The use of CDM approved methodology is applied under the framework of VCS; this is a good example of an effective waste to energy project, which in turn improves the long-term sustainability of the Thai starch industry

Social:

The project activity provides direct and indirect employment to the local community during construction of the project activity as well as during operation. During construction, employment was offered for a lot of local unskilled labors contributing to social wellbeing and economic wellbeing. The involvement of local employees in the project activity helps to enhance the skills of the labour in the region by training them in different technical areas. In addition, the close

collaboration between external experts and local counterparts is expected to promote long-term sustainable partnerships, benefiting the local stakeholders.

The substitution of fuel oil with biogas from the project activity results in increased availability of these fuels in the local market. The noise, arising from pumps and blowers operating in the biogas plant, is insignificant. There are no other occupational health issues identified. The safety aspects of operating the biogas plant are sufficiently addressed.

Environment:

Due to higher efficiency and improved process control, the quality of treated wastewater is expected to improve substantially with the implementation of the project activity. In fact, the biogas reactor system allows the starch factory to recycle the treated effluent in a starch production process; this constitutes sustainability in water supply while ensuring that groundwater shortage should not be a problem for local community. It must be mentioned that the project activity has zero discharge to the river or other natural sources such as soils and groundwater. Note that wastewater overflow might happen during the rainy season if the precipitation rate is higher than the outflow rate of the final pond for a sustained period of time. As can be seen from Figure 2, under Section 1.12, the starch plant and the pond systems are surrounded by agricultural land. Wastewater overflow can lead to a variety of problems that have significant environmental impacts. Excess nutrients in the wastewater stimulate excessive plant growth which can disrupt normal functioning of the ecosystem, known as Eutrophication. Such problem could lead to social conflicts within the community. While wastewater can overflow from any ponds in the old anaerobic lagoon, the overflow can only happen from the post-treatment ponds in the closed anaerobic system. Since the average water quality at the outlet of the project activity is better than that in the anaerobic lagoon ponds, the environmental impacts from overflow of wastewater are significantly reduced. Overall, the project has positive impacts on the local environment by improving air quality through reduction in odour and cleaner emissions. This can in turn improve the standard of living of the local population. The capacity of this technological process to replace fuel oil and generate electricity can also be regarded as a potential for reducing dependency on fossil fuels and for promoting diversification of energy resources. Ensuring energy security in this way can be seen as a contribution to sustainable development, particularly during this era of growing fuel prices.

Geographic/site specific:

The project can be uniquely identified with no barriers regarding logistic. In addition, it is not located in sensitive area such as protected area or where there is any fragile or vulnerable habitats close by. Thus, there are no issues preventing the eligibility of the project in this regard.

Temporal information:

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

Further Information

This section is not applicable.

There is no additional relevant legislative, technical, economic, sectoral, social, environmental, geographic, site-specific and/or temporal information that may have a bearing on the eligibility of the project, the net GHG emission reductions or removals, or the quantification of the project's net GHG emission reductions or removals.

2 SAFEGUARDS

2.1 No Net Harm

There is no negative environmental and socio-economic impact. The project is a renewable energy biogas based thermal and electrical 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.

2.2 Local Stakeholder Consultation

Invitation procedure

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

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

Place and date of meeting

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

Meeting participants

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

1. Local residents
2. Local government representatives

There were 23 participants have attended the meeting.

Language

Documentation and meeting were conducted in Thai (local language)

Meeting procedures

- Opening (10 min)
- Purpose of the consultation (10 min)

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

Meeting documents and protocols

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

1. Presence list with name, address and occupation.
2. Non-technical description of the project
3. Documentation on environmental impacts of the project
4. Filled out Appendix E of Gold Standard (checklist)
5. Notes for additional comments on the project activity

Compilation of comments received

Oral hearing for local stakeholders:

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

- Reduction of methane emission which is a potent Greenhouse gas (GHG);
- Reduction of the odour nuisance associated to the open lagoon wastewater system, improving quality of life and health of surrounding communities
- Conservation of groundwater resources from the use of HDPE lining at the bottom of the lagoons, which can prevent wastewater from contaminating groundwater;
- Reduction in the use of non-renewable energy such as fuel oil, while at the same enhancing energy security by increasing diversity of fuel supply;
- Involvement of local communities through public participation meeting, in which most people encouraged the project activity;
- Increased employment by employing local people to construct and operate the project activity;

- Promoting technological excellence and innovation in Thailand by implementing a cleaner technology solution for wastewater treatment in the tapioca starch sector, which could be replicated across Thailand and the region; and
- Demonstrating the use of a new financial mechanism for funding of waste management projects via carbon credit revenues.

2.3 Environmental Impact

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

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

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

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

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

Wastewater pollution – although Kean Charoen (1) Co., Ltd., has already installed the wastewater treatment system, there are some aspects of environmental impacts that should still be considered, which are:

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

- Wastewater overflow - wastewater overflow might happen during the rainy season if the precipitation rate is higher than the outflow rate of the final pond for a sustained period of time. Wastewater overflow can lead to a variety of problems that have significant environmental impacts. Excess nutrients in the wastewater will stimulate excessive plant growth which can disrupt normal functioning of the ecosystem, known as eutrophication. Such problem could lead to social conflicts within the community. While wastewater can overflow from any ponds in the old anaerobic lagoon, the overflow can only happen from the post-treatment ponds in the closed anaerobic system. Since the average water quality at the outlet of the project activity is better than that in the anaerobic lagoon ponds, the environmental impacts from overflow of wastewater will be significantly reduced.

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

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

2.4 Public Comments

After receiving the comments during the stakeholder consultation process held on 10 July 2008, there were no any comments including environmental, social and economic concerns which cause to change the project design. Hence, the project activity is implemented as an original plan. It can be summarized that the project activity is perceived as a positive example using a covered lagoon wastewater system to treat the wastewater generated from tapioca manufacturing in a cleaner way; and that the project is expected to contribute to sustainable development in Thailand.

For the current practice, the project proponent maintains a register at the plant, to make sure any current feedback is provided by local people in fair and transparent manner.

2.5 AFOLU-Specific Safeguards

The project activity is not AFOLU project. Thus, this section is not required.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

The following approved CDM methodologies are applied to this project activity.

Methane avoidance component:

Type III:	Other project activities
Category III.H:	Methane Recovery in Wastewater Treatment
Sectoral Scope 13:	Waste handling and disposal
Version:	19

Fuel replacement component:

Type I:	Renewable energy projects
Category I.C:	Thermal energy production with or without electricity
Sectoral Scope 1:	Energy industries (renewable /non-renewable sources)
Version:	21

Electricity generation component:

Type I:	Renewable energy projects
Category I.D:	Grid connected renewable electricity generation
Sectoral Scope 1:	Energy industries (renewable /non-renewable sources)
Version:	18

The latest version of the following methodological tools are also used in this Project activity:

- “Project emissions from flaring”, version 03.0;
- “Tool to calculate project or leakage CO2 emissions from fossil fuel combustion”, version 03.0;
- “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”, version 03.0;
- “Tool to calculate the emission factor for an electricity system”, version 07.0;
- “Tool to determine the remaining lifetime of equipment”, version 01;
- “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period”, version 03.0.1;
- “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”, version 03.0

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

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

3.2 Applicability of Methodology

Applicability of AMS-III.H.

The project activity is in line with the approved methodology AMS-III.H., version 19; specific features of project and applicability of the methodology are discussed below:

Applicability Criteria	Project Status
2 This methodology comprises measures that recover methane from biogenic organic matter in wastewaters by means of one, or a combination, of the following options: (a) Substitution of aerobic wastewater or sludge treatment systems with anaerobic system with biogas recovery and combustion; (b) Introduction of anaerobic sludge treatment system with biogas recovery and combustion to a wastewater treatment plant without sludge treatment; (c) Introduction of biogas recovery and combustion to a sludge treatment system; (d) Introduction of biogas recovery and combustion to an anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an on-site industrial plant;¹⁰ (e) Introduction of anaerobic wastewater treatment with biogas recovery and combustion, with or without anaerobic sludge treatment, to an untreated wastewater stream; (f) Introduction of a sequential stage of wastewater treatment with methane recovery and combustion, with or without sludge treatment, to an existing wastewater treatment system without methane recovery (e.g. introduction of treatment in an anaerobic reactor with methane recovery as a sequential treatment step for the wastewater that is presently being treated in an anaerobic lagoon without methane recovery).	In absence of the project activity the wastewater was being treated in open lagoons. These open lagoons have depth greater than 2 meters, without aeration, and the ambient temperature on a monthly average basis being greater than 15°C. In addition, the wastewater generation rate is at around 2,000 m³ day and the COD concentration of the wastewater is at 16,912 mg/L i.e. 16.9 kg/m³. With the minimum interval between two consecutives sludge removal during the baseline scenario also being greater than 30 days, the baseline open lagoons satisfied the anaerobic conditions specified under AMS III.H. (version 19). With the project activity involving the installation of 2 covered lagoons to treat high COD wastewater generated and methane recovery. Therefore, it also satisfies the applicability criterion (f).
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	The wastewater would have been treated in an open anaerobic lagoon in the absence of the project.

¹⁰ Other technologies in Table 6.3 of Chapter 6: Wastewater Treatment and Discharge of 2006 IPCC Guidelines for National Greenhouse Gas Inventories are included.

Applicability Criteria	Project Status
aeration. The value for depth is obtained from engineering design documents, or through direct measurement, or by dividing the surface area by the total volume. If the lagoon filling level varies seasonally, the average of the highest and lowest levels may be taken; (b) Ambient temperature above 15°C, at least during part of the year, on a monthly average basis; (c) The minimum interval between two consecutive sludge removal events shall be 30 days.	(a) The baseline system is 11 anaerobic lagoons with the average depth of 3.2 m which is greater than 2 m; (b) The average atmospheric temperature in the region is 28 degree Celsius¹¹; (c) There was no any sludge removals before the implementation of project activity. The minimum interval is definitely more than 30 days. Therefore, the project activity is applicable for this criterion.
4 The recovered biogas from the above measures may also be utilised for the following applications instead of combustion/flaring: (a) Thermal or mechanical,¹² 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;	The project activity also involves the facility to capture biogas and further to utilize for heat and power generation. Hence, the project activity satisfies the criterion (a).

¹¹ <http://www.e-report.energy.go.th/weather.html> (accessed on 13/03/2020)

¹² For example, combusted in a prime mover such as an engine coupled to a machine such as grinding machine.

Applicability Criteria		Project Status
	(e) Use as fuel in transportation applications after upgrading.	
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 category under Type I.	The recovered biogas is used for heat and power generation as mentioned above and these components of the project activity use the categories under type 1 methodology, i.e., AMS-I.C and AMS-I.D.
6	For project activities covered under paragraph 4(b), if bottles with upgraded biogas are sold outside the project boundary, the end-use of the biogas shall be ensured via a contract between the bottled biogas vendor and the end-user. No emission reductions may be claimed from the displacement of fuels from the end use of bottled biogas in such situations. If, however, the end use of the bottled biogas is included in the project boundary and is monitored during the crediting period CO ₂ emissions avoided by the displacement of fossil fuel can be claimed under the corresponding Type I methodology, e.g. “AMS-I.C.: Thermal energy production with or without electricity”.	The project activity satisfies paragraph 4(a). Therefore, this condition is not relevant to the project activity.
7	For project activities covered under paragraph 4(c)(i), emission reductions from the displacement of the use of natural gas are eligible under this methodology, provided the geographical extent of the natural gas distribution grid is within the host country boundaries.	The project activity satisfies paragraph 4(a). 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 4(a). 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	The project activity satisfies paragraph 4(a). Therefore, this condition is not relevant to the project activity.

	Applicability Criteria	Project Status
	wastewater treatment” shall be followed in this regard.	
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 4(a). 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 4(a). 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 4(a). 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 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.	This is neither a Greenfield project, nor does it result in a capacity addition of the wastewater or sludge treatment system compared to the designed capacity of the baseline treatment system, thus this applicability criterion is of no relevance.
14	The location of the wastewater treatment plant as well as the source of generating the wastewater shall be uniquely defined and described in the PDD.	The unique location of the project activity is clearly defined in section 1.12 of this PD. Similarly, the source of the generating wastewater is well described in section 1.11 and 3.3 in this VCS PD. Hence, this applicability criterion being satisfied.
15	Measures are limited to those that result in aggregate emission reductions of less than or equal to 60 kt CO ₂ equivalent annually	Annual emission reductions from all type III components of the project activity are estimated at 15,625 tCO ₂ , which is lower than the defined cap (60 kt CO ₂ e). Hence,

Applicability Criteria	Project Status
from all type III components of the project activity.	the project activity satisfies this applicability criterion as well.

Applicability of AMS-I.C.

The project activity is in line with the approved methodology AMS-I.C., version 21; specific features of project and applicability of the methodology are discussed below:

Applicability Criteria	Project Status
2 This methodology comprises renewable energy technologies that supply users¹³ 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.	The project activity also involves the facility to capture biogas and further to utilize for heat generation. Therefore, the project activity fulfils this applicability criterion. In addition, the project activity does not involve the co-gen facility.
3 Biomass-based cogeneration and trigeneration systems are included in this category.	Not applicable
4 Emission reductions from a biomass cogeneration or trigeneration system can accrue from one of the following activities: (a) Electricity 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).	The project activity is not a biomass cogeneration system. This is not applicable to the project activity.
5 Project activities that seek to retrofit or modify an existing facility for renewable energy generation are included in the category.	The thermal displacement is only partial. The boiler uses fuel oil and biogas. The burner of the boiler was changed with the project implementation to allow co-firing (fuel oil and biogas).
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 under consideration is not a greenfield project and does represent a capacity expansion compared to the baseline scenario; thus this criterion is not relevant.

¹³ E.g., residential, industrial or commercial facilities.

Applicability Criteria		Project Status
7	The total installed/rated thermal energy generation capacity of the project equipment is equal to or less than 45 MW thermal ¹⁴ .	The total installed/rated thermal energy generation capacity of the project equipment is equal to 10.23 MW _{thermal} , which is less than 45 MW _{thermal} thresholds. Hence, the project activity satisfies this applicability criterion.
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.	The total installed/rated thermal energy generation capacity of the project equipment is equal to 10.23 MW _{thermal} , which is less than 45 MW _{thermal} thresholds. Hence, the project activity satisfies this applicability criterion.
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 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 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 electricity component), the total installed thermal energy production capacity of the project equipment shall not exceed 45 MW thermal; (c) If the emission reductions of the project activity are solely on account of electrical energy production (i.e. no emission reductions accrue from thermal energy component), the total	Not applicable

¹⁴ 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 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.

	Applicability Criteria	Project Status
	installed electrical energy generation capacity of the project equipment shall not exceed 15 MW.	
10	The capacity limits specified in paragraphs 7 to 9 above apply to both new facilities and retrofit projects. In the case of project activities that involve the addition of renewable energy units at an existing renewable energy facility, the total capacity of the units added by the project shall comply with capacity limits specified in the paragraphs 7 to 9, and shall be physically distinct from the existing units.	The total capacity complies with the limit specified in paragraphs 7 to 9.
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.	Not applicable
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 the there is no double-counting of emission reductions.	Not applicable
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.	AMS-I.C. component of this project activity is only applicable to the fuel oil displacement in the starch drying process of Kean Charoen starch plant. Since the project activity and the starch plant belong to the same owner, this applicability criterion is already satisfied.
14	If the project activity recovers and utilizes biogas for producing electricity and/or thermal energy and applies this methodology on a standalone basis i.e. without using a Type III component of a SSC methodology, any incremental emissions occurring due to the implementation of the project activity (e.g. physical leakage of the anaerobic digester, emissions due to inefficiency of the flaring), shall be taken into	The project activity also involves a Type III component of a Small Scale methodology, as the introduction of a wastewater treatment with biogas recovery of the project activity is applicable under the methodology AMS-III.H.

	Applicability Criteria	Project Status
	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).	Not applicable
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.	Not applicable
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.	Not applicable

Applicability of AMS-I.D.

The project activity is in line with the approved methodology AMS-I.D., version 18; specific features of project and applicability of the methodology are discussed below:

Applicability Criteria	Project Status
2 This methodology comprises renewable energy generation units, such as photovoltaic, hydro, tidal/wave, wind, geothermal and renewable biomass: (a) Supplying electricity to a national or a regional grid; or (b) Supplying electricity to an identified consumer facility via national/regional grid through	The project activity uses biogas as fuel to generate electricity. This in turn displaces fossil-fuel based grid electricity by PEA. Therefore, the project activity satisfies this applicability condition.
3 Illustration of respective situations under which each of the methodology (i.e. “AMS-I.D.: Grid connected renewable electricity generation”, “AMS-I.F.: Renewable electricity generation for captive use and mini-grid” and “AMS-I.A.: Electricity generation by the user) applies is included in the appendix.	The project activity uses a part of biogas (a renewable fuel) which is captured from the methane avoidance component of the project activity to generate electricity in the gas engine. The electricity generated will be exported to the national grid. Hence, this can be concluded that the AMS-I.D is the appropriate methodology.
4 This methodology is applicable to project activities that (a) Install a Greenfield plant; (b) Involve a capacity addition; (c) Involve a retrofit of (an) existing plant(s); (d) Involve a rehabilitation of (an) existing plant(s)/unit(s); or (e) Involve a replacement of (an) existing plant(s).	The project activity installed a power plant at a site where there was no renewable energy power plant operating prior to the implementation of the project.
5 Hydro power plants with reservoirs that satisfy at least one of the following conditions are eligible to this methodology: (a) The project activity is implemented in an existing reservoir with no change in the volume of reservoir; (b) The project activity is implemented in an existing reservoir, where the volume of reservoir is increased and the power density of the project activity, as per	Not applicable

	Applicability Criteria	Project Status
	definitions given in the project emissions section, is greater than 4 W/m²; (c) The project activity results in new reservoirs and the power density of the power plant, as per definitions given in the project emissions section, is greater than 4 W/m².	
6	If the new unit has both renewable and non-renewable components (e.g. a wind/diesel unit), the eligibility limit of 15 MW for a small-scale CDM project activity applies only to the renewable component. If the new unit co-fires fossil fuel, the capacity of the entire unit shall not exceed the limit of 15 MW.	The generation sets used in the project activity are used only for the combustion of biogas. The renewable component has a total generation capacity of an approximate 1.904 MW_e. Hence, the project activity satisfies the applicability condition.
7	Combined heat and power (co-generation) systems are not eligible under this category.	Not applicable
8	In the case of project activities that involve the addition of renewable energy generation units at an existing renewable power generation facility, the added capacity of the units added by the project should be lower than 15 MW and should be physically distinct from the existing units.	Not applicable
9	In the case of retrofit, rehabilitation or replacement, to qualify as a small-scale project, the total output of the retrofitted, rehabilitated or replacement power plant/unit shall not exceed the limit of 15 MW.	Not applicable
10	In the case of landfill gas, waste gas, wastewater treatment and agro-industries projects, recovered methane emissions are eligible under a relevant Type III category. If the recovered methane is used for electricity generation for supply to a grid then the baseline for the electricity component shall be in accordance with procedure prescribed under this methodology. If the recovered methane is used for heat generation or cogeneration other applicable Type-I methodologies such as “AMS-I.C.: Thermal energy production with or without electricity” shall be explored.	The approved baseline and monitoring methodologies AMS-I.C. and AMS-I.D. are used for the thermal and electricity generation components of the project activity.
11	In case biomass is sourced from dedicated plantations, the applicability criteria in the	Not applicable

Applicability Criteria		Project Status
	tool “Project emissions from cultivation of biomass” shall apply.	

3.3 Project Boundary

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

Source	Gas	Included?	Justification/Explanation
On-site electricity use	CH ₄	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	N ₂ O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	CO ₂	Excluded	Excluded as per the methodology deviation. This is conservative.
	CH ₄	Excluded	Excluded for simplification. This is conservative
	N ₂ O	Excluded	Excluded for simplification. This is conservative

The flow diagram of the development of biogas system is shown step-by-step in these figures below.

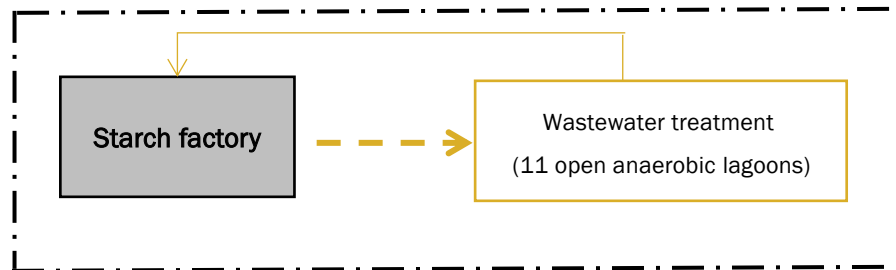


Figure 3: The baseline system boundary

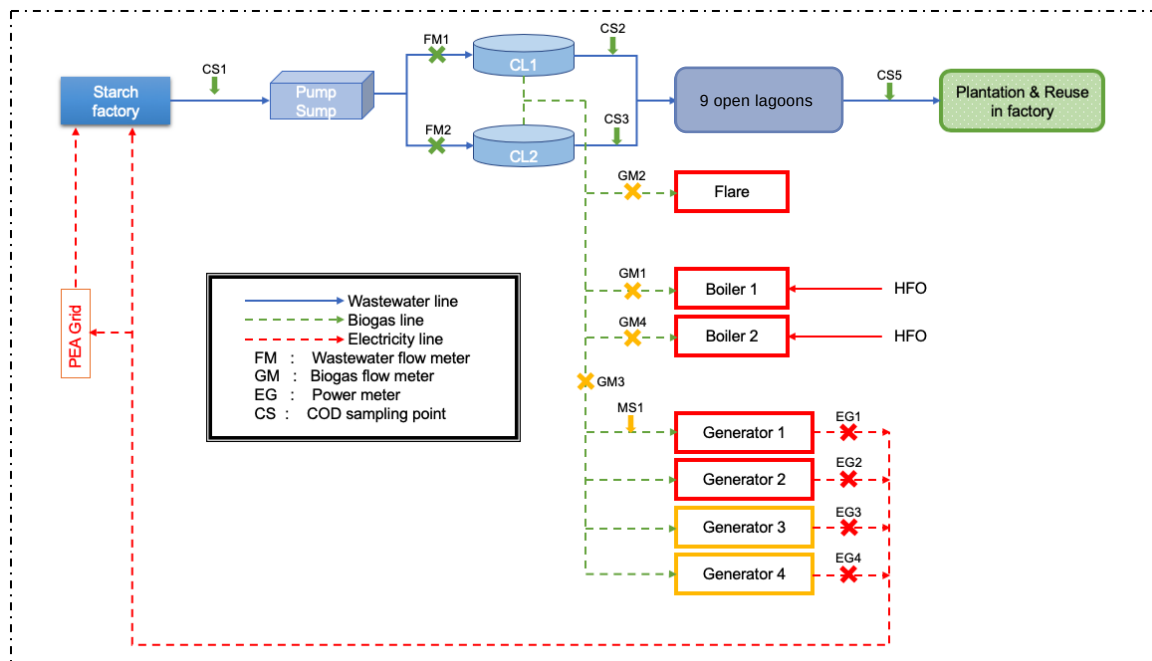


Figure 4: The project system boundary

3.4 Baseline Scenario

With the references to the VCS standard (version 4), section 3.8.8 “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), thermal generation component (AMS-I.C) and electricity generation component (AMS-I.D)

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 3.8.9 of VCS standard, version 4, the regular surplus for the project has been demonstrated in the section 1.14 of this PD. The project description is updated accordingly. The additionality as mentioned in section 3.5 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 3.8.9 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 ¹⁵ . 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	The project description is updated and revised according to the latest approved version of AMS-

¹⁵ https://www.jetro.go.jp/ext_images/thailand/pdf/MOIEffluentStandards2560.pdf

Assessment as per VCS standard	Justification
validation. Such updates shall be based upon the latest approved version of the methodology or its replacement. Where the project does not meet the requirements of the latest approved version of the methodology or its replacement, the project proponent shall select another applicable approved methodology (which may be a new methodology or methodology revision it has had approved via the methodology approval process), or shall apply a methodology deviation (where a methodology deviation is appropriate). Failing this, the project shall not be eligible for renewal of its project crediting period.	III.H, AMS-I.C and AMS-I.D including the relevant tools to the applied methodologies.

Methane avoidance component:

At the project location, open anaerobic lagoons without biogas recovery represent the existing wastewater treatment system and methane recovery and combustion system is being introduced to an existing anaerobic wastewater treatment system (as defined under applicability conditions for project activity measures under Paragraph 2 (f) of the applied methodology, see section 3.2 above).

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

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

Table 4: Open lagoons (prior to project implementation)

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

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 19 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 5: 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 3.4. 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 ¹⁶ .
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.
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 ¹⁷ . The technical lifetime of baseline system exceeds the crediting period for which renewal is requested.

¹⁶ https://www.jetro.go.jp/ext_images/thailand/pdf/MOIEffluentStandards2560.pdf

¹⁷ Cinara, 2004 “Waste stabilization ponds for wastewater treatment, International Water and Sanitation Centre”

<http://www.irc.nl/page/8237>

Table 5: the validity of original baseline for methane avoidance component	
Assessment as per CDM tool	Justification
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 energy generation component:

Thermal energy is necessary in the process of starch drying. In the absence of project activity, this process would have been done through utilization of fuel oil. A deviation in coherence with paragraphs 34 and 24 (c) of AMS.I.C version 21 is used to calculate the baseline emissions from this component. Refer to section 5.1 for further explanation. For reference, an average fuel oil consumption over the period between the years 2005-2006 (pre-project period) is calculated at 0.0396 liters per kg of dry starch.

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 6: 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	The identified baseline scenario at the validation of this project was the continuation of

Table 6: the validity of original baseline for thermal energy production component	
Assessment as per CDM tool	Justification
investment is the most likely scenario for the crediting period for which renewal is requested.	the use of fossil fuel in thermal oil boiler as there was no mandatory national and/or sectoral policies requirement for replacement of fuel used in the starch production process. The technical lifetime of the replaced thermal oil boiler 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.
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.

Electricity generation component

In accordance to Paragraph 10 of the methodology AMS-I.D. (Version 18), with this project activity being a wastewater treatment project and the recovered biogas is used for electricity generation, the baseline shall be calculated using Paragraph 22 in the methodology:

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

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

- (a) A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the ‘Tool to calculate the emission factor for an electricity system’. or
- (b) The weighted average emissions (in kg CO₂e/kWh) of the current generation mix. The data of the year in which project generation occurs must be used. Calculations must be based on data from an official source (where available) and made publicly available.”

The project activity uses combined margin approach as the same is made available by official source¹⁸ by Thailand Greenhouse Gas Management Organization (Public Organization). The approach is selected since the data and estimation is made available by a national authority.

¹⁸ <http://ghgreduction.tgo.or.th/download-tver/68-2017-11-28-06-43-22/353-2559.html>

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 7: the validity of original baseline for electricity generation 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	In Thailand, there is no mandatory national and/or sectoral policies requirement for the implementation of power generation at a wastewater treatment plant. The electricity generated in the project would have been generated in the grid, which is primarily based on fossil fuel. Therefore, it is assessed that the current baseline for the electricity generation component is in compliance with regulation.
Step 1.2: Assess the impact of circumstances	There is no change in the circumstance that would impact the continuation of electricity from national grid 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 identified baseline scenario at the validation of this project was the continuation of the use of electricity from national grid, which is mainly generated by fossil fuel fired power plants. The technical lifetime of electricity generation 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 update is undertaken; (a) Emission factor of electricity system (EF _y)
Outcome: the justification provided in step 1 demonstrates that the current baseline scenario for electricity generation 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.

3.5 Additionality

For projects renewing the crediting period, no re-assessment of additionality is required according to paragraph 3.8.9 of VCS standard, version 4. The additionality was assessed in the

former registered PD. In addition, the original baseline scenario is valid as per the justification provided in section 3.4. 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 1.14. 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.

3.6 Methodology Deviations

Determination of $EG_{thermal}$

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

As per paragraph 34, AMS-I.C version 21, for steam/heat produced using fossil fuels, the baseline emissions are calculated as;

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

Where:

$EG_{thermal,CO2,y}$	Net quantity of steam/heat supplied by the project activity during the year y in TJ
$EF_{FF,CO2}$	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, alternatively, IPCC default emission factors can be used.
$\eta_{BL,thermal}$	Efficiency of the plant using fossil fuel that would have been used in the absence of the project activity

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

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

The statements above can be confirmed through interview with technical expert if necessary. In addition, the energy balance for a particular year, considering amount of biogas and fossil fuel used, would easily justify the assumption that energy input required in dual fuel system is higher than in baseline system. Assuming an approximate 10% loss in efficiency, the assumption to replace 100% fuel oil usage is conservative.

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

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

Deviation 1

Where:

$Q_{\text{starch}, y}$ Quantity of dry starch produced in year "y" (tonnes)
 $Q_{\text{FO}, \text{starch}}$ Quantity of fossil fuel per unit of dry starch (liter/tonne)

$q_{FO,y}$	Quantity of fossil fuel consumed at the project site in year “y” (litres)
D_{FO}	Density of fossil fuel (kg/litre)
NCV_{FO}	Net Calorific value of the fuel oil (TJ/ton)

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

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

The project follows the AMS-III.H small scale methodology for Methane Recovery in Wastewater Treatment, Version 19, to estimate the amount of GHG emitted into the atmosphere. The project also uses AMS-I.C. small scale methodology (Version 21) for Thermal energy emissions as well as AMS-I. D. (Version 18) for calculating emission from fossil-fuel based grid-connected electricity.

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

Baseline Emissions for AMS-III.H:

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

Where:

BE_y	Baseline emissions in year y (t CO ₂ e)
$BE_{power,y}$	Baseline emissions from electricity or fuel consumption in year y (t CO ₂ e)
$BE_{ww,treatment,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (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 (t CO 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

BE_{power,y}:

The baseline emissions from electricity and fossil fuel consumption are not considered. The power consumed in baseline case is negligible and is ignored for conservative estimation of baseline emissions. No fossil fuels have been consumed in the operation of the open anaerobic lagoons in the baseline scenario, therefore, the baseline emissions from fuel consumption are zero as.

Therefore, BE_{power,y} is assumed zero and removed from further consideration.

BE_{ww,treatment,y}:

Methane emissions from the baseline wastewater treatment systems affected by the project are determined using the COD removal efficiency of the baseline plant:

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

Where:

$Q_{ww,i,y}$	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 (t/m ³). Average value may be used through sampling with the confidence/precision level 90/10
$\eta_{COD,BL,i}$	COD removal efficiency of the baseline treatment system i
$MCF_{ww,treatment,BL,i}$	Methane correction factor for baseline wastewater treatment systems i
i	Index for baseline wastewater treatment system
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC value of 0.25 kgCH ₄ /kg COD)
UF_{BL}	Model correction factor to account for model uncertainties (0.89)
GWP_{CH4}	Global Warming Potential for methane

BE_{ww,discharge,y}:

In the baseline scenario, treated wastewater is not discharged into sea/lake/river, therefore methane emissions from degradable organic carbon in treated wastewater discharged (BE_{ww,discharge,y}) is taken as zero.

BE_{s,treatment,y} and BE_{s,final,y}:

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

Baseline Emissions for AMS-I.D

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

$$BE_{elec,y} = EG_{PJ,y} \times EF_{grid,y}$$

Where:

BE_y	Baseline emissions in year y (t CO ₂)
$EG_{PJ,y}$	Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity in year y (MWh)
$EF_{grid,y}$	Combined margin CO ₂ emission factor for grid connected power generation in year y (t CO ₂ /MWh)

Baseline Emissions for AMS-I.C

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

According to paragraph 34 of AMS-I.C., the baseline emissions are estimated based on the amount of heat/steam delivered by the equipment (as per equation below).

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

However, the deviation explained in section of the PD takes into account the baseline efficiencies and a simplified approach is explained here to estimate the baseline emissions, the approach is based on historical consumption of fuel oil per tonne of starch generation. This is based on the methodology deviation provided in section 3.6.

Quantifying GHG emission and/or removals for the baseline scenario

The following table provides details of ex-ante estimation of baseline emissions for the project activity. More details can be found in the calculation spreadsheet for the emission reductions.

The main calculation parameters and results are provided below:

Methodology: AMS-III.H (Methane avoidance component)		
Formula:		
$BE_{ww,treatment,y} = \sum (Q_{ww,i,y} \times COD_{inflow,i,y} \times \eta_{COD,BL,i} \times MCF_{ww,treatment,BL,i}) \times B_{o,ww} \times UF_{BL} \times GWP_{CH4}$		
$Q_{ww,i,y}$	441,833 m ³	Based on design value of wastewater treated: 2,000 m ³ /day and 225 operating days/year
$COD_{inflow,i,y}$	16,913 mg/l	Historical average COD in covered lagoon
$\eta_{COD,BL,i}$	87.16%	Based on 10-days measurement campaign multiply by 0.89 conservative factor
$MCF_{ww,treatment,BL,i}$	0.8	Default value for anaerobic deep lagoons

B _{o,ww}	0.25 kgCH ₄ /kg COD	Default value
UF _{BL}	0.89	Model correction factor from AMS-III.H
GWP _{CH4}	25	Default value
Calculation: BE_{ww,treatment,y} = (441,833 x 0.016913 x 87.16% x 0.8) x 0.25 x 0.89 x 25 = 28,983 tCO_{2e}		
Methodology: AMS-I. C (Fuel replacement component)		
Formula: $BE_{thermal,CO2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) \times EF_{FF,CO}$ $= (Q_{starch,y} \times Q_{FO,starch} - q_{FO,y}) \times D_{FO} \times NCV_{FO} \times EF_{CO2} / 10^6$		
Q _{FO}	661.25 tonnes	Quantity of residual fuel oil is back calculated from the amount of biogas expected to be utilised for thermal production i.e. 1,351,045 Nm ³ /y. $(Biogas_{boiler} \times NCV_{biogas}) / NCV_{FO}$ $= (1,351,045 \times 20.93) / 42.763 / 1,000$
NCV _{FO}	42.763 GJ/tonne	Energy Situation Report of January to August 2019 published by the Department of Alternative Energy Development and Efficiency, Ministry of Energy
EG _{thermal, y}	28.28 TJ	Calculated from amount of HFO displaced: $Q_{FO} \times NCV_{FO}$ $= (661.25 \times 42.76) / 1,000$
η _{bl, thermal}	100%	Assume at 100% for conservativeness
EF _{CO2}	77.4 tCO ₂ /TJ	Emission factor of fossil fuel replaced (IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23)
Calculation: BE_{thermal,CO2,y} = (28.28/100%) x 77.4) = 2,187 tCO_{2e}		
Methodology: AMS-I.D (Power generation component)		
Formula: $BE_{elec,y} = EG_{PJ,y} \times EF_{grid,y}$		
EG _{PJ,y}	2,672.21 MWh	Based on info available for gas engines and biogas used for generation process, efficiency of gas engine and NCV of biogas as well as accounting for 10% losses in power generation $= 1,351,045 \text{ Nm}^3 \times 20,930 \text{ kJ/m}^3 \times 0.378 / 3600 \times$

		90%
$EF_{grid,y}$	0.5637 tCO ₂ /MWh	Grid emission factor
Calculation: $BE_{elec,y} = 2,672.21 \times 0.5637 = 1,506 \text{ tCO}_2e$		

4.2 Project Emissions

Project Emissions for AMS-III.H:

Project emissions are the sum of emissions from the wastewater treatment systems affected by the project and not equipped with biogas recovery, methane fugitive emissions on account of inefficiencies in capture systems, methane emissions due to incomplete flaring, CO₂ emissions on account of power and fuel used by the project activity facilities (calculated according to AMS-III.H- version 19.0, paragraph 39).

$$PE_y = PE_{power,y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y}$$

Where:

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

$PE_{power,y}$:

Emissions from electricity consumption by the project activity facilities are calculated based on the paragraph 26 of AMS-III.H., whereas $PE_{power,y}$ shall be estimated according to the “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”, version 03.0 as given below.

$$PE_{power,y} = \sum EC_{PJ,j,y} \times EF_{EL,j,y} \times (1+TDL_{j,y})$$

Where:

$EC_{PJ,j,y}$	Electricity consumption by the project activity (MWh)
$EF_{EL,j,y}$	Thailand National Grid emission factor (tCO ₂ e/MWh)
$TDL_{j,y}$	Average technical transmission and distribution losses for providing electricity to source j in year y
j	Source of electricity consumption in the project

In the absence of electric meter for the electricity consumption of project activity, maximum rated consumption shall be used to calculate the emissions from PE_{power} as follows:

$$PE_{power,y} = \sum P_{el} * (100\% + TDL_{j,y}) * 8,760 * EF_{EL,j,y} / 1000$$

Where:

P_{el}	Total electrical capacity of the equipments installed in the project activity (kW) – for reference, this is 458 kW for this project activity.
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Taking into account the distribution losses, 20% has been applied to the total electricity consumption for the sake of simplicity and conservative. As well, the calculated electricity consumption is based on an assumption that the electrical appliances will be running at full capacity for the entire year.

$PE_{ww,treatment,y}$:

Methane emissions from wastewater treatment systems affected by the project activity are calculated as per the paragraph 27, AMS-III.H. The following equation is used.

$$PE_{ww,treatment,y} = \sum (Q_{ww,k,y} \times COD_{inflow,k,y} \times \eta_{PJ,k,y} \times MCF_{ww,treatment,PJ,k}) \times B_{o,ww} \times UF_{PJ} \times GWP_{CH4}$$

Where:

$Q_{ww,k,y}$	Volume of wastewater treated in baseline wastewater treatment system k in year y (m ³)
$COD_{inflow,k,y}$	Chemical oxygen demand of the wastewater inflow to the project treatment system k in year y (t/m ³).
$\eta_{PJ,k,y}$	COD removal efficiency of the baseline treatment system k
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for project wastewater treatment systems k
k	Index for project wastewater treatment system
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC value of 0.25 kgCH ₄ /kg COD)
UF_{PJ}	Model correction factor to account for model uncertainties (1.12)
GWP_{CH4}	Global Warming Potential for methane

PE_{s,treatment,y}:

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

PE_{ww,discharge,y}:

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

PE_{s,final,y}:

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

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

PE_{fugitive,y}:

Project activity emissions from methane release in capture systems are determined as per paragraph 40 (a) of AMS-III.H., as given below.

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

Where:

$PE_{fugitive,ww,y}$	Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year y (t CO ₂ e)
$PE_{fugitive,s,y}$	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y (t CO ₂ e)

These emissions are calculated as follow:

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

Where:

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

$$MEP_{ww,treatment,y} = Q_{ww,y} \times B_{o,ww} \times UF_{PJ} \times \sum COD_{removed,PJ,k,y} \times MCF_{ww,treatment,PJ,k}$$

Where:

$COD_{removed,PJ,k,y}$	The chemical oxygen demand removed by the treatment system k of the project activity equipped with biogas recovery in the year y (t/m ³)
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for the project wastewater treatment system k equipped with biogas recovery equipment
UF_{PJ}	Model correction factor to account for model uncertainties (1.12)

PE_{fugitive,s,y}:

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

PE_{biomass,y}:

Biomass storage is not envisaged in the project activity. Therefore methane emissions from biomass stored under anaerobic conditions which does not take place in the baseline situation are omitted.

PE_{flaring,y}:

Methane emissions due to incomplete flaring in year y are calculated as per the “Tool to determine project emissions from flaring gases containing methane” (tCO_{2e}). The project proponent has installed an open flare system. The calculation procedures provided below determine the project emissions from flaring the residual gas (PE_{flare,y}) based on the flare efficiency ($\eta_{flare,m}$) and the mass flow of methane to flare ($F_{CH4,RG,m}$). The flare efficiency is determined for each minute m of year y based either on monitored data or default values.

The project emissions calculation procedure is given in the following steps:

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

This step determines the mass flow of methane ($F_{CH4,m}$) 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 greenhouse gas in a gaseous stream”, version 03.0.

$F_{CH4,RG,m}$, 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 ($F_{CH4,RG,m}$). $F_{CH4,m}$ shall be determined on a dry basis. Therefore, the measurement option A as per the Table 2 of the tool is selected to determine the volume flow and the volumetric fraction of the residue gaseous stream on the dry basis. As per the condition of the gaseous stream, the temperature (T_t) is required at ambient condition¹⁹, which is less than 60 deg C at the flow measurement point. Therefore, as per Option A (b), the gaseous stream is considered dry.

¹⁹ The average ambient temperature of Province by the Energy Policy and Planning Office, Ministry of Energy. Available from: <http://www.e-report.evenergy.go.th/weather.html>

$F_{CH_4,m}$ is determined as following equation;

$$F_{CH_4,m} = V_{m,db} \times V_{CH_4,m,db} \times \rho_{CH_4,m}$$

Where:

$F_{CH_4,m}$	Mass flow of greenhouse gas CH ₄ in the residual gaseous stream in the minute m (kg gas/m)
$V_{m,db}$	Volumetric flow of the residual gaseous stream in minute m on dry basis (Nm ³ dry gas/m)
$V_{CH_4,m,db}$	Volumetric fraction of the greenhouse gas CH ₄ in the gaseous stream in minute m on dry basis (%)
$\rho_{CH_4,m}$	Density of greenhouse gas CH ₄ in the gaseous stream in minute m (0.716 kg/m ³) at reference conditions

Step 2: Determination of flare efficiency

As per the tool, for the open flare, the default value must be applied. In the case of open flare, the flare efficiency in the minute m ($\eta_{flare,m}$) is 50% when the flame is detected in the minute m (Flame_m), otherwise $\eta_{flare,m}$ is 0%.

Step 3: Calculation of project emissions from flaring

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

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

Where:

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

Project Emissions for AMS-I.D:

As per AMS-I.D., paragraph 39, for the most renewable energy project activity, $PE_y = 0$. The project emission under AMS-I.D are considered zero.

Quantifying GHG emission and/or removals for the project scenario

The following table provides details of ex-ante estimation of project emissions for the project activity. More details can be found in the calculation spreadsheet for the emission reductions.

The main calculation parameters and results are provided below:

Methodology: AMS-III.H (Methane avoidance component)		
Emissions in wastewater treatment system without biogas recovery		
Formula: $PE_{ww,treatment,y} = \sum (Q_{ww,k,y} \times COD_{inflow,k,y} \times \eta_{PJ,k,y} \times MCF_{ww,treatment,PJ,k}) \times B_{o,ww} \times UF_{PJ} \times GWP_{CH4}$		
$Q_{y, ww}$	441,833 m ³	Based on design value of wastewater treated: 2,000 m ³ /day and 225 operating days/year
$COD_{inflow,k,y}$	0.00338	Based on COD removal by lagoon system after the project activity
$\eta_{PJ,k,y}$	87.16%	Based on 10-days measurement campaign multiply by 0.89 conservative factor
$MCF_{ww,treatment,PJ,k}$	0.8	Default value
$B_{o,ww}$	0.25kg CH ₄ /kg COD	Default value
UF_{PJ}	1.12	Model correction factor from AMS-III.H.
GWP_{CH4}	25	Default value
Calculation: $PE_{ww,treatment,y} = (441,833 \times 0.00338 \times 87.16\% \times 0.8) \times 0.25 \times 1.12 \times 25 = 7,295 \text{ tCO}_2 \text{ e}$		
Fugitive emissions in wastewater treatment system with biogas recovery		
Formula: $PE_{fugitive,ww,y} = (1 - CFE_{ww}) \times MEP_{ww,treatment,y} \times GWP_{CH4}$		
CFE_{ww}	0.9	Default value
$MEP_{ww,treatment,y}$	1,339 tonnes	Methane emission potential of wastewater treatment systems equipped with biogas recovery: $MEP_{ww,treatment,y} = Q_{ww,y} \times B_{o,ww} \times UF_{PJ} \times \sum COD_{removed,PJ,k,y} \times MCF_{ww,treatment,PJ,k}$ $= 441,833 \times 0.25 \times 1.12 \times 0.01353 \times 0.8$
GWP_{CH4}	25	Default value
Calculation:		

PE_{fugitive,ww,y} = 1,339 x (1-0.9) x 25 = 3,348 tCO₂ e		
Methodology: AMS-I.D (Power generation component)		
Formula: $PE_{power,y} = \sum EC_{PJ,j,y} \times EF_{EL,j,y} \times (1+TDL_{j,y})$		
EC _{PJ,j,y}	4,012 MWh	Based on power capacity installed (458 kW) at 8,760 hours
EF _{EL,j,y}	0.5637 tCO ₂ /MWh	Grid emission factor of Thailand
TDL _{j,y}	20%	Default value
Calculation: $PE_{power,y} = 4,012 \times 0.5637 \times (1+20\%) = 2,714 \text{ tCO}_2\text{e}$		
Methane emissions due to incomplete flaring		
Formula: $PE_{flare,y} = GWP_{CH_4} \times \sum_{m=1}^{525600} F_{CH_4, RG, m} \times (1 - \eta_{flare, m}) \times 10^{-3}$		
$\eta_{flare, m}$	0.5	Efficiency of the open flare
$F_{CH_4, RG, m}$	0 kg	No biogas flared (only emergency)
Calculation: $PE_{flare,y} = (0 \times (1-0.5) \times 25) / 1,000 = 0 \text{ tCO}_2\text{e}$		

4.3 Leakage

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

4.4 Net GHG Emission Reductions and Removals

Overall emission reductions are calculated as the sum of all three project components under methodologies AMS-III.H, AMS-I.C and AMS-I.D described below.

AMS-III.H

As per the guidance given in the paragraph 44 of AMS-III.H, ex post emission reductions shall be based on the lowest value of the following:

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

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

As per paragraph 45 of AMS-III.H, in the case of flaring/combustion MD_y will be measured using the conditions of the flaring process:

$$MD_y = BG_{burnt,y} \times w_{CH4,y} \times D_{CH4} \times FE \times GWP_{CH4}$$

Where:

$BG_{burnt,y}$	Biogas flared/combusted in year y (m^3)
$w_{CH4,y}$	Methane content of the biogas in the year y (volume fraction)
D_{CH4}	Density of methane at the temperature and pressure of the biogas in the year y (t/m^3)
FE	Flare efficiency in year y (fraction). If the biogas is combusted for gainful purposes, e.g. fed to an engine, an efficiency of 100 per cent may be applied

AMS-I.C and AMS-I.D

As per the paragraph 81 of AMS-I.C, version 21.0, and paragraph 43 of AMS-I.D, version 18.0, emission reductions are estimated based on the formulas described in baseline, project and leakage emissions sections above, as follows:

$$ER_y = BE_y - PE_y - LE_y$$

Where:

ER_y	Emission reductions in year y (tCO_2e)
BE_y	Baseline emissions in year y (tCO_2e)
PE_y	Project emissions in year y (tCO_2e)
LE_y	Leakage emissions in year y (tCO_2e)

After calculating the ER_y under each project component, the sum of all three values amounts to total ex ante emission reductions achieved by the project activity.

Total ex ante estimates of emission reductions:

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
Year 2019 (15-July-2019 to 31-December-2019)	17,699	7,235	0	10,464
Year 2020	32,676	13,357	0	19,319
Year 2021	32,676	13,357	0	19,319
Year 2022	32,676	13,357	0	19,319
Year 2023	32,676	13,357	0	19,319
Year 2024	32,676	13,357	0	19,319
Year 2025	32,676	13,357	0	19,319
Year 2026	32,676	13,357	0	19,319
Year 2027	32,676	13,357	0	19,319
Year 2028	32,676	13,357	0	19,319
Year 2029 (01-January-2029 to 14-July-2029)	14,976	6,122	0	8,854
Total	326,759	133,570	0	193,189

Methane avoidance component, AMS-III.H version 19.0:

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
Year 2019	15,699	7,235	0	8,464

(15-July-2019 to 31-December-2019)				
Year 2020	28,983	13,357	0	15,626
Year 2021	28,983	13,357	0	15,626
Year 2022	28,983	13,357	0	15,626
Year 2023	28,983	13,357	0	15,626
Year 2024	28,983	13,357	0	15,626
Year 2025	28,983	13,357	0	15,626
Year 2026	28,983	13,357	0	15,626
Year 2027	28,983	13,357	0	15,626
Year 2028	28,983	13,357	0	15,626
Year 2029 (01-January-2029 to 14-July-2029)	13,283	6,122	0	7,161
Total	289,829	133,570	0	156,259

Heat generation component, AMS-I.C version 21.0:

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
Year 2019 (15-July-2019 to 31-December-2019)	1,185	0	0	1,185
Year 2020	2,187	0	0	2,187

Year 2021	2,187	0	0	2,187
Year 2022	2,187	0	0	2,187
Year 2023	2,187	0	0	2,187
Year 2024	2,187	0	0	2,187
Year 2025	2,187	0	0	2,187
Year 2026	2,187	0	0	2,187
Year 2027	2,187	0	0	2,187
Year 2028	2,187	0	0	2,187
Year 2029 (01-January-2029 to 14-July-2029)	1,002	0	0	1,002
Total	21,870	0	0	21,870

Electricity generation component, AMS-I.D version 18.0:

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
Year 2019 (15-July-2019 to 31-December-2019)	816	0	0	816
Year 2020	1,506	0	0	1,506
Year 2021	1,506	0	0	1,506
Year 2022	1,506	0	0	1,506
Year 2023	1,506	0	0	1,506
Year 2024	1,506	0	0	1,506

Year 2025	1,506	0	0	1,506
Year 2026	1,506	0	0	1,506
Year 2027	1,506	0	0	1,506
Year 2028	1,506	0	0	1,506
Year 2029 (01-January-2029 to 14-July-2029)	690	0	0	690
Total	15,060	0	0	15,060

5 MONITORING

5.1 Data and Parameters Available at Validation

Data / Parameter	GWP _{CH4}
Data unit	tCO ₂ e/tCH ₄
Description	Global warning potential for methane
Source of data	According EB 69 - Annex 3, the second commitment period GWP shall be effective from 01/01/2013
Value applied	25
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline and project emissions.
Comments	-

Data / Parameter	B _{0,ww}
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Data unit	kg CH ₄ /kg COD
Description	Methane producing capacity of the wastewater
Source of data	IPCC default value as per methodology AMS III-H version 19.0
Value applied	0.25
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline and project emissions.
Comments	-

Data / Parameter	UF _{BL}
Data unit	-
Description	Model correction factor to account of model uncertainties
Source of data	AMS-III.H version 19.0; Reference: FCCC/SBSTA/2003/10/Add.2, page 25
Value applied	0.89
Justification of choice of data or description of measurement methods and procedures applied	As per AMS-III.H
Purpose of Data	Calculation of baseline emissions.
Comments	-

Data / Parameter	UF _{PJ}
Data unit	-
Description	Model correction factor to account of model uncertainties
Source of data	AMS-III.H version 19.0
Value applied	1.12

Justification of choice of data or description of measurement methods and procedures applied	As per AMS-III.H
Purpose of Data	Calculation of project emissions.
Comments	-

Data / Parameter	$MCF_{ww,treatment,BL,lagoon}$
Data unit	-
Description	Methane correction factor for the baseline anaerobic wastewater treatment systems
Source of data	Table 2 from AMS-III.H, version 19.0, IPCC default values
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	The baseline wastewater treatment system consists of a succession of anaerobic deep lagoons (depth more than 2 metres) therefore the MCF value is chosen as 0.8
Purpose of Data	Calculation of baseline emissions.
Comments	-

Data / Parameter	$MCF_{ww,treatment,PJ,lagoon}$
Data unit	-
Description	Methane correction factor for project wastewater treatment system k
Source of data	Table 2 from AMS-III.H, version 19.0, IPCC default values
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	In the project scenario the post treatment of wastewater treatment system without biogas recovery consists of a succession of lagoons, with depth greater than 2 metres, thus the value of 0.8 has been chosen.
Purpose of Data	Calculation of project emissions.

Comments	IPCC Default values from chapter 6 of volume 5. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.					
Data / Parameter	COD removal efficiency – baseline					
Data unit	%					
Description	COD removal efficiency of the baseline system					
Source of data	Measured – Colorimetric analysis historical values					
Value applied	87.16%					
Justification of choice of data or description of measurement methods and procedures applied	The COD removal efficiency is based, on COD values for baseline system before implementation of project activity. The COD reduction across the baseline treatment system is multiplied by a factor of 0.89 for conservative estimation of baseline emissions. Actual reduction across the system is approximately 97.93% ²⁰ .					
	Sample No.	Parameters	Unit	COD inlet	COD outlet	%COD removal
	1	COD	mg/L	15,690	235	98.50%
	2	COD	mg/L	17,845	295	98.35%
	3	COD	mg/L	17,930	375	97.91%
	4	COD	mg/L	14,290	270	98.11%
	5	COD	mg/L	18,065	345	98.09%
	6	COD	mg/L	16,370	390	97.62%
	7	COD	mg/L	16,710	230	98.62%
	8	COD	mg/L	19,100	375	98.04%
	9	COD	mg/L	17,355	485	97.21%
	10	COD	mg/L	15,770	490	96.89%
	Average COD			16,913	349	97.93%
	Purpose of Data	Calculation of baseline and project emissions				
Comments	-					

²⁰ COD measurement records can be used to substantiate this value. Water analysis reports showing the quality of treated wastewater during pre-project scenario has been submitted to the DOE.

Data / Parameter	CFE _{ww}
Data unit	Fraction
Description	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems
Source of data	AMS-III.H, version 19.0
Value applied	0.9
Justification of choice of data or description of measurement methods and procedures applied	Default value as per AMS-III.H, version 19.0
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	EF _{grid,y}
Data unit	tCO ₂ e/MWh
Description	Combined margin CO ₂ emission factor for grid connected power generation in year y
Source of data	A Study on Thailand Grid Emission Factor by Thai DNA
Value applied	0.5637
Justification of choice of data or description of measurement methods and procedures applied	The study of the estimation of grid emission factor is carried out by Thai DNA in accordance with the Methodological Tool: Tool to calculate the emission factor for an electricity system. The choice of data has been detailed in the published study by Thai DNA ²¹ .
Purpose of Data	Calculation of baseline and project emissions
Comments	-

Data / Parameter	EF _{HFO,CO2}
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²¹ The latest study in 2017 is available at the time of validation for renewable of crediting period.

<http://ghgreduction.tgo.or.th/download-tver/68-2017-11-28-06-43-22/353-2559.html> (accessed on 13/03/2020)

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 tCO ₂ /TJ
Justification of choice of data or description of measurement methods and procedures applied	IPCC default values used for unavailability of national data. In pre-project scenario the residual fuel oil has been main source of thermal energy for the processes.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	NCV _{HFO}
Data unit	GJ/tonne
Description	Net calorific value of heavy fuel oil
Source of data	Page 4 of the Energy Situation Report of January to August 2019 published by the Department of Alternative Energy Development and Efficiency, Ministry of Energy ²²
Value applied	42.763
Justification of choice of data or description of measurement methods and procedures applied	The data source (c) Regional or national default values as per the applied tool “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”, version 03. The value based on the Energy Situation Report is 39.77 MJ/l. The density of heavy fuel oil 0.93 kg/l is applied for net calorific value. = 39.77 MJ/l / 0.93 kg/l = 42.763 MJ/kg or GJ/tonne
Purpose of Data	Calculation of project emissions
Comments	-

²² https://www.dede.go.th/download/stat62/frontpage_jan_nov62.pdf(accessed on 13/03/2020)

Data / Parameter	NCV _{biogas}
Data unit	MJ/m ³
Description	NCV of biogas
Source of data	Thailand Energy Situation Report ²³
Value applied	20.93
Justification of choice of data or description of measurement methods and procedures applied	Default value from official source in Thailand
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	Q _{FO,starch}
Data unit	l/tonne
Description	Liters of fossil fuel required per tonne of dry starch historically
Source of data	Historic data
Value applied	39.6 litres/tonne
Justification of choice of data or description of measurement methods and procedures applied	Based on average values from 2005 and 2006 (January-October) 2005 = 40.0 litres/tonne 2006 (January – October) = 39.2 litres/tonne
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	D _{CH4}
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

²³ https://www.dede.go.th/download/stat62/frontpage_jan_nov62.pdf (accessed on 13/03/2020)

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	ρ_{HFO}
Data unit	kg/litre
Description	Density of fossil fuel
Source of data	Thai local value (PTT) https://www.pttplc.com/th/Media-Center/Energy-Knowledge/Documents/MD25%20knowledge02/nc_en_ee-01_01.pdf
Value applied	0.93
Justification of choice of data or description of measurement methods and procedures applied	Thai local value is used
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	DE
Data unit	%
Description	Destruction efficiency of the electricity generator
Source of data	SSC WG
Value applied	100%

Justification of choice of data or description of measurement methods and procedures applied	According to clarification from SSC WG “in the case that the biogas is combusted for a gainful use of the released energy as in an engine or a power plant, a destruction efficiency of 100% can be used for the portion of biogas that is combusted when applying AMS III.H., i.e. use a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use” ²⁴
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	P_{el}
Data unit	kW
Description	Total electrical capacity of the equipments installed in the project activity
Source of data	Plant data
Value applied	458 kW ²⁵
Justification of choice of data or description of measurement methods and procedures applied	Extract from nameplate of the electrical equipments.
Purpose of Data	Calculation of project emissions
Comments	-

5.2 Data and Parameters Monitored

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

²⁴ Please refer to paragraph 29 SSC WG 22 external report, page 6. Please note that the respond to this query, F-CDM-SSCwg ver 01 SSC_324 dated 29/07/2009, can be accessed through the following link: <http://cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKUHEF5LBO7QICT1P>

²⁵ Please refer to Table 3 under section 1.11 in this PD for more clarity on the available auxiliary drives.

Source of data	Measured continuously – Volumetric flow meters
Description of measurement methods and procedures to be applied	The electromagnetic volumetric flow meter with an acceptable level of accuracy is installed at the plant. For reference, the newly purchased wastewater flow meter has test records showing an uncertainty level of up to 0.07% (+/-) In recording this parameter, plant's operators shall first manually archive the monitored data onto log sheets then transfer to the computer for electronic storage. Please note that continuous measurement will be made and cumulative reading will be recorded daily. In case the flow meter value is not available for a particular day, the same shall be estimated in a conservative manner.
Frequency of monitoring/recording	The monitoring will be done continuously using the flow meter recording will be conducted on daily basis.
Value applied	441,833 based on design value for ex ante estimation
Monitoring equipment	Flow meter for wastewater
QA/QC procedures to be applied	Once in three year calibrations for flow meter is to be conducted via an external agency according to an approved national or international standard. This calibration is plan for off season to ensure data accuracy and sufficiency in operation days. For reference, the calibration for this new meter has been calibrated according to ISO 9104
Purpose of data	Calculation of baseline and project emissions
Calculation method	-
Comments	-

Data / Parameter	COD _{ww,untreated,y}
Data unit	t COD/m ³
Description	The chemical oxygen demand of the wastewater before the treatment system affected by the project activity
Source of data	Measured (in every operational day) – Colorimetric analysis

Description of measurement methods and procedures to be applied	The COD content will be analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The results will be logged by the operators in the plant operation report on a daily basis. In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
Frequency of monitoring/recording	The monitoring and recording will be conducted on daily basis
Value applied	0.016913 based on historical average values for ex ante estimation
Monitoring equipment	The colorimeter meter will be used for COD analysis. The equipment is in line with the requirement of national or international standards.
QA/QC procedures to be applied	The colorimetric method is well documented and well accepted either by national or international standards. In addition, to ensure accuracy in our measurements, the plant shall periodically send wastewater samples to be tested by external laboratory and compare these results with internal measurements at least once per year.
Purpose of data	Calculation of baseline and project emissions
Calculation method	-
Comments	The figures here are simple average, however all calculations are based on weighted daily measurements of COD and wastewater for a transparent estimate of VERs.

Data / Parameter	COD _{ww,treated,y}
Data unit	t COD/m ³
Description	The chemical oxygen demand of the wastewater after the treatment system affected by the project activity
Source of data	Measured (in every operational day) – Colorimetric analysis
Description of measurement methods and procedures to be applied	The COD content will be analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The results will be logged by the operators in the plant operation report on a daily basis. In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.

Frequency of monitoring/recording	The monitoring and recording will be conducted on daily basis
Value applied	0.00338
Monitoring equipment	The colorimeter meter will be used for COD analysis. The equipment is in line with the requirement of national or international standards.
QA/QC procedures to be applied	The colorimetric method is well documented and well accepted either by national or international standards. In addition, to ensure accuracy in our measurements, the plant shall periodically send wastewater samples to be tested by external laboratory and compare these results with internal measurements at least once per year.
Purpose of data	Calculation of baseline and project emissions
Calculation method	-
Comments	There are two measurement conducted: one after Cover lagoon 1 and one after Cover lagoon 2. The average of two measurements shall be used.

Data / Parameter	COD _{discharge,PJ,y}
Data unit	t COD/m ³
Description	The chemical oxygen demand of water after the secondary treatment process, before being reused
Source of data	Measured (in every operational day) – Colorimetric analysis
Description of measurement methods and procedures to be applied	The COD content will be analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The results will be logged by the operators in the plant operation report on a daily basis. In case the COD value is not available for a particular day, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
Frequency of monitoring/recording	The monitoring and recording will be conducted on daily basis
Value applied	0.000434
Monitoring equipment	The colorimeter meter will be used for COD analysis. The equipment is in line with the requirement of national or international standards.

QA/QC procedures to be applied	The colorimetric method is well documented and well accepted either by national or international standards. In addition, to ensure accuracy in our measurements, the plant shall periodically send wastewater samples to be tested by external laboratory and compare these results with internal measurements at least once per year.
Purpose of data	Calculation of baseline and project emissions
Calculation method	-
Comments	-

Data / Parameter	$S_{final,PJ,y}$
Data unit	t
Description	Amount of dry matter in the sludge
Source of data	Weighing equipment available at site are used before using the material for any other purpose. Plant record every time sludge is removed from the system
Description of measurement methods and procedures to be applied	Proper log records shall be maintained for sludge removal and disposal at the project site.
Frequency of monitoring/recording	The monitoring will be done continuously using the flow meter recording will be conducted on daily basis.
Value applied	0 Assumption for ex ante estimation as sludge will be used aerobically for soil application, this will not affect the calculation of emission reductions
Monitoring equipment	Weighing equipment
QA/QC procedures to be applied	Calibration of weighbridge will be done on a once in three year basis.
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	This parameter is included in the unlikely event that the sludge is removed from the covered lagoons.

Data / Parameter	BG _{burst, y}
Data unit	Nm ³
Description	Amount of biogas combusted for gainful use
Source of data	Calculated from a summation of total biogas utilised in boilers, generation sets.
Description of measurement methods and procedures to be applied	BG_{combusted, y} is estimated by summing the volume of biogas sent to the boiler and generation sets. Measurements of volume of biogas sent to boiler and gas engines shall be continuously using gas flow meters. In recording these parameters, plant's operators shall first manually archive the monitored data onto log sheets then transfer to the computer for electronic storage. The archive shall be done on a daily basis. Please note that continuous measurement will be made and cumulative reading will be recorded daily. In case the flow meter values are not available for reason such as faulty meter, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
Frequency of monitoring/recording	The monitoring will be done continuously using the flow meters installed before boiler and gas engines which the recording of volume of biogas sent to boiler and gas engines will be conducted on daily basis.
Value applied	2,702,090 Calculate from design values – see attached calculation sheet
Monitoring equipment	Gas flow meter
QA/QC procedures to be applied	The flow meters at each utilizing facility shall be subject to once in three year calibration according to the equipment's specifications and applicable industrial standards. This will certainly help in ensuring that our calculation will be of a reasonable level in terms of accuracy. For reference, the newly purchased gas flow meter has been calibrated and is traceable to the National Institute of Standards and Technology to an uncertainty of +/-1.0% of reading +/- 0.2% of full scale measurements traceable to NIST Standards in accordance with Mil-Std-45662A.
Purpose of data	Calculation of baseline emissions

Calculation method	-
Comments	-

Data / Parameter	WCH _{4,y}
Data unit	%
Description	Methane content in biogas
Source of data	Measured – Gas analyzer to monitor % of methane in biogas
Description of measurement methods and procedures to be applied	Online monitoring equipment is incorporated to increase the accuracy. Data from here will be recorded and stored electronically on a continuous basis. In the case the online gas analyzer is not available or not functioning, periodic measurements will be done using portable gas analyzer at 90/10 confidence level.
Frequency of monitoring/recording	The monitoring will be done continuously using online gas analyzer. In case of malfunction or unavailability of online gas analyzer, portable gas analyzer shall be used ensuring 90/10 confidence level. The recording will be conducted on daily basis.
Value applied	55%
Monitoring equipment	Online gas analyzer / portable gas analyzer
QA/QC procedures to be applied	Once in three year calibrations for the gas analyzer is to be conducted via an external agency. This calibration is planned for off season to ensure data accuracy and sufficiency in operation days. In the case of breakdown of the online gas analyzer, periodic measurements will be done using portable gas analyzer at 95% confidence level.
Purpose of data	Calculation of baseline and emissions
Calculation method	-
Comments	-

Data / Parameter	BG _{burnt, flared,y}
Data unit	Nm ³

Description	Amount of biogas that is flared
Source of data	Measured using gas flow meter
Description of measurement methods and procedures to be applied	The gas flow meter with an accepted level of accuracy will be installed at the plant. Measurements of volume of biogas sent to flare shall be done continuously using gas flow meter. In recording this parameter, plant's operators shall first manually archive the monitored data onto log sheets then transfer to the computer for electronic storage. The archive shall be done on a daily basis. Please note that continuous measurement will be made and cumulative reading will be recorded daily.
Frequency of monitoring/recording	The monitoring will be done continuously using the flow meter recording will be conducted on daily basis.
Value applied	0 Biogas is expected to be fully utilized by boiler and gas engines
Monitoring equipment	Gas flow meter
QA/QC procedures to be applied	Once in three year calibrations for flow meter is to be conducted via an external agency. This calibration is planned for off season to ensure data accuracy and sufficiency in operation days. In case the flow meter values are not available for reason such as faulty meter, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$Q_{FO,y}$
Data unit	Litres
Description	Quantity of fossil fuel used in boiler in year y

Source of data	Usage data (monitored from boiler panel). Value is used for conservative estimation of biogas / methane used in replacement of fossil fuel during an year y.
Description of measurement methods and procedures to be applied	Fuel oil meter is incorporated to the hot oil boiler. In recording this parameter, plant's operators shall first manually archive the monitored data onto log sheets then transfer to the computer for electronic storage. The archive shall be done on a daily basis. In case the oil meter values are not available for reason such as faulty meter, the same shall be estimated in a conservative manner.
Frequency of monitoring/recording	The monitoring will be done continuously using the flow meter recording will be conducted on daily basis.
Value applied	614.96 Calculated as per GHG calculation sheet – note that it is equivalent to 661.25 tonne of fuel oil at density of 0.93
Monitoring equipment	Fuel oil meter
QA/QC procedures to be applied	Usage data is cross-check with fuel oil purchase records maintained at the project site. Energy balance shall also ensure aptness of monitored data depending on energy consumption of dry starch production before project implementation.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	$Q_{\text{starch},y}$
Data unit	Tonnes
Description	Quantity of dry starch produced
Source of data	Based on operational log sheet at the plant
Description of measurement methods and procedures to be applied	A proper record of all starch produced shall be maintained at the project site. In recording this parameter, plant's operators shall first manually archive the monitored data onto log sheets then transfer to the

	computer for electronic storage. The archive shall be done on a daily basis.
Frequency of monitoring/recording	The monitoring and recording will be conducted as per the starch factory procedure.
Value applied	38,660 Average starch production data in 2005 – 2008 is applied
Monitoring equipment	Weighing equipment at starch factory
QA/QC procedures to be applied	Production data can cross-checked with sales record if necessary. Accuracy in the monitoring parameter can be assured since it is the main income source of the starch plant.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	EG _{PJ,y}
Data unit	MWh/y
Description	Net electricity production by the generators during year y
Source of data	Measured – Electricity meters installed at the generation sets. Power sale invoices if power is sold to PEA.
Description of measurement methods and procedures to be applied	Measured electronically on a continuous basis. Data will be recorded manually on a daily basis in the plant operation report. In recording this parameter, plant's operators shall first manually archive the monitored data onto log sheets then transfer to the computer for electronic storage. The archive shall be done on a daily basis.
Frequency of monitoring/recording	The monitoring will be done continuously and the daily recording will be conducted.
Value applied	2,672 MWh (Estimation based on design values)
Monitoring equipment	Electricity meter
QA/QC procedures to be applied	The electricity meter shall be subject to periodic calibration according to the equipment's specifications and applicable industrial standards (generally on a once in three year basis).
Purpose of data	Calculation of baseline emissions

Calculation method	-
Comments	-

Data / Parameter	EC _y
Data unit	MWh
Description	Electricity consumption by wastewater treatment plant in year y
Source of data	Maximum rated consumption is calculated by multiplying total electrical capacity with 8,760 hours and 10% additional factor to be conservative.
Description of measurement methods and procedures to be applied	Calculation based on maximum rated consumption is conducted in a conservative manner (as per paragraph 35 in AMS-III.H., version 19)
Frequency of monitoring/recording	-
Value applied	4,012 Maximum rated consumption is estimated
Monitoring equipment	-
QA/QC procedures to be applied	In the absence of electric meter for the electricity consumption of project activity, maximum rated consumption shall be used to calculate the emissions from PE _{power, y} . Since this approach has taken into account the distribution losses of 10% and the calculation is based on an assumption that the electrical appliances will be running at full capacity for the entire year, the QA/QC aspect has already been assured.
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	F _{RG,m}
Data unit	Nm ³
Description	Volumetric flow of the residual gas on dry basis at normal conditions in the minute <i>m</i>

Source of data	Measured using gas flow meter (same gas flow meter of BG _{burst, flared, y})
Description of measurement methods and procedures to be applied	The gas flow meter with an accepted level of accuracy will be installed at the plant. Measurements of volume of biogas sent to flare shall be done continuously using gas flow meter. In recording this parameter, plant's operators shall first manually archive the monitored data onto log sheets then transfer to the computer for electronic storage. The archive shall be done on a daily basis. Please note that continuous measurement will be made and cumulative reading will be recorded daily.
Frequency of monitoring/recording	The monitoring will be done continuously using the flow meter recording will be conducted on daily basis.
Value applied	0 Biogas is expected to be fully utilized by boiler and gas engines
Monitoring equipment	Gas flow meter
QA/QC procedures to be applied	Once in three year calibrations for flow meter is to be conducted via an external agency. This calibration is planned for off season to ensure data accuracy and sufficiency in operation days. In case the flow meter values are not available for reason such as faulty meter, the same shall be estimated in a conservative manner or ignored out of emission reduction estimation.
Purpose of data	Calculation of project emissions
Calculation method	-
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
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	0 Assumed 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	-
Comments	In case the parameter is not recorded or monitored in line with its procedure, the $\eta_{\text{flare},m}$ is considered as 0%.

Data / Parameter	$\eta_{\text{flare},m}$
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	-
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	-
Comments	In case the parameter is not recorded or monitored in line with its procedure, the $\eta_{\text{flare,m}}$ is considered as 0%.

5.3 Monitoring Plan

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

- Monitoring management

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

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

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

The plant will form a team to maintain and operate the project activity and monitor the parameters required by the methodology. The team composed of one plant manager dealing with data processing and transfer, two heads of boiler team, one head of biogas team, one head of gas generator team, one head of maintenance team and 8 operators. Figure 5 outlines the structure of operational and management of the project activity.

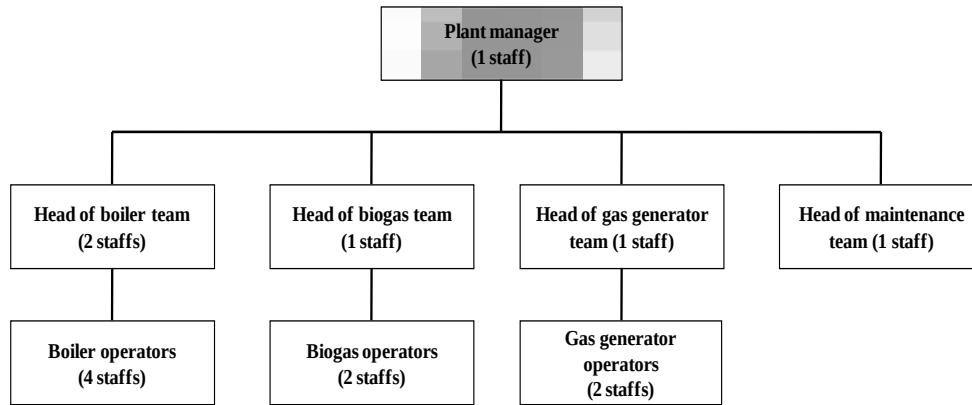


Figure 5: Organization chart showing the persons involved in the project activity

- Quality insurance and Quality control

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

- On-site procedures

Plant performance is recorded daily in log sheets and later stored in electronic format for periodic download onsite or remote transfer for further processing. In terms of procedures for calibration of equipment, the on-site operators carry out calibration according to international standards. Note that the plant in-charge operators are responsible for executing timely calibration as per the specification from the equipment supplier or at least once in three years.

- Data storage and filing – electric workbook

All relevant data is first stored manually in operational log sheets, then electronically in a computer unit, with external storage media and transferred. A daily log is printed. All parameters monitored under the monitoring plan will be kept for a period of two years following the end of the crediting period or the last issuance of VERs for the project activity, whichever occurs later.

- Emergency preparedness

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

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

APPENDIX

There is no appendix applicable for the project activity details.