



SD BIOSUPPLY WASTEWATER TREATMENT AND BIOGAS UTILIZATION PROJECT



Project title	SD Biosupply Wastewater Treatment and Biogas Utilization Project
Project ID	VCS 416
Monitoring period	01-May-2021 to 31-October-2022 (both days are included)
Original date of issue	28-January-2023
Most recent date of issue	16-May-2024
Version	03
VCS Standard Version	4.7
Prepared by	South Pole Carbon Asset Management Ltd.

CONTENTS

PROJECT DETAILS	4
1.1 Summary Description of the Implementation Status of the Project.....	4
1.2 Audit History.....	4
1.3 Sectoral Scope and Project Type.....	5
1.4 Project Proponent	5
1.5 Other Entities Involved in the Project	6
1.6 Project Start Date	6
1.7 Project Crediting Period	6
1.8 Project Location.....	7
1.9 Title and Reference of Methodology	7
1.10 Double Counting and Participation under Other GHG Programs.....	8
1.11 Double Claiming, Other Forms of Credit, and Scope 3 Emissions.....	8
1.12 Sustainable Development Contributions.....	9
1.13 Commercially Sensitive Information.....	11
2 SAFEGUARDS AND STAKEHOLDER ENGAGEMENT	11
2.1 Stakeholder Engagement and Consultation.....	11
2.2 Risks to Stakeholders and the Environment.....	14
2.3 Respect for Human Rights and Equity	16
2.4 Ecosystem Health	17
3 IMPLEMENTATION STATUS	19
3.1 Implementation Status of the Project Activity	19
3.2 Deviations	19
3.3 Grouped Projects	22
3.4 Baseline Reassessment.....	23
4 DATA AND PARAMETERS.....	23
4.1 Data and Parameters Available at Validation.....	23
4.2 Data and Parameters Monitored.....	27
4.3 Monitoring Plan.....	43
5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS	43
5.1 Baseline Emissions	44

5.2	Project Emissions	44
5.3	Leakage Emissions	50
5.4	GHG Emission Reductions and Carbon Dioxide Removals	58
APPENDIX 1: COMMERCIALLY SENSITIVE INFORMATION.....		62

PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

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

Prior to the implementation of the project activity, the wastewater of the starch plant was treated in eight cascading open anaerobic lagoons. These conditions result in an anaerobic environment within the ponds, resulting in methane generation from the organic content of the wastewater. Meanwhile, the energy supplied in the starch drying process was produced by heavy fuel oil (HFO) consuming in two hot oil boilers of starch factory. The consumption of HFO as fossil fuel is conserved as a baseline thermal component of the project.

The project had been registered under VCS since 06/05/2010. The first crediting period was from 28/03/2006 to 27/03/2016, while the second crediting period is from 28/03/2016 to 27/03/2026. This is the fifth monitoring period under the second crediting period, which started from 01/05/2021 to 31/10/2022. The total emission reductions achieved in this monitoring period is 68,840 tCO₂e. The audit history of the project is listed below.

1.2 Audit History

Audit type	Period	Program	Validation/verification body name	Number of years
Validation	28/03/2006 to 27/03/2016	VCS	SGS Climate Change Programme	10 years
Verification	28/03/2006 to 31/12/2008	VCS	SGS Climate Change Programme	2 years 9 months 6 days
Verification	01/01/2009 to 31/05/2012	VCS	Germanischer Lloyd Certification GmbH	3 years 5 months
Verification	01/06/2012 to 14/09/2014	VCS	RINA Services S.p.A (RINA)	2 years 3 months 15 days

Verification	15/09/2014 to 27/03/2014	VCS	RINA Services S.p.A (RINA)	1 years 6 months 13 days
Validation	28/03/2016 to 27/03/2026	VCS	RINA Services S.p.A (RINA)	10 years
Verification	28/03/2016 to 31/12/2016	VCS	KBS Certification Services Pvt. Ltd.	9 months 5 days
Verification	01/01/2017 to 31/12/2019	VCS	KBS Certification Services Pvt. Ltd.	3 years
Verification	01/01/2020 to 02/03/2020	VCS	TUV NORD CERT GmbH	2 months 2 days
Verification	03/03/2020 to 30/04/2021	VCS	TUV NORD CERT GmbH	1 year 1 months 27 days
Verification	01/05/2021 to 31/10/2022	VCS	LGAI Technological Center, S.A. (Applus+ Certification)	1 year 6 months 2 days
Total	28/03/2006 to 31/10/2022			16 years 7 months 5 days

1.3 Sectoral Scope and Project Type

Sectoral scope ¹	13 Waste Handling and Disposal
Project activity type	III-H. Methane recovery in wastewater treatment version 18.0

Sectoral scope	1 Energy Industries
Project activity type	I-C. Thermal energy production with or without electricity version 20.0

1.4 Project Proponent

Organization name	SD Biosupply Co., Ltd (Project owner: Responsible for implementation and operation of the project activity)
Contact person	Mr. Sivaroj Suralaertrungsri

¹ Projects, activities, or methodologies may be developed under any of the 16 VCS sectoral scopes: <https://verra.org/programs/verified-carbon-standard/vcs-program-details/#sectoral-scopes>

Title	Managing Director
Address	113 Soi Chokchaijonjamrern, Rama III Road, Bangpongpan, Yannawa, Bangkok 10120, Thailand
Telephone	+66 2 683 1900-7
Email	mdroj_2work@somdej.co.th

1.5 Other Entities Involved in the Project

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

1.6 Project Start Date

Project start date	16-September-2005
Justification	Project start date is the date when emission reductions began which is the first date that the factory started operating.

1.7 Project Crediting Period

Crediting period	☐ Seven years, twice renewable ☐ Ten years, fixed ☒ Other (Ten years, twice renewable. Since the registered project has completed validation on or before 19 March 2020, it remains eligible to apply the crediting period requirements under VCS Version 3.)
------------------	---

Start and end date of first or fixed crediting period

1st: 28-March-2006 to 27-March-2016

2nd: 28-March-2016 to 27-March-2026

1.8 Project Location

The project site is located on the site of the SD Starch factory, located at 99 Moo 10, Somdej-Khuchinarai Road, Kambong sub-district, Huai Phueng district, Kalasin, Thailand, is approximately 580 km away from Bangkok. The project coordinates are 16° 40'40.20"N and 103° 48' 19.67'E as shown in Figure 1.

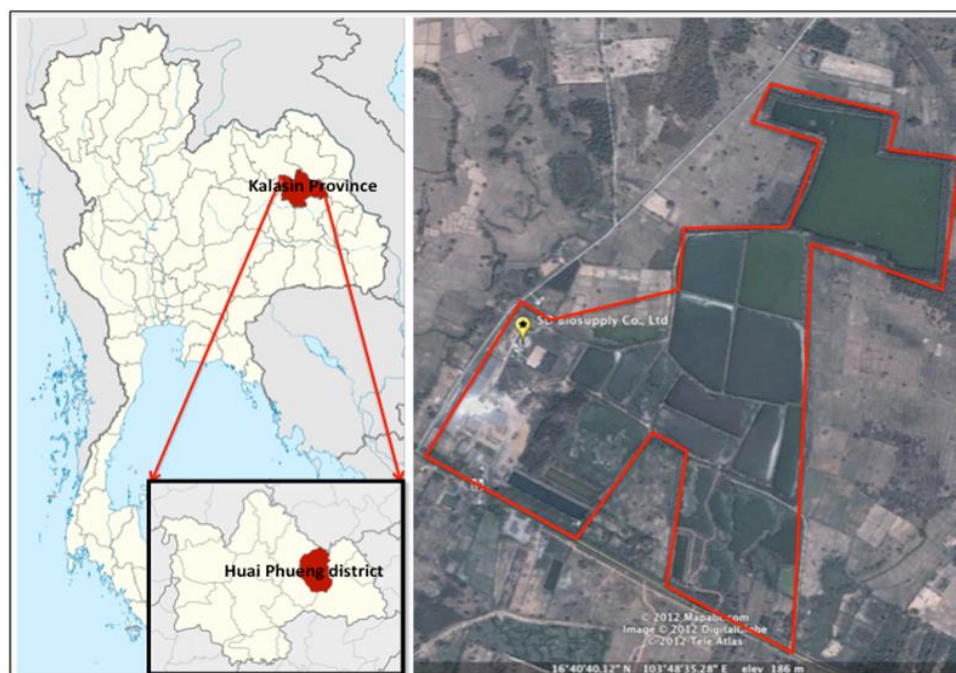


Figure 1 Project location and boundaries

1.9 Title and Reference of Methodology

Type (methodology, tool or module).	Reference ID, if applicable	Title	Version
Methodology	AMS-III.H	AMS-III.H Methane recovery in wastewater treatment	18.0
Methodology	AMS-I.C	AMS-I.C Thermal energy production with or without electricity	20.0

Tool	03	Tool 03 Tool to calculate project or leakage CO ₂ emissions from fossil fuel combustion	3.0
Tool	05	Tool 05 Baseline, project and/ or leakage emissions from electricity consumption and monitoring of electricity generation	3.0
Tool	06	Tool 06 Project emissions from flaring	3.0

1.10 Double Counting and Participation under Other GHG Programs

1.10.1 No Double Issuance

Is the project receiving or seeking credit for reductions and removals from a project activity under another GHG program?

☐ Yes ☒ No

1.10.2 Registration in Other GHG Programs

Was the project registered or seeking registration under any other GHG programs?

☐ Yes ☒ No

1.11 Double Claiming, Other Forms of Credit, and Scope 3 Emissions

1.11.1 No Double Claiming with Emissions Trading Programs or Binding Emission Limits

Are project reductions and removals or project activities also included in an emissions trading program or binding emission limit? See the *VCS Program Definitions* for definitions of emissions trading program and binding emission limit.

☐ Yes ☒ No

1.11.2 No Double Claiming with Other Forms of Environmental Credit

Has the project activity sought, received, or is planning to receive credit from another GHG-related environmental credit system? See the *VCS Program Definitions* for definition of GHG-related environmental credit system.

☐ Yes ☒ No

1.11.3 Supply Chain (Scope 3) Emissions

Do the project activities affect the emissions footprint of any product(s) (goods or services) that are part of a supply chain?

☐ Yes

☒ No

1.12 Sustainable Development Contributions

During this monitoring period, the project activities implemented has contributed to several Sustainable Development Goals such as the SDG 7, 8 and 13. This installation reduces the amount of greenhouse gas released into the atmosphere, which corresponds to the improvement of the SDG 13, Climate Action. The generated biogas was also utilized for replacing heavy fuel oil and therefore reducing dependence on fossil-fuel-based energy sources which corresponds to the improvement of the SDG 7, Affordable and Clean Energy. Moreover, the operation of the project activity ensures the employment of local residents, contributing to the SDG 8, Decent Work and Economic Growth.

Table 1: Sustainable Development Contributions

Row number	SDG target	SDG indicator	Net impact on SDG indicator	Current project contributions	Contributions over project lifetime
1)	7.2	7.2.1 Renewable energy share in the total final energy consumption	Implemented activities to increase	The project activity has utilized 77.42 TJ by replacing the use of fossil fuel during this monitoring period.	The project activity has utilized 1,076.51 TJ by replacing the use of fossil fuel for project lifetime.
2)	8.5	8.5.2 Unemployment rate, by sex, age and persons with disabilities	Implemented activities to increase	The project activity has created 9 job opportunities during this monitoring period.	The project activity has provided full employment to 9 people per year.
3)	13.2	13.2.2 Tonnes of greenhouse gas emissions avoided or removed	Implemented activities to decrease	Prevented emitting of 68,840 tCO ₂ e into the atmosphere during the monitoring period.	The project activity has prevented emitting of total 570,879 tCO ₂ es into the atmosphere.

Summary of Net Impact on SDG Indicators

SDG 7: Affordable and Clean Energy

Crediting Period	Monitoring Period	Baseline contribution (TJ)	Project contribution (TJ)	Net benefit (TJ)
2 nd	5 th : 01/05/2021 – 31/10/2022	0	77.42	77.42

SDG 8 Decent Work and Economic Growth

Crediting Period	Period	Baseline contribution (number)	Project contribution (number)	Net benefit (number)
2 nd	5 th : 01/05/2021 – 31/10/2022	0	9	9

SDG 13 Climate Action

Crediting Period	Period	Baseline contribution (tCO _{2e})	Project contribution (tCO _{2e})	Net benefit (tCO _{2e})
2 nd	5 th : 01/05/2021 – 31/10/2022	69,745	905	68,840

1.13 Commercially Sensitive Information

There is no commercially sensitive information in this monitoring report.

2 SAFEGUARDS AND STAKEHOLDER ENGAGEMENT

2.1 Stakeholder Engagement and Consultation

2.1.1 Stakeholder Identification

Stakeholder Identification

All potential stakeholders are identified by considering any individuals or groups who have an interest in the project.

	The list of stakeholders is further categorized to the group who have a direct impact and indirect impact as follows. - Direct impact - o Employees - o Nearby communities (Huai Phueng District) - o Cassava farmers (Kham Bong Subdistrict) - Indirect impact - o Governmental agency (Huai Phueng District Administrative Organization and Regional Environmental Office)
Legal or customary tenure/access rights	The stakeholders have no customary tenure/ access rights to territories and resources, collective and conflicting rights, held by stakeholders, Indigenous People (IPs), Local Communities (LCs) and customary rights of the projects.
Stakeholder diversity and changes over time	Huai Phueng District has a total population² of 30,955 people, divided into 15,497 males, accounting for 51%, and 15,458 females, accounting for 49%. The population density is 120 people per square kilometer. The majority of the population is engaged agricultural such as cassava plantation, rice plantation and sugar cane plantation.
Expected changes in well-being	Compared to baseline scenario, which is open lagoon wastewater treatment without biogas capturing, the project implementation could create jobs for local community, improve air quality and remove odor from biogas capturing. There will be no changes in ecosystem services identified as important to stakeholders as the treated wastewater will be utilized within the project boundary.
Location of stakeholders	In the area of Huai Phueng District Municipality, natural water sources obtained from rainwater and underground water. There is no canal or stream. Most of the population relies on water for consumption and agricultural from regional water supply systems. As the effluent from wastewater treatment system is to be used on-site for

² Reference: <https://district.cdd.go.th/huaiphueng/about-us/ประวัติความเป็นมา/>

	irrigation, there will be no discharged wastewater. The wastewater treatment facility is designed to achieve a Chemical Oxygen Demand (COD) of less than the national water standard for industrial effluents. The standard, however, does not apply to the project as there will be no discharge from the facility
Location of resources	The geography of Huai Phueng District has the water channel flows through the mountain creek, creating the rich-mineral soil in the surrounding area. With these conditions, most of the population turns to do agriculture as their main occupation. Overall, in Huai Phueng District, there is no severe environmental problem that significantly impacts the municipality. There is no large industrial factory within the area. Only a few medium-sized and small factories, located within the district, that have some minor environmental impact regarding waste disposal, air quality.

2.1.2 Stakeholder Consultation and Ongoing Communication

Ongoing consultation	The project activity has the grievance mechanism in place. The local stakeholder can either report to the security guard when they have any issue which wants to be raised to the plant or report the issue to the head of their village, then the head of the village would gather all the information and raise it to the plant. During this monitoring period, there was no complaint raised against the project activity. This could be confirmed during the remote audit.
Date(s) of stakeholder consultation	No stakeholder consultation was held during this monitoring period.
Communication of monitored results	No stakeholder consultation was held during this monitoring period.
Consultation records	If the stakeholder consultation was organized, the meeting would be recorded as a minute of meeting (MOM).
Stakeholder input	No stakeholder consultation was held during this monitoring period.

2.1.3 Free, Prior, and Informed Consent

Consent	This project does not involve indigenous people thus this section is not applicable.
Outcome of FPIC	-

2.1.4 Grievance Redress Procedure

The project activity has the grievance mechanism in place. The local stakeholder can either report to the security guard when they have any issue which want to raise to the plant or report the issue to the head of their village, then the head of the village would gather all the information and raise it to the plant.

However, there was no complaint raised against the project activity during this monitoring period.

Grievances received	Resolution and outcome
NA	-

2.1.5 Public Comments

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

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

Summary of comments received	Actions taken
NA	-

2.2 Risks to Stakeholders and the Environment

2.2.1 Management Experience

The Stakeholder Consultation has been conducted by the project owner, SD Biosupply Co., Ltd with an assistance from other entity, South Pole Carbon Asset Management Limited (SPCAM, Switzerland based company responsible for VCS project development). SPCAM is also responsible for project design.

SPCAM has experienced in developing carbon project under Verified Carbon Standard. For example, CYY Biopower Wastewater treatment plant including biogas reuse for thermal oil replacement and electricity generation project (VCS2261), VP Biosupply wastewater treatment and biogas utilization project (VCS415) and Banpong tapioca flour industrial wastewater treatment and biogas utilization project (VCS405). With all these experiences, it can be assured that communities engaging, and project activities implementation were done professionally.

2.2.2 Risk assessment

	Risk identified	Mitigation or preventative measure(s) taken
Natural and human-induced risks to stakeholders' wellbeing	Water quality	People are concerned about the wastewater being discharged into natural water resources. However, PP informed that the effluent is to be used on-site for irrigation, so no wastewater will be discharged. This shall be monitored periodically to ensure to villagers.
Risks to stakeholder participation	No risk identified	The project involves no risk to the stakeholder participation.
Working conditions	Occupational health and safety	Provide safety plan, awareness, and enforcement. Provide worker health program. Prepare emergency procedures.
Safety of women and girls	No risk identified	The project does not involve specifically safety of women and girls.
Safety of minority and marginalized groups, including children	No risk identified	The project does not involve specifically the marginalized group.
Pollutants (air, noise, discharges to water, generation of waste, and release of hazardous materials and chemical pesticides and fertilizers)	1. Wastewater discharge	1.1 As the effluent is to be used on-site for irrigation, there will not be any discharged wastewater. 1.2 The wastewater treatment facility is designed to achieve a Chemical Oxygen Demand (COD) not exceeding the national water standard for industrial effluents.

	2. Air pollutant emissions from boilers	2.1 Ensure proper operation and maintenance of scrubbers.
	3. Odor nuisance	3.1 Proper maintenance of wastewater lagoon and HDPE sheet. 3.2 Provision of adequate storage areas and capacities on-site for sludge.

2.3 Respect for Human Rights and Equity

2.3.1 Labor and Work

	Risks identified ³	Mitigation or preventative measure(s) taken
Discrimination	No risk identified	There is no discrimination according to the law of Thailand which the project follows.
Sexual harassment	No risk identified	There is no sexual harassment according to the law of Thailand which the project follows.
Gender equity in labor and work	No risk identified	Gender equity in labor and work has been respected by the project proponent. Employee payment has been paid by following the Thai Labor Protection Act.
Forced labor	No risk identified	There is no forced labor in the project activity as it follows the Thai Labor Protection Act.
Child labor	No risk identified	There is no child labor in the project activity as it follows the Thai Labor Protection Act.
Human trafficking	No risk identified	There is no human trafficking in the project activity as it follows the Thai Labor Protection Act.

³ The identified risks and commensurate mitigation or preventative measure(s) for forced labor, child labor, and human trafficking, must be inclusive of staff and contracted workers employed by third parties.

2.3.2 Human Rights

Risks identified	Mitigation or preventative measure(s) taken
No risk identified	This project does not involve IPs, LCs, and customary rights holders as its location is the property of the project owner.

2.3.3 Indigenous Peoples and Cultural Heritage

Risks identified	Mitigation(s) or preventative measure taken
No risk identified	This project does not involve cultural heritage as its location is the property of the project owner.

2.3.4 Property Rights

Risks identified	Mitigation or preventative measure(s) taken
No risk identified	This project does not involve the property rights of IPs, LCs, and customary rights holders as its land is the property of the project owner.

2.3.5 Benefit Sharing

Summary of the benefit sharing plan	This project activity does not involve the property rights. Thus, this section is not applicable.
Benefit sharing during the monitoring period	This project activity does not involve the property rights. Thus, this section is not applicable.

2.4 Ecosystem Health

	Risk identified	Mitigation or preventative measure(s) taken during the monitoring period
Impacts on biodiversity and ecosystems	No risk identified	The project activity does not involve impacts on biodiversity and ecosystems.
Soil degradation and soil erosion	No risk identified	The project activity does not involve impacts on soil degradation and soil erosion.

Water consumption and stress	No risk identified	The project activity does not involve water consumption and stress.
------------------------------	--------------------	---

2.4.1 Rare, Threatened, and Endangered species

Species or habitat	The project activity is not located in, or adjacent to habitats for rare, threatened, or endangered species. Thus, this section is not applicable.
Areas needed for habitat connectivity	The project activity is not located in, or adjacent to habitats for rare, threatened, or endangered species. Thus, this section is not applicable.

	Risks identified	Mitigation or preventative measure(s) taken
Habitats for rare, threatened, and endangered species	No risk identified	The project activity is not located in, or adjacent to habitats for rare, threatened, or endangered species.
Areas for habitat connectivity	No risk identified	The project activity is not located in, or adjacent to habitats for rare, threatened, or endangered species.

2.4.2 Introduction of species

Species introduced	Classification	Justification for use	Adverse effects and mitigation
N/A	-	-	-

Existing invasive species	Mitigation measures to prevent the spread or continued existence of invasive species
N/A	-

	Risks identified	Mitigation or preventative measure(s) taken
Invasive species	No risk identified	The project activity does not involve in planting or species introduction.

2.4.3 Ecosystem conversion

	Risks identified	Mitigation or preventative measure(s) taken
Ecosystem conversion	No risk identified	The project activity is neither ARR, ALM, WRC nor ACoGS project type.

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

The project was registered on 06th May 2010. The current monitoring period is from 1st May 2021 to 31st October 2022 (both days included). The emission reduction for this period is 68,840 tCO₂e (VCUs). The implementation status of the project activity during this monitoring period is in-line with the registered PD. There haven't been natural disasters or any accidents that lead to a significant change in the amount of emission reduction this period.

Table 2 List of the main equipment implemented in the project activity.

Technology implemented	Manufacturer	Capacity	Number of units
Acidification pond	Papop Co., Ltd (Technology provider of the project)	6,000 m ³	1 Acidification Pond
UASB tank	Papop Co., Ltd (Technology provider of the project)	5,000 m ³ /day	1 UASB tank
Boilers	Sherrer (Boiler 1)	3.780 MW _{th}	Total of 2 boilers
	VEGA (Boiler2)	3.489 MW _{th}	
Flaring system (Open Flare System)	Papop Co., Ltd (tech. provider of the project)	Combustion rate 750 Nm ³ /hr	1 unit

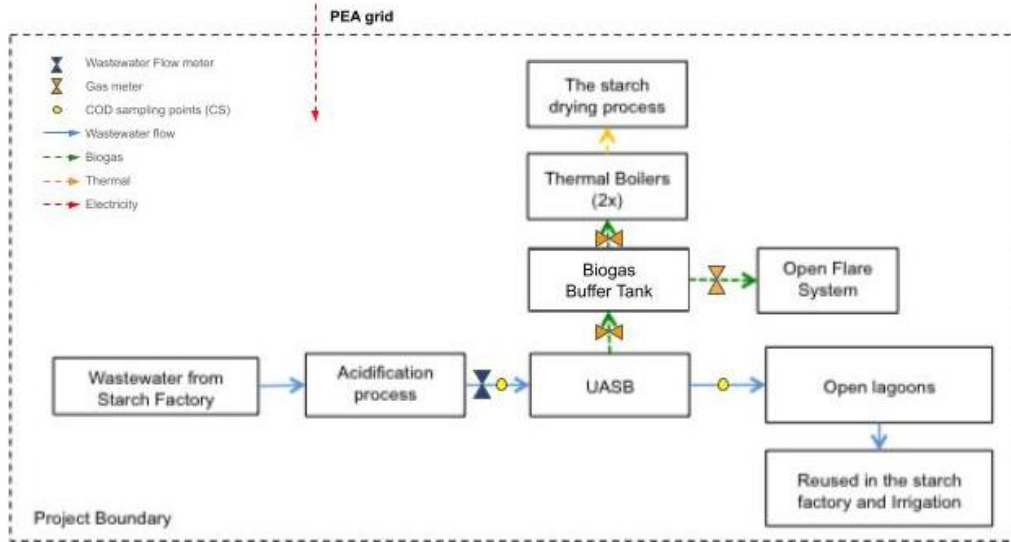


Figure 2. Flow Diagram of the project activity

3.2 Deviations

3.2.1 Methodology Deviations

Determination of $EG_{thermal}$

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

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

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

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

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

The project proponent is not able to conduct the measurement of temperature (in and out) and the flow of the thermal fluid as per the applied methodology. Therefore, the deviated approach is introduced as following.

The monitoring parameter of $EG_{thermal, y}$ can be estimated based on production historical data and actual fuel energy input. By considering historical data, the estimation is considered from heat requirements per tonne of starch prior the implementation of project activity. The approach estimates the thermal energy delivered by the project activity based on historical fuel oil consumption and starch production for the given year. The conservative approach is ensured by

comparing the total energy delivered by the fuels burnt in the project activity and thermal energy estimate based on historical fuel oil consumption values. The conservativeness of the historical data: the historical data of Somdej Flour Mill Co., Ltd is available for 3 years (2002-2004) on starch production and heavy oil consumption as follows:

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

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

The calculation formula is determined as following:

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

Historical production approach:

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

Where:

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

Fuel energy input approach:

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

Where:

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

NCV _{CH4}	NCV of methane (TJ/tonne)
--------------------	---------------------------

Justification for deviation

When compared to the industrial research as per published data at Thai Tapioca Starch Association website⁴, the average of 33.6 litre of HF0/ tonne of dried starch (range: 25.9-39.4) is found. The lowest historical data of 33.8 l/t is considered, as it is the most conservative and precise value based on the applied technology and equipment at Somdej starch plant.

3.2.2 Project Description Deviations

Deviation 1

Description

The AMS-I.C methodology deviation relies on two approaches, the historical and the fuel energy input approach. The amount of biogas combusted, and starch produced, in the project scenario, at any given year are to be monitored for calculating the project scenario thermal energy generation. Meanwhile, the quantity of starch produced for any given year is applied to calculate the historical thermal energy.

Start date

During the monitoring period, 1st January 2020 onwards, a new monitoring parameter had been introduced, the $Q_{\text{starch},y}$ under section 4.2 of the MR, which is not included in the registered project description.

Justification

Additional of the parameter does not have an impact on the applicability of the methodology, additionality, nor the appropriateness of the baseline scenario. The deviation should be followed in all subsequent monitoring period as per paragraph 3.19.2, sub-paragraph 2 of the VCS Standard version 4.2.

Deviation 2

Description

Deviation involves a change in the procedures for measurement and monitoring of the parameter Flame_m . As per the registered project description, the parameters should be measured using an equipment with frequency of monitoring/ recording for the flame on/ off in minute.

Start date

⁴ Source: http://www2.diw.go.th/PIC/download/Guidelines/TTSA_MIS_Thai.pdf

It was noted during the verification assessment from 01st January 2020 onwards, that there was no flame detector installed in the project activity. The value taken for the parameter Flame_m has been taken as “0”, zero. Referring to the tool to calculate project emission from flaring, the duration of flame detected in minute would be used for the identification of the flare efficiency. Since the value from Flame_m is 0, the flare efficiency used for the project activity could not be monitored.

Justification

Since the flame detector was not installed, the 0% of flare efficiency has been taken. This approach is conservative and the change in procedures for measurement and monitoring of the parameter does not have an impact on the applicability of the methodology, additionality, nor the appropriateness of the baseline scenario. The deviation should be followed in all subsequent monitoring period as per paragraph 3.19.2, sub-paragraph 2 of the VCS Standard version 4.2.

3.3 Grouped Projects

This project is not a grouped project.

3.4 Baseline Reassessment

Did the project undergo baseline reassessment during the monitoring period?

☐ Yes ☒ No

4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

Data / Parameter	GWP _{CH4}	
Data unit	tCO ₂ e/tCH ₄	
Description	Global Warming Potential for Methane	
Source of data	Default value as per IPCC	
Value applied	Monitoring Period	Value Applied
	01/05/2021 to 31/12/2021	28
	01/01/2022 to 31/10/2022	28
Justification of choice of data or description of measurement methods and procedures applied	Default value as per IPCC	
Purpose of Data	Calculation of baseline emission and project emissions	

Comments	According to paragraph 3.14.4 of VCS standard 4.2 mentions that All GHG emission reductions shall be converted to CO₂e using 100-year global warming potential (GWP) values. For GHG emission reductions occurring on or after 1 January 2021, all ex-ante estimates and ex-post calculations shall be converted to CO₂e using GWP values from the IPCC Fifth Assessment Report (AR5).
----------	---

Data / Parameter	B _{0,ww}
Data unit	kg CH ₄ /kg COD
Description	Methane producing capacity of the wastewater
Source of data	AMS-III.H v.18.0
Value applied	0.25
Justification of choice of data or description of measurement methods and procedures applied	IPCC defaults value
Purpose of Data	Calculation of baseline emission and project emissions
Comments	-

Data / Parameter	UF _{BL}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS-III.H v.18.0
Value applied	0.89
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of baseline emission
Comments	-

Data / Parameter	UF _{PJ}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS-III.H v.18.0

Value applied	1.12
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	$MCF_{ww,treatment,BL,i}$
Data unit	Fraction
Description	Methane correction factor for baseline wastewater treatment systems i
Source of data	AMS-III.H v.18.0, Table 2
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of baseline emission
Comments	-

Data / Parameter	$MCF_{ww,treatment,PJ,k}$
Data unit	Fraction
Description	Methane correction factor for project wastewater treatment systems k
Source of data	AMS-III.H v.18.0, Table 2
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emission
Comments	-

Data / Parameter	COD removal efficiency-baseline
Data unit	%

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

Data / Parameter	CFE _{ww}
Data unit	-
Description	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems.
Source of data	AMS-III.H v.18.0
Value applied	0.9
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emission
Comments	-

Data / Parameter	EF _y
Data unit	tCO ₂ e/MWh
Description	CO ₂ emission factor for grid power
Source of data	Thai DNA ⁵
Value applied	0.56375
Justification of choice of data or description of measurement methods and procedures applied	The value is based on the official public data.
Purpose of Data	Calculation of baseline emission and project emission

⁵ Source: <https://ghgreduction.tgo.or.th/th/download-tver/120-tver-gwp-emission-factor.html>

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
Source of data	Tool to determine project emissions from flaring gases containing methane.
Value applied	0.716
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of Data	Calculation of project emission
Comments	-

Data / Parameter	$\eta_{BL,thermal}$
Data unit	%
Description	Efficiency of the boiler using fossil fuel that would have been used in the absence of the project activity.
Source of data	AMS-I.C v.20.0
Value applied	100
Justification of choice of data or description of measurement methods and procedures applied	Default values, 100% is the most conservative choice as per AMS-I.C.
Purpose of Data	Calculation of baseline emission
Comments	-

4.2 Data and Parameters Monitored

Data / Parameter	Q _{ww,y}
Data unit	m ³
Description	Volume of wastewater treated in year y
Source of data	Plant data

Description of measurement methods and procedures to be applied	Measurement was undertaken using flow meter																													
Frequency of monitoring/recording	Monitored continuously (at least hourly measurement are undertaken, if less, confidence/precision level of 90/10 should be attained.) Though during this monitoring period, the continuous flow meter has been used, the adjustment of the value was not necessary.																													
Value monitored	<table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value monitored (m³)</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>01/05/2021 to 31/12/2021</td><td>286,625</td><td>286,751</td></tr><tr><td>01/01/2022 to 31/10/2022</td><td>345,856</td><td>345,856</td></tr></table>			Monitoring period	Value monitored (m³)		Lower	Higher	01/05/2021 to 31/12/2021	286,625	286,751	01/01/2022 to 31/10/2022	345,856	345,856																
Monitoring period	Value monitored (m³)																													
	Lower	Higher																												
01/05/2021 to 31/12/2021	286,625	286,751																												
01/01/2022 to 31/10/2022	345,856	345,856																												
Monitoring equipment	<table><tr><td>Serial Number</td><td colspan="2">6B00F220000</td></tr><tr><td>Manufacturer</td><td colspan="2">Endress+Hauser</td></tr><tr><td>Model</td><td colspan="2">Promag 10W</td></tr><tr><td>Accuracy</td><td colspan="2">±0.50%</td></tr><tr><td>Installation</td><td colspan="2">20/04/2017 until now</td></tr><tr><td>Calibration frequency</td><td colspan="2">annually</td></tr><tr><td rowspan="4">Calibration</td><td>Cal. date</td><td>Validity</td></tr><tr><td>18/05/2020</td><td>17/05/2021</td></tr><tr><td>21/06/2021</td><td>20/06/2022</td></tr><tr><td>08/06/2022</td><td>07/06/2023</td></tr></table>			Serial Number	6B00F220000		Manufacturer	Endress+Hauser		Model	Promag 10W		Accuracy	±0.50%		Installation	20/04/2017 until now		Calibration frequency	annually		Calibration	Cal. date	Validity	18/05/2020	17/05/2021	21/06/2021	20/06/2022	08/06/2022	07/06/2023
Serial Number	6B00F220000																													
Manufacturer	Endress+Hauser																													
Model	Promag 10W																													
Accuracy	±0.50%																													
Installation	20/04/2017 until now																													
Calibration frequency	annually																													
Calibration	Cal. date	Validity																												
	18/05/2020	17/05/2021																												
	21/06/2021	20/06/2022																												
	08/06/2022	07/06/2023																												
QA/QC procedures to be applied	The meter has been calibrated annually or as per the manufacturer’s recommendations to maintain the measuring accuracy. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager.																													
Purpose of the data	Calculation of baseline and project emissions																													
Calculation method	Not applicable																													
Comments	The calibration gap is taken during 18/05/2021 to 20/06/2021. The error applied during the gap period is 0.50%.																													

Data / Parameter	COD _{ww,untreated,y}
Data unit	tCOD/m³
Description	The chemical oxygen demand of the wastewater before the treatment system affected by the project activity
Source of data	Plant data

Description of measurement methods and procedures to be applied	The COD content was analyzed using a colorimetry method in the on-site laboratory of the project. The results were logged in the plant operation report on a daily basis. The COD analysis was conducted according to national or international standards. COD was measured through representative sampling.		
Frequency of monitoring/recording	The monitoring was conducted on a daily basis. Samples and measurement were ensured a 90/10 confidence/precision level.		
Value monitored	Monitoring period	Value applied (tCOD/m ³)	
		Lower	Higher
	01/05/2021 to 31/12/2021	0.0311	0.0320
	01/01/2022 to 31/10/2022	0.0300	0.0311
Monitoring equipment	The equipment of COD analysis was in line with the requirement of national or international standards. The results were logged in the plant operation report on a daily basis.		
	Serial Number	041090C53333	
	Manufacturer	HACH	
	Model	DR890	
	Accuracy	0.24% (±0.005 A @1.0 ABS Nominal)	
	Calibration frequency	Once in two years	
	Calibration	Cal. date	Validity
		09/03/2021	08/03/2023
QA/QC procedures to be applied	The analysis method should be well documented and well accepted either by national or international standards. The relevant equipment has been calibrated annually to maintain the measuring accuracy. The readings reported during the day were crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager. The standard deviation calculation method was used for ensuring the confidence/ precision level of 90/10. The adjustment has been applied to the average COD value.		
Purpose of the data	Calculation of baseline emission		
Calculation method	Not applicable		
Comments	-		

Data / Parameter	COD _{ww,treated,y}
Data unit	tCOD/m ³
Description	The chemical oxygen demand of the wastewater after the treatment system affected by the project activity
Source of data	Plant data

Description of measurement methods and procedures to be applied	This can be referred to description of parameter COD _{ww,untreated,y} .		
Frequency of monitoring/recording	Same as parameter COD _{ww,untreated,y}		
Value monitored	Monitoring period	Value applied (tCOD/m ³)	
		Lower	Higher
	01/05/2021 to 31/12/2021	0.0010	0.0011
	01/01/2022 to 31/10/2022	0.0012	0.0013
Monitoring equipment	Same as parameter COD _{ww,untreated,y}		
QA/QC procedures to be applied	Same as parameter COD _{ww,untreated,y}		
Purpose of the data	Calculation of project emissions		
Calculation method	Same as parameter COD _{ww,untreated,y}		
Comments	Same as parameter COD _{ww,untreated,y}		

Data / Parameter	S _{final,PJ,y}							
Data unit	ton							
Description	Amount of dry matter in the sludge							
Source of data	Plant data							
Description of measurement methods and procedures to be applied	The project proponent did not envisage the generation of any sludge during the monitoring period. Whenever sludge was removed from the reactor the practice of final disposal should be monitored by keeping written evidence of the amount of sludge removes and its application. Measurement of the total quantity of sludge on a wet basis should be conducted. The volume (m³) and density or direct weighting might be used to determine the sludge amount (wet basis). Representative samples (ensuring 90/10 confidence level) would be taken to determine moisture content to calculate the total sludge amount on dry basis.							
Frequency of monitoring/recording	Whenever the sludge was removed, the quantity should be recorded and documented.							
Value monitored	<table><tr><th>Monitoring period</th><th>Value applied (ton)</th></tr><tr><td>01/05/2021 to 31/12/2021</td><td>0</td></tr><tr><td>01/01/2022 to 31/10/2022</td><td>0</td></tr></table>		Monitoring period	Value applied (ton)	01/05/2021 to 31/12/2021	0	01/01/2022 to 31/10/2022	0
Monitoring period	Value applied (ton)							
01/05/2021 to 31/12/2021	0							
01/01/2022 to 31/10/2022	0							
Monitoring equipment	At the project activity, there are two weigh points. The sludge would be sent to weight on the weighbridge before end use.							

	The detail of the weighbridge is as follows.		
	Serial Number	2015024	
	Manufacturer	Liner Instrument	
	Model	D2002	
	Accuracy	0.01%	
	Installation	February 2017 to now	
	Calibration frequency	Once in two years	
	Calibration	Cal. date	Validity
		16/05/2019	15/05/2021
		04/02/2021	03/02/2023
	The following weighbridge is another one		
	Serial Number	2015003	
	Manufacturer	Liner Instrument	
	Model	PM7	
	Accuracy	0.01%	
	Installation	Commissioning to now	
	Calibration frequency	Once in two years	
	Calibration	Cal. date	Validity
		16/05/2019	15/05/2021
		06/09/2021	05/09/2023
QA/QC procedures to be applied	The measurement equipment has been calibrated at least once every two years based on relevant national requirement. The calibrations were conducted by the Central Bureau of Weights and Measures according to the national requirement.		
Purpose of the data	Calculation of project emissions		
Calculation method	Not applicable		
Comments	-		

Data / Parameter	BG _{burnt,y}
Data unit	Nm ³
Description	Biogas volume in year y
Source of data	Plant data
Description of measurement methods and procedures to be applied	In all cases, the amount of biogas recovered, fueled, flared or otherwise utilized was monitored ex post, using continuous flow meters. If the biogas stream flared and fueled (or utilized) were monitored separately, the two fractions can be added together to determine the total biogas recovered, without the need to monitor the recovered biogas before the separation.

Frequency of monitoring/recording	The measurement monitoring was conducted continuously. At least hourly measurements, if less, confidence/precision level of 90/10 should be attained. During this monitoring period, the adjustment was not necessary as the flowmeter with continuous kind has been used. The monitored data was recorded into the log sheet on daily basis.																														
Value monitored	<table><tr><th>Monitoring period</th><th>Value applied (Nm3)</th></tr><tr><td>01/05/2021 to 31/12/2021</td><td>2,592,730</td></tr><tr><td>01/01/2022 to 31/10/2022</td><td>3,120,672</td></tr></table>		Monitoring period	Value applied (Nm3)	01/05/2021 to 31/12/2021	2,592,730	01/01/2022 to 31/10/2022	3,120,672																							
Monitoring period	Value applied (Nm3)																														
01/05/2021 to 31/12/2021	2,592,730																														
01/01/2022 to 31/10/2022	3,120,672																														
Monitoring equipment	The biogas was monitored using a continues flow meter. The volumetric flow meters have been automatically measured temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm³). <table><tr><td>Serial Number</td><td colspan="2">9A070602000</td></tr><tr><td>Manufacturer</td><td colspan="2">Endress+Hauser</td></tr><tr><td>Model</td><td colspan="2">T-mass 65</td></tr><tr><td>Accuracy</td><td colspan="2">±0.50%</td></tr><tr><td>Calibration frequency</td><td colspan="2">Once in two years</td></tr><tr><td rowspan="5">Calibration</td><td><table><tr><th>Cal. date</th><th>Validity</th></tr><tr><td>07/06/2019</td><td>06/06/2021</td></tr><tr><td>19/05/2020</td><td>18/05/2022</td></tr><tr><td>22/06/2021</td><td>21/06/2023</td></tr><tr><td>09/06/2022</td><td>08/06/2024</td></tr></table></td><td></td></tr></table>			Serial Number	9A070602000		Manufacturer	Endress+Hauser		Model	T-mass 65		Accuracy	±0.50%		Calibration frequency	Once in two years		Calibration	<table><tr><th>Cal. date</th><th>Validity</th></tr><tr><td>07/06/2019</td><td>06/06/2021</td></tr><tr><td>19/05/2020</td><td>18/05/2022</td></tr><tr><td>22/06/2021</td><td>21/06/2023</td></tr><tr><td>09/06/2022</td><td>08/06/2024</td></tr></table>	Cal. date	Validity	07/06/2019	06/06/2021	19/05/2020	18/05/2022	22/06/2021	21/06/2023	09/06/2022	08/06/2024	
Serial Number	9A070602000																														
Manufacturer	Endress+Hauser																														
Model	T-mass 65																														
Accuracy	±0.50%																														
Calibration frequency	Once in two years																														
Calibration	<table><tr><th>Cal. date</th><th>Validity</th></tr><tr><td>07/06/2019</td><td>06/06/2021</td></tr><tr><td>19/05/2020</td><td>18/05/2022</td></tr><tr><td>22/06/2021</td><td>21/06/2023</td></tr><tr><td>09/06/2022</td><td>08/06/2024</td></tr></table>	Cal. date	Validity	07/06/2019	06/06/2021	19/05/2020	18/05/2022	22/06/2021	21/06/2023	09/06/2022	08/06/2024																				
	Cal. date	Validity																													
	07/06/2019	06/06/2021																													
	19/05/2020	18/05/2022																													
	22/06/2021	21/06/2023																													
09/06/2022	08/06/2024																														
QA/QC procedures to be applied	The flow meter was subjected to periodic calibration according to the equipment’s specifications (Operating Instructions document, page 68 ⁶) which is defined as once in two years.																														
Purpose of the data	Calculation of baseline and project emissions																														
Calculation method	Not applicable																														
Comments	-																														

Data / Parameter	W _{CH4}
Data unit	%
Description	Methane content in the biogas in the year y
Source of data	Plant data
Description of measurement methods and procedures to be applied	The fraction of methane in the biogas was measured with a continuous analyzer, or alternatively, with periodic measurement ensuring a 90/10 confidence/precision level. The methane

⁶ <https://www.instrumart.com/assets/Proline-T-Mass-65F-65I-manual.pdf>

	content measurement was carried out close to a location in the system where a biogas flow measurement takes place.																																						
Frequency of monitoring/recording	Daily basis																																						
Value monitored	<table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value applied</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>01/05/2021 to 31/12/2021</td><td>54.37%</td><td>66.85%</td></tr><tr><td>01/01/2022 to 31/10/2022</td><td>57.05%</td><td>61.83%</td></tr></table>	Monitoring period	Value applied		Lower	Higher	01/05/2021 to 31/12/2021	54.37%	66.85%	01/01/2022 to 31/10/2022	57.05%	61.83%																											
Monitoring period	Value applied																																						
	Lower	Higher																																					
01/05/2021 to 31/12/2021	54.37%	66.85%																																					
01/01/2022 to 31/10/2022	57.05%	61.83%																																					
Monitoring equipment	The methane fraction should be measured using continuous gas analyzer. In case the continuous gas analyzer was not available (or not functioning), a portable gas analyzer was used to monitor the methane content. The measurement using portable gas analyzer was ensured with 90/10 confidence/precision level. <table><tr><td>Serial Number</td><td colspan="3">ARAM-0090</td></tr><tr><td>Manufacturer</td><td colspan="3">Draeger</td></tr><tr><td>Model</td><td colspan="3">X-am 7000</td></tr><tr><td>Accuracy</td><td colspan="3">±5.0 %</td></tr><tr><td>Calibration frequency</td><td colspan="3">Every 6 months</td></tr><tr><td rowspan="5">Calibration</td><td>Cal. date</td><td>Validity</td><td></td></tr><tr><td>28/10/2020</td><td>27/4/2021</td><td></td></tr><tr><td>09/09/2021</td><td>08/03/2022</td><td></td></tr><tr><td>05/11/2021</td><td>04/05/2022</td><td></td></tr><tr><td>02/12/2022</td><td>01/06/2023</td><td></td></tr></table>			Serial Number	ARAM-0090			Manufacturer	Draeger			Model	X-am 7000			Accuracy	±5.0 %			Calibration frequency	Every 6 months			Calibration	Cal. date	Validity		28/10/2020	27/4/2021		09/09/2021	08/03/2022		05/11/2021	04/05/2022		02/12/2022	01/06/2023	
Serial Number	ARAM-0090																																						
Manufacturer	Draeger																																						
Model	X-am 7000																																						
Accuracy	±5.0 %																																						
Calibration frequency	Every 6 months																																						
Calibration	Cal. date	Validity																																					
	28/10/2020	27/4/2021																																					
	09/09/2021	08/03/2022																																					
	05/11/2021	04/05/2022																																					
	02/12/2022	01/06/2023																																					
QA/QC procedures to be applied	The monitoring equipment was calibrated as recommended by the manufacturer, once a year. The readings reported during the day are crosschecked at end of the day by biogas plant supervisor and approved by assistant plant manager. The standard deviation calculation method was used for ensuring the confidence/ precision level of 90/10. The adjustment has been applied to the average methane value.																																						
Purpose of the data	Calculation of baseline emissions																																						
Calculation method	Not applicable																																						
Comments	There are two calibration gaps. The first calibration gap is taken during 01/05/2021 to 08/09/2021 with the applied error during the gap period of 6.0%. The second calibration gap is taken during 05/05/22 to 31/10/22 with the applied error during the gap period of 4.0%.																																						
Data / Parameter	BG _{combusted,y}																																						
Data unit	Nm ³																																						

Description	Amount of biogas sent to boiler in year y			
Source of data	Plant data			
Description of measurement methods and procedures to be applied	The biogas sent to boiler is monitored by using the continuous flow meter directly.			
Frequency of monitoring/recording	The measurement monitoring was conducted continuously. At least hourly measurements were undertaken, if less, confidence/precision level of 90/10 should be attained. During this monitoring period, the adjustment was not necessary as the flowmeter with continuous kind has been used. The monitored data was recorded into the log sheet on daily basis.			
Value monitored	Monitoring period		Value applied (Nm3)	
	01/05/2021 to 31/12/2021		2,583,932	
	01/01/2022 to 31/10/2022		3,111,215	
Monitoring equipment	The biogas was monitored using a continuous flow meter. The volumetric flow meters have been automatically measured temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm³).			
	Serial Number		EA033D02000	
	Manufacturer		Endress+Hauser	
	Model		T-mass 65	
	Accuracy		±0.50%	
	Calibration frequency		Once in two years	
	Calibration date	Cal. date	Validity	
		07/06/2019	06/06/2021	
		19/05/2020	18/05/2022	
		22/06/2021	21/06/2023	
		09/06/2022	08/06/2024	
QA/QC procedures to be applied	The flow meter was subject to periodic calibration according to the equipment’s specifications (Operating Instructions document, page 68 ⁷) which is defined as once in two years. If the monitoring data has been monitored less than hourly measurements, confidence/precision level of 90/10 should be attained. During this monitoring period, the adjustment was not necessary as the flowmeter with continuous kind has been used.			
Purpose of the data	Calculation of baseline emissions			

⁷ <https://www.instrumart.com/assets/Proline-T-Mass-65F-65I-manual.pdf>

Calculation method	Not applicable
Comments	-

Data / Parameter	V _{RG,h}			
Data unit	Nm ³			
Description	Volumetric flow of the residual gas (methane) on dry basis at reference conditions in the minute m			
Source of data	Plant records			
Description of measurement methods and procedures to be applied	The biogas produced is monitored using the continuous flow meter directly.			
Frequency of monitoring/recording	The measurement monitoring was conducted continuously. At least hourly measurements, if less, the monitoring data has been monitored less than hourly measurements, confidence/precision level of 90/10 should be attained. During this monitoring period, the adjustment was not necessary as the flowmeter with continuous kind has been used. The monitored data was recorded into the log sheet on daily basis.			
Value monitored	Monitoring period		Value applied (Nm3)	
	01/05/2021 to 31/12/2021		1,831	
	01/01/2022 to 31/10/2022		2,979	
Monitoring equipment	The gas flow meters with an accepted level of accuracy (0.50%) have been installed and integrated with the SCADA system (Supervisory Control And Data Acquisition system) at the plant, providing continuous measurements of the total biogas volume produced by the UASB system. Volumetric flow meters have been automatically measured temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm ³).			
	The meter detail can be found as follows.			
	Serial Number		N413E702000	
	Manufacturer		Endress+Hauser	
	Model		T-mass 65	
	Accuracy		±0.50%	
	Calibration frequency		Once in two years	
	Installation		12/07/2018 until now	
	Calibration	Cal. date	Validity	
		07/06/2019	06/06/2021	
		19/05/2020	18/05/2022	
		22/06/2021	21/06/2023	

		09/06/2022	08/06/2024	
QA/QC procedures to be applied	The flow meter was subjected to periodic calibration according to the equipment's specifications (Operating Instructions document, page 68 ⁸) which is defined as once in two years.			
Purpose of the data	Calculation of baseline emissions			
Calculation method	-			
Comments	The parameters could be seen as "BG Flare,y" under the submitted ER calculation sheet.			

Data / Parameter	FC _{HFO,y}																																
Data unit	Liters/y																																
Description	Quantity of fuel type i (HFO) combusted in process j during the year y																																
Source of data	Plant data, onsite measurement																																
Description of measurement methods and procedures to be applied	The fuel oil consumption is monitored using the fuel oil meter directly.																																
Frequency of monitoring/recording	Continuous monitoring. The monitored data was recorded into the log sheet on daily basis.																																
Value monitored	<table><tr><th>Monitoring period</th><th colspan="2">Value applied (Litres)</th></tr><tr><td>01/05/2021 to 31/12/2021</td><td colspan="2">0</td></tr><tr><td>01/01/2022 to 31/10/2022</td><td colspan="2">0</td></tr></table>			Monitoring period	Value applied (Litres)		01/05/2021 to 31/12/2021	0		01/01/2022 to 31/10/2022	0																						
Monitoring period	Value applied (Litres)																																
01/05/2021 to 31/12/2021	0																																
01/01/2022 to 31/10/2022	0																																
Monitoring equipment	There are two fuel oil meters used in this monitoring period. A proper record of all the fossil fuel consumed was maintained at the project site. The OM2 meter was replaced with a new one (Aquametro) on 1st October 2022. OM1 (SCHERRER) <table><tr><td>Serial Number</td><td colspan="3">92093 ID: TMC-4-1-0068-44</td></tr><tr><td>Manufacturer</td><td colspan="3">ABB</td></tr><tr><td>Model</td><td colspan="3">ABB 25 RC</td></tr><tr><td>Accuracy</td><td colspan="3">1.0%</td></tr><tr><td>Calibration frequency</td><td colspan="3">Once in two years</td></tr><tr><td>Calibration</td><td><table><tr><th>Cal. date</th><th>Validity</th></tr><tr><td>10/06/2019</td><td>09/06/2021</td></tr><tr><td>22/05/2020</td><td>21/05/2022</td></tr></table></td><td colspan="2"></td></tr></table>			Serial Number	92093 ID: TMC-4-1-0068-44			Manufacturer	ABB			Model	ABB 25 RC			Accuracy	1.0%			Calibration frequency	Once in two years			Calibration	<table><tr><th>Cal. date</th><th>Validity</th></tr><tr><td>10/06/2019</td><td>09/06/2021</td></tr><tr><td>22/05/2020</td><td>21/05/2022</td></tr></table>	Cal. date	Validity	10/06/2019	09/06/2021	22/05/2020	21/05/2022		
Serial Number	92093 ID: TMC-4-1-0068-44																																
Manufacturer	ABB																																
Model	ABB 25 RC																																
Accuracy	1.0%																																
Calibration frequency	Once in two years																																
Calibration	<table><tr><th>Cal. date</th><th>Validity</th></tr><tr><td>10/06/2019</td><td>09/06/2021</td></tr><tr><td>22/05/2020</td><td>21/05/2022</td></tr></table>	Cal. date	Validity	10/06/2019	09/06/2021	22/05/2020	21/05/2022																										
Cal. date	Validity																																
10/06/2019	09/06/2021																																
22/05/2020	21/05/2022																																

⁸ <https://www.instrumart.com/assets/Proline-T-Mass-65F-65I-manual.pdf>

		25/06/2021	24/06/2023		
		13/06/2022	12/06/2024		
	OM2 (VEGA) – stop using				
	Serial Number	4164890 ID: TMC-0157-43			
	Manufacturer	ABB			
	Model	ABB 25 RC			
	Accuracy	1.0%			
	Calibration frequency	Once in two years			
	Calibration date	Cal. date	Validity		
		10/06/2019	09/06/2021		
22/05/2020		21/05/2022			
25/06/2021		24/06/2023			
OM2 – NEW (installed on 1 st October 2022)					
Serial Number	5857704				
Manufacturer	Aquametro Oil & Marine				
Model	VZO 25 RC 130/16				
Accuracy	1.0%				
Calibration frequency	Once in two years				
Calibration date	Cal. date	Validity			
	01/07/2021	30/06/2023			
QA/QC procedures to be applied	The meter was calibrated at least once in two years or as per the manufacturer’s recommendations to maintain the measuring accuracy. The metered fuel consumption quantity should also be cross-checked with available purchase invoices.				
Purpose of the data	Calculation of project emissions				
Calculation method	-				
Comments	-				

Data / Parameter	EG _{thermal,y}
Data unit	TJ/year
Description	Net quantity of thermal energy supplied by the project activity during the year y
Source of data	Plant records
Description of measurement methods	The thermal oil flow rate and the temperature difference of the thermal oil before and after the boiler should be monitored. In case the monitoring equipment is not available, the methodology

and procedures to be applied	deviation approach is applied. The approach estimates the thermal energy delivered by the project activity based on historical fuel oil consumption and starch production for the given year. The conservative approach is ensured by comparing the total energy delivered by the fuels burnt in the project activity and thermal energy estimate based on historical fuel oil consumption values. Therefore, the amount of dry starch and quantity of biogas utilised are the monitored parameters in order to determine the thermal energy required in the project activity.												
Frequency of monitoring/recording	Continuous monitoring, aggregated annually During this monitoring period the deviation has been introduced, please refer to the frequency of BG _{combusted} , and Q _{starch}												
Value monitored	Fuel Oil Energy Input Approach <table border="1"> <thead> <tr> <th>Monitoring period</th><th>Value applied (TJ)</th></tr> </thead> <tbody> <tr> <td>01/05/2021 to 31/12/2021</td><td>50.30</td></tr> <tr> <td>01/01/2022 to 31/10/2022</td><td>63.55</td></tr> </tbody> </table> Historical Production Approach <table border="1"> <thead> <tr> <th>Monitoring period</th><th>Value applied (TJ)</th></tr> </thead> <tbody> <tr> <td>01/05/2021 to 31/12/2021</td><td>35.10</td></tr> <tr> <td>01/01/2022 to 31/10/2022</td><td>42.31</td></tr> </tbody> </table>	Monitoring period	Value applied (TJ)	01/05/2021 to 31/12/2021	50.30	01/01/2022 to 31/10/2022	63.55	Monitoring period	Value applied (TJ)	01/05/2021 to 31/12/2021	35.10	01/01/2022 to 31/10/2022	42.31
Monitoring period	Value applied (TJ)												
01/05/2021 to 31/12/2021	50.30												
01/01/2022 to 31/10/2022	63.55												
Monitoring period	Value applied (TJ)												
01/05/2021 to 31/12/2021	35.10												
01/01/2022 to 31/10/2022	42.31												
Monitoring equipment	The monitoring equipment is referred to monitoring parameter BG _{combusted} , and Q _{starch} . The value applied is based on the calculation as per the deviation approach.												
QA/QC procedures to be applied	This section is referred to parameter BG _{combusted} , and Q _{starch} .												
Purpose of the data	Calculation of baseline emissions.												
Calculation method	Calculation method is based on the measurement of historical production data and energy input. The deviation approach is provided in section 3.2.1 of this monitoring report.												
Comments	-												

Data / Parameter	EF _{FF,HFO}
Data unit	tCO ₂ /TJ
Description	Emission factor of fossil fuel replaced-residual fuel oil
Source of data	IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23
Description of measurement methods and procedures to be applied	Not Applicable

Frequency of monitoring/recording	Default value as per IPCC
Value monitored	77.4
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of Data	This parameter was used to calculate the baseline emissions from the use of the fossil fuel that would be used in the baseline scenario.
Calculation method	Not applicable
Comments	-

Data / Parameter	NCV _{HFO}
Data unit	TJ/tonne
Description	Weighted average net calorific value of fuel type i (HFO) in year y
Source of data	IPCC 2006, Volume 2: Energy, Table 1.2.
Description of measurement methods and procedures to be applied	Not Applicable
Frequency of monitoring/recording	Default value as per IPCC
Value monitored	0.0404
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of Data	Calculation of baseline emission
Calculation method	Not applicable
Comments	-

Data / Parameter	EC _y
Data unit	MWh/year
Description	Quantity of electricity consumed by the project electricity consumption source j in year y
Source of data	Monthly joint meter readings

Description of measurement methods and procedures to be applied	Electricity consumption was monitored continuously by an import electricity meter of the PEA. The reading was based on monthly meter reading reports.													
Frequency of monitoring/recording	Continuous monitoring by electricity meter of the PEA.													
Value monitored	<table><tr><th>Monitoring period</th><th>Value applied (MWh)</th></tr><tr><td>01/05/2021 to 31/12/2021</td><td>694.863</td></tr><tr><td>01/01/2022 to 31/10/2022</td><td>799.432</td></tr></table>		Monitoring period	Value applied (MWh)	01/05/2021 to 31/12/2021	694.863	01/01/2022 to 31/10/2022	799.432						
Monitoring period	Value applied (MWh)													
01/05/2021 to 31/12/2021	694.863													
01/01/2022 to 31/10/2022	799.432													
Monitoring equipment	The monitoring was done by the import power meter, which is under Provincial Electricity Authority of Thailand (PEA) asset. <table><tr><td>PEA Number</td><td>6001693334</td></tr><tr><td>Manufacturer</td><td>TTC</td></tr><tr><td>Spec</td><td>110V</td></tr><tr><td>Phase</td><td>3-WIRE</td></tr><tr><td>Model</td><td>ST-33TL</td></tr><tr><td>Accuracy</td><td>Class 0.5s</td></tr></table>		PEA Number	6001693334	Manufacturer	TTC	Spec	110V	Phase	3-WIRE	Model	ST-33TL	Accuracy	Class 0.5s
PEA Number	6001693334													
Manufacturer	TTC													
Spec	110V													
Phase	3-WIRE													
Model	ST-33TL													
Accuracy	Class 0.5s													
QA/QC procedures to be applied	The electricity meter is under the ownership of the PEA and under PEA jurisdiction.													
Purpose of the data	Calculation of project emissions													
Calculation method	Not applicable													
Comments	The meter maintenance is not under the jurisdiction of project proponent.													

Data / Parameter	TDL _{j,y}
Data unit	%
Description	Average technical transmission and distribution losses for providing electricity to source j in year y
Source of data	World bank database (Thailand 2014) This is annual average value based on the most recent data available within the host country
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	Annually. In the absence of data from the relevant year, most recent figures has been used, but not older than 5 years.

Value monitored	Monitoring period	Value applied (%)
	01/05/2021 to 31/12/2021	7.74
	01/01/2022 to 31/10/2022	6.93
Monitoring equipment	-	
QA/QC procedures to be applied	-	
Purpose of the data	Calculation of project emissions	
Calculation method	Not applicable	
Comments	The supportive document for the TDL calculation and the references of all the values used have been prepared and submitted during the verification. The TDL value is based on the average technical transmission and distribution losses of year 2020 ⁹ .	

Data / Parameter	$\eta_{\text{Flare-h}}$
Data unit	%
Description	Flare efficiency in the minute m
Source of data	Default value for open flares as per tool “project emission from flaring”
Description of measurement methods and procedures to be applied	The flare efficiency of 50% in the minute m is applied when the flare is detected in the minute m (Flame_m). If these conditions are not met, 0% default value has been used for this period.
Frequency of monitoring/recording	Continuous measurement
Value monitored	0
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	Not applicable
Comments	Since the flame detector was not installed at the project site. The flaring efficiency of 0% has been selected for the monitoring period. This approach is conservative.

⁹ https://www.dede.go.th/ewt_news.php?nid=47341

Data / Parameter	Q _{starch,y}			
Data unit	Tonnes			
Description	Quantity of dry starch produced			
Source of data	Based on operational log sheet at starch plant			
Description of measurement methods and procedures to be applied	A proper record of all starch produced was maintained at the project site. In recording this parameter, the plant’s operators should first manually archive the monitored data onto log sheets. The archive was done daily.			
Frequency of monitoring/recording	Recorded on daily basis, and the monthly data was taken for the calculation			
Value monitored	Monitoring period	Value applied		
	01/05/2021 to 31/12/2021	27,684.05		
	01/01/2022 to 31/10/2022	33,370.66		
Monitoring equipment	The measurement equipment are two weighbridges. The quality of starch product is controlled by the operator. During normal operation, operators transfer production data that pass QA/QC process into the log sheet of starch factory. In this monitoring period, two weight scales measure the starch product, please see following details.			
	S/N	2015024		
	Equipment type	Weight bridge		
	Manufacturer	Linear Instrument		
	Model	D2002		
	Max. Capacity	80,000 kg.		
	Repeatability	±10 kg.		
	Date of installation	28/02/2017 to present		
	Calibration	Cal. date	Validity	
		05/12/2019	04/12/2021	
		04/02/2021	03/02/2023	
	S/N	2015003		
	Equipment type	Weight bridge		
	Manufacturer	Linear Instrument		
	Model	PM7		
Max. Capacity	80,000 kg.			
Repeatability	±10 kg.			
Date of installation	Commissioning to present			

	Calibration	Cal. date	Validity	
		05/12/2019	04/12/2021	
		06/09/2021	05/09/2023	
QA/QC procedures to be applied	Accuracy in the monitoring parameter can be assured since it is the main income source of the starch plant. The calibration frequency would be calibrated at least once every two years based on relevant national requirement. The calibrations were conducted by the Central Bureau of Weights and Measures according to the national standard.			
Purpose of the data	Calculation of the baseline emission			
Calculation method	Not applicable			
Comments	-			

4.3 Monitoring Plan

1. Monitoring Management

The details on monitoring approaches used in qualifying and reporting GHG emissions and/ or removals relevant for the project and baseline scenario were elaborated in section 3.1 and 3.2. Data acquisition for the gas and wastewater flow meters is executed through the process control unit of biogas plant (SCADA) and the plant operation software. Lab data is fed into the operations software through a manual data entry user interface. The biogas plant is operated by four operators (working in 3 shifts a day) who also collect data under the supervision of the assistant manager. All biogas plant staffs are trained by the Papop Company prior to full commissioning biogas plant. Figure 3 outlines the structure of operational and management of the project activity.

2. Quality Assurance and Quality Control

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

3. On-site Procedures

The operations software creates daily logs of plant performance which are printed out and recorded electronically for periodic download onsite or remote transfer for further processing.

4. Procedures for calibration of equipment

The biogas plant operators carry out calibration according to international standards.

5. Data Storage and Filling – Electronic Workbook

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

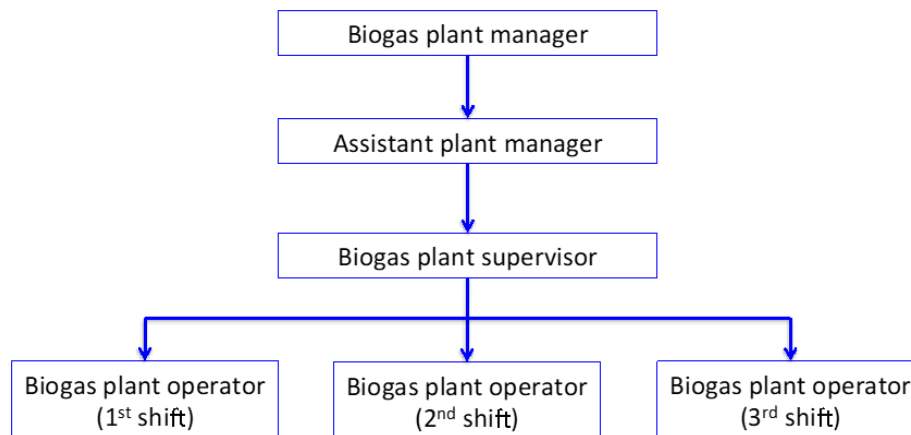


Figure 3. Structure of operational and management of the project activity

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

(a) Methane destruction component (AMS.III.H version 18.0)

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

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

Baseline emissions (BE_y)

The baseline emissions are calculated as follows.

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

Where:

Parameter	Details	Quantification
BE _y	Baseline emissions in year y (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 30,884 <u>01/01/2022 to 31/10/2022</u> = 38,861
BE _{power, y}	Baseline emissions from electricity or fuel consumption in year y (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0
BE _{ww, treatment, y}	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 38,967 <u>01/01/2022 to 31/10/2022</u> = 45,314
BE _{s, treatment, y}	Baseline emissions of the sludge treatment systems affected by the project activity in year y (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0
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).	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0
BE _{s, final, y}	Baseline methane emissions from anaerobic decay of the final sludge produced in year y (tCO ₂ e). If the sludge is controlled combusted, disposed in a landfill with biogas recovery, or used for soil application in the baseline scenario, this term would be neglected.	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0

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

Methane emissions from the baseline wastewater treatment systems affected by the project (BE_{ww, treatment, y}) are determined using the methane generation potential of the wastewater treatment systems as per the paragraph 29 of AMS III.H version 18. The following equation is used.

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

Where:

Parameter	Details	Quantification
BE _{ww, treatment, y}	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 38,967 <u>01/01/2022 to 31/10/2022</u> = 45,314

$Q_{ww, i, y}$	Volume of wastewater treated in baseline wastewater treatment system i in year y (m^3)	<u>01/05/2021 to 31/12/2021</u> = 286,624 <u>01/01/2022 to 31/10/2022</u> = 345,856
$COD_{ww, untreated, y}$	Chemical oxygen demand of the wastewater inflow to the baseline treatment system i in year y . Average value may be used through sampling with the confidence/precision level 90/10 (t/m^3). Lower value from section 4.2 were selected for the calculation.	<u>01/05/2021 to 31/12/2021</u> = 0.0311 <u>01/01/2022 to 31/10/2022</u> = 0.0300
$\eta_{COD, BL, i}$	COD removal efficiency of the baseline treatment system i	87.62%
$MCF_{ww, treatment, BL, i}$	Methane correction factor for the baseline anaerobic wastewater treatment i (MCF values as per table III.H.2)	0.8
i	Index for baseline wastewater treatment system	-
$B_{o, ww}$	Methane producing capacity of the wastewater (IPCC lower value for domestic wastewater of 0.25 $kg\ CH_4/kg\ COD$) ¹⁰	0.25
UF_{BL}	Model correction factor to account for model uncertainties (0.89) ¹¹	0.89
GWP_{CH_4}	Global Warming Potential for methane (value of 28)	<u>01/05/2021 to 31/12/2021</u> = 28 <u>01/01/2022 to 31/10/2022</u> = 28

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

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

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

³ The IPCC default value of 0.25 $kg\ CH_4/kg\ COD$ was corrected to take into account the uncertainties. Project activities may use the default value of 0.6 $kg\ CH_4/kg\ BOD$, in case the parameter $BOD_{5,20}$ is used to determine the organic content of the wastewater. In this case, baseline and project emissions calculations shall use BOD instead of COD in the formulas, and the monitoring of the project activity shall be based in direct measurements of $BOD_{5,20}$, i.e., the estimation of BOD values based on COD measurements is not allowed.

⁴ Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

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

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

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

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

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

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

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

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

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

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

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

Furthermore, it was noted in paragraph 45 – 46 of AMS III.H that the ex-post emission reduction should be based on the lowest value of the following:

(a) The amount of biogas recovered and fueled or flared (MD_y) during the crediting period, that is monitored ex post; MD approach.

(b) Ex post calculated baseline, project and leakage emissions based on actual monitored data for the project activity: COD approach.

As per equation number 15 in the applied methodology, AMS-III.H version 18, emission reductions achieved on any year are the lowest value of the following:

$$ER_{y, ex-post} = \min (BE_{y, ex-post} - PE_{y, ex-post} - LE_{y, ex-post}), (MD_y - PE_{power, y} - LE_{y, ex-post}) \quad (3)$$

As per paragraph 47 in AMS III.H., in case of flaring/combustion MD_y was measured using the conditions of the flaring process:

$$MD_y = BG_{burnt, y} * W_{CH_4, y} * D_{CH_4} * FE * GWP_{CH_4} \quad (4)$$

Where:

Parameter	Details	Quantification
-----------	---------	----------------

MD _y	Methane captured and destroyed/gainfully used by the project activity in the year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 28,167 <u>01/01/2022 to 31/10/2022</u> = 35,586
BG _{burnt, y}	Biogas flared/combusted in year y (m ³)	BG _{combusted, y} <u>01/05/2021 to 31/12/2021</u> = 2,583,932 <u>01/01/2022 to 31/10/2022</u> = 3,111,215 V _{RG, h} or BG _{flared, y} <u>01/05/2021 to 31/12/2021</u> = 1,831 <u>01/01/2022 to 31/10/2022</u> = 2,979
W _{CH4}	Methane content in the biogas in the year y (mass fraction) The lower value as per section 4.2 is selected for the calculation.	<u>01/05/2021 to 31/12/2021</u> = 0.5437 <u>01/01/2022 to 31/10/2022</u> = 0.5705
GWP _{CH4}	Global Warming Potential for methane	<u>01/05/2021 to 31/12/2021</u> = 28 <u>01/01/2022 to 31/10/2022</u> = 28
D _{CH4}	Density of methane at the temperature and pressure of the biogas in the year y (tonnes/m ³)	0.000716
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.	0

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

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

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

Where:

Parameters	Details	Quantification
------------	---------	----------------

BE _{thermal,CO2,y}	the baseline emissions from steam/heat displaced by the project activity during the year y in tCO _{2e}	<u>01/05/2021 to 31/12/2021</u> = 2,717 <u>01/01/2022 to 31/10/2022</u> = 3,275
EG _{thermal,y}	the net quantity of steam/heat supplied by the project activity during the year y in TJ. (The value achieved from EG _{thermal, historical} was selected for the calculation as it is the minimum between 2 approaches as described in section 3.2.1 methodology deviation)	EG _{thermal,y} (historical - selected) <u>01/05/2021 to 31/12/2021</u> = 35.10 <u>01/01/2022 to 31/10/2022</u> = 42.31 EG _{thermal,y} (energy input) <u>01/05/2021 to 31/12/2021</u> = 50.30 <u>01/01/2022 to 31/10/2022</u> = 63.55
EF _{FF,CO2}	the CO ₂ emission factor per unit of energy of the fuel that would have been used in the baseline plant in (tCO ₂ /TJ), obtained from reliable local or national data if available, otherwise, IPCC default emission factors are used.	77.40
η _{BL,thermal}	the efficiency of the plant using fossil fuel that would have been used in the absence of the project activity	100%

In the ex-post calculations, the amount of energy delivered by the dual fuel fired boiler is used to estimate the baseline emissions. This is based on the methodology deviation provided in section 2.2. In order to estimate the replacement of fossil fuel. The project proponent uses a conservative approach based on amount of heat required for starch drying, which in turn is estimated on historic heat requirements per tonne of starch and compensating heat energy supplied by HFO and the amount of biogas delivered to the starch factory. The details as following;

1. EG_{thermal} : Determination based on historical data of starch production:

$$EG_{thermal, historical} = (Q_{starch} * q_{FO, starch}) * D_{HFO} * NCV_{HFO}$$

2. EG_{thermal}: Determination based on monitored value of biogas delivered to starch factory:

$$EG_{thermal, energy input} = BG_{combusted,y} * W_{CH4} * D_{CH4} * NCV_{CH4}$$

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

Where:

Parameter	Details	Quantification
EG _{thermal, historical}	The net quantity of steam/heat supplied by the project activity during the year y (TJ) – based on historical data of starch production	<u>01/05/2021 to 31/12/2021</u> = 35.10 <u>01/01/2022 to 31/10/2022</u> = 42.31
EG _{thermal, energy input}	The net quantity of steam/heat supplied by the project activity during the year y (TJ) – based on monitored value of biogas delivered to starch factory	<u>01/05/2021 to 31/12/2021</u> = 50.30 <u>01/01/2022 to 31/10/2022</u> = 63.55
BG _{combusted,y}	Amount of biogas sent to boiler in year y (Nm ³)	<u>01/05/2021 to 31/12/2021</u> = 2,583,932 <u>01/01/2022 to 31/10/2022</u> = 3,111,215
WCH ₄	Methane content in the biogas in the year y (%) Lower value as per section 4.2 was selected for the calculation.	<u>01/05/2021 to 31/12/2021</u> = 54.37% <u>01/01/2022 to 31/10/2022</u> = 57.05%
Q _{starch,y}	Quantity of dry starch produced in year y (tonnes)	<u>01/05/2021 to 31/12/2021</u> = 27,684.05 <u>01/01/2022 to 31/10/2022</u> = 33,370.66
q _{HFO,starch}	Quantity of fossil fuel per unit of dry starch (liter/tonne)	33.75
NCV _{HFO}	Net calorific value of the fuel oil (TJ/tonne)	0.04
D _{HFO}	Density of fuel oil in the year y (tonnes/m ³)	0.93
NCV _{CH₄}	Net calorific value of methane (TJ/tonne)	0.05
D _{CH₄}	Density of methane at the temperature and pressure of the biogas in the year y (kg/m ³)	0.72

5.2 Project Emissions

Methane Avoidance Component (AMS-III.H)

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

- CO₂ emissions from electricity and fuel used by the project facilities (PE_{power, y});

- b) Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{ww, treatment, y}$);
- c) Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{s, treatment, y}$);
- d) Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater ($PE_{ww discharge, y}$);
- e) Methane emissions from the decay of the final sludge generated by the project activity treatment systems ($PE_{s, final, y}$);
- f) Methane fugitive emissions on account of inefficiencies in capture systems ($PE_{fugitive, y}$);
- g) Methane emissions due to incomplete flaring ($PE_{flaring, y}$);
- h) Methane emissions from biomass stored under anaerobic conditions which does not take place in the baseline situation ($PE_{biomass, y}$).

$$PE_y = \{PE_{power, y} + PE_{ww, treatment} + PE_{s, treatment} + PE_{ww discharge, y} + PE_{s, final, y} + PE_{fugitive, y} + PE_{biomass, y} + PE_{flaring, y}\} \quad (6)$$

Where:

Parameter	Details	Quantification
PE_y	Project emissions in year y (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 7,923 <u>01/01/2022 to 31/10/2022</u> = 9,773
$PE_{power, y}$	Emissions from electricity or fuel consumption in the year y (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 423 <u>01/01/2022 to 31/10/2022</u> = 482
$PE_{ww, treatment, y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 1,896 <u>01/01/2022 to 31/10/2022</u> = 2,777
$PE_{s, treatment, y}$	Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0
$PE_{ww, discharge, y}$	Methane emissions from degradable organic carbon in treated wastewater in year y (tCO ₂ e)	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0

PE _{s, final, y}	Methane emissions from anaerobic decay of the final sludge produced in year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0
PE _{fugitive, y}	Methane emissions from biogas release in capture systems in year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 5,579 <u>01/01/2022 to 31/10/2022</u> = 6,477
PE _{biomass, y}	Methane emissions from biomass stored under anaerobic conditions (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0
PE _{flaring, y}	Methane emissions due to incomplete flaring in year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 25 <u>01/01/2022 to 31/10/2022</u> = 37

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

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

$$PE_{Power, y} = EC_{PJ, j, y} * EF_{EF, j, y} * (1 + TDL_{j, y}) \quad (7)$$

Where:

Parameters	Details	Quantification
PE _{y, power}	Emissions from electricity consumption in the year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 423 <u>01/01/2022 to 31/10/2022</u> = 482
EC _y	Electricity from the grid consumed by the project activity (wastewater treatment, biogas recovery and biogas utilisation/flaring systems) (MWh)	<u>01/05/2021 to 31/12/2021</u> = 694.86 <u>01/01/2022 to 31/10/2022</u> = 799.43
TDL _{j, y}	Average technical transmission and distribution losses for providing electricity to source j in year y (%)	<u>01/05/2021 to 31/12/2021</u> = 7.74% <u>01/01/2022 to 31/10/2022</u> = 6.93%
EF _y	Thailand National Grid emission factor (tCO _{2e} /MWh)	0.56375

The project activity consumes power from the national grid system. In this monitoring period under the second crediting period, the emission factor of the project is referred to the published value announced by Thai DNA. This is in line with paragraph 17 of Tool 7 version 05, EB87 Annex 9.

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

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

$$PE_{ww,treatment,y} = \sum (Q_{ww,y} * COD_{ww,treated,y} * \eta_{PJ,k,y} * MCF_{ww,treatment,PJ,k}) * B_{o,ww} * UF_{PJ} * GWP_{CH4} \quad (8)$$

Where:

Parameter	Details	Quantification
$PE_{ww,treatment,y}$	Emissions from degradable organic carbon in treated wastewater in year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 1,896 <u>01/01/2022 to 31/10/2022</u> = 2,777
$Q_{ww,k,y}$	Volume of wastewater treated in project activity (m ³)	<u>01/05/2021 to 31/12/2021</u> = 286,751.30 <u>01/01/2022 to 31/10/2022</u> = 345,856.00
$COD_{ww,treated,y}$	The chemical oxygen demand of the wastewater after the treatment system affected by the project activity (t/m ³) The higher values from the monitored parameter in section 4.2 have been selected for the calculation 2021: 1,054/ 10 ⁶ = 0.0011 t/m ³ 2022: 1,573/ 10 ⁶ = 0.0016 t/m ³	<u>01/05/2021 to 31/12/2021</u> = 0.0011 <u>01/01/2022 to 31/10/2022</u> = 0.0013
$\eta_{COD,PJ,k,y}$	COD removal efficiency of the project wastewater treatment system k in year y (t/m ³) measured based on inflow COD and outflow COD in system k (%)	100
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for the project wastewater treatment system k (MCF values as per table 2 in AMS III.H. version 18)	0.8

B _{o, ww}	Methane producing capacity of the wastewater (IPCC lower value for domestic wastewater of 0.25 kg CH ₄ /kg COD) ¹²	0.25
UF _{PJ}	Model correction factor to account for model uncertainties (1.12)	1.12
GWP _{CH4}	Global warming potential for methane (value of 28)	<u>01/05/2021 to 31/12/2021</u> = 28 <u>01/01/2022 to 31/10/2022</u> = 28

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

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

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

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

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

$$PE_{ww, discharge, y} = 0$$

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

No final sludge has been removed from the digester during this monitoring period. If there were some sludge being removed from the digester, the project proponent would have applied final sludge for field application as fertilizer and the final disposal of the sludge should be monitored during the crediting period. Therefore, as suggested by the AMS III.H, the emission from anaerobic decay from the final sludge produced can be omitted.

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

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

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

$$PE_{fugitive, y} = PE_{fugitive, ww, y} + PE_{fugitive, s, y} \quad (9)$$

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

Where:

Parameter	Details	Quantification
PE _{fugitive, y}	Methane emissions from methane release in capture and utilization/combustion/flare systems in year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 5,579 <u>01/01/2022 to 31/10/2022</u> = 6,477
PE _{fugitive, ww, y}	Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 5,579 <u>01/01/2022 to 31/10/2022</u> = 6,477
PE _{y, fugitive, s}	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0

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

These emissions are calculated as follows:

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

Where:

Parameter	Details	Quantification
CEF _{ww}	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems (a default value of 0.9 was used)	0.9
MEP _{treatment, y}	Methane emission potential of wastewater treatment systems equipped with biogas recovery system in year y (tonne)	<u>01/05/2021 to 31/12/2021</u> = 1,992.32 <u>01/01/2022 to 31/10/2022</u> = 2,313.19

$$MEP_{ww, treatment, y} = Q_{ww, y} * B_{o, ww} * UF_{PJ} * \sum_k COD_{removed, PJ, k, y} * MCF_{ww, treatment, PJ, k} \quad (6)$$

Where:

Parameter	Details	Quantification
Q _{ww, y}	Volume of wastewater treated in project wastewater treatment system k in year y (m ³ /year)	<u>01/05/2021 to 31/12/2021</u> = 286,751.30 <u>01/01/2022 to 31/10/2022</u> = 345,856.00

$B_{o,ww}$	Methane producing capacity of the wastewater	0.25
UF_{PJ}	Model correction factor to account for model uncertainties (1.12)	1.12
$COD_{removed,PJ,k,y}$	The chemical oxygen demand removed by the treatment system k of the project activity equipped with biogas recovery in the year y (tonnes/m³) This was calculated based on the difference between $COD_{ww,untreated,y}$ & $COD_{ww,treated,y}$. $(COD_{ww,untreated,y} \text{ (higher)} - COD_{ww,treated,y} \text{ (lower)}) \div 10^6$ For 2021: $0.0320 - 0.0011 = 0.0309$ For 2022: $0.0299 - 0.0013 = 0.0286$	<u>01/05/2021 to 31/12/2021</u> = 0.0310 <u>01/01/2022 to 31/10/2022</u> = 0.0299
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for the project wastewater treatment system k equipped with biogas recovery equipment (MCF values as per table III.H.2)	0.8

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

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

$$PE_{y,fugitive,s} = 0$$

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

Methane emissions due to incomplete flaring in year y were calculated as per the methodological tool "Project emissions from flaring".

$$PE_{flaring,y} = GWP_{CH_4} * \sum F_{CH_4,RG,m} * (1 - \eta_{flare}) * 10^{-3} \quad (7)$$

Where:

Parameter	Details	Quantification
$PE_{flaring,y}$	Project emissions from flaring of the residual gas in year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 25 <u>01/01/2022 to 31/10/2022</u>

		= 37
GWP _{CH4}	Global warming potential of methane valid for the commitment period (tCO _{2e} /tCH ₄)	<u>01/05/2021 to 31/12/2021</u> = 28 <u>01/01/2022 to 31/10/2022</u> = 28
F _{CH4,RG,m}	Mass flow of methane in the residue gas in the minute m (kg)	<u>01/05/2021 to 31/12/2021</u> = 876.40 <u>01/01/2022 to 31/10/2022</u> = 1,318.88
η _{flare,m}	Flare efficiency in minute m	0%

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

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

$$PE_{biomass,y} = 0$$

Thermal energy production (AMS.I.C):

According to paragraph 66 of AMS-I.C, CO₂ emissions from on-site consumption of fossil fuels due to the project activity was calculated using the latest version of “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”. As per paragraph 6 of the tool, the formula is determined as below.

$$PE_{FC,j,y} = \sum F_{CHFO,y} * COEF_{i,y} \quad (8)$$

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

$$COEF_{i,y} = NCV_{HFO} * EF_{HFO,CO2} \quad (9)$$

Where:

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

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

$$PE_{FC,j,y} = \sum F_{CHFO,y} * NCV_{HFO} * EF_{HFO,CO2} \quad (10)$$

Where:

Parameter	Details	Quantification
-----------	---------	----------------

PE _{FC, y}	Project emissions due to combustion of fossil fuel in year y (tCO _{2e})	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0
FC _{HFO, y}	Amount of fossil used in the boiler in ton/yr	<u>01/05/2021 to 31/12/2021</u> = 0 <u>01/01/2022 to 31/10/2022</u> = 0
NCV _{HFO}	NCV of fossil fuel used in the process (TJ/tonne)	0.0404
EF _{HFO, CO2}	Emission factor of Heavy fuel oil as per IPCC (tCO ₂ /TJ)	77.4

5.3 Leakage Emissions

The used technology has no equipment transferred from another activity, therefore according to AMS.III.H and AMS.I.C, there is no leakage to be considered.

5.4 GHG Emission Reductions and Carbon Dioxide Removals

As per the paragraph 48 of AMS III.H and paragraph 80 of AMS I.C, emission reduction achieved in this project activity using formulas mentioned in baseline, project & leakage emissions sections above. Emission reductions are calculated as follows;

$$ER_{y, \text{ ex-post}} = BE_{y, \text{ ex-post}} - (PE_{y, \text{ ex-post}} + LE_{y, \text{ ex-post}}) \quad (11)$$

According to the equation 16, the emission reduction as per the paragraph 48 of AMS III.H and paragraph 80 of AMS I.C achieved on any year are as following;

Parameter	Details	Quantification
ER _{y, ex-post}	Emission reductions achieved by the project activity based on monitored values for year y (tCO _{2e})	For AMS-III.H COD approach & AMS-I.C <u>01/05/2021 to 31/12/2021</u> = 33,761 <u>01/01/2022 to 31/10/2022</u> = 38,816 For AMS-III.H MD approach & AMS-I.C <u>01/05/2021 to 31/12/2021</u> = 30,461 <u>01/01/2022 to 31/10/2022</u> = 38,379
BE _{y, ex-post}	Baseline emissions calculated as per paragraph ex post monitored values	<u>01/05/2021 to 31/12/2021</u> = 41,684 <u>01/01/2022 to 31/10/2022</u> = 48,589

	BE _y (AMS-III.H COD approach) + BE _y (AMS-I.C.)	
BE - MD _y approach	Methane captured and destroyed/gainfully used by the project activity in the year y BE _y (AMS-III.H MD _y approach) + BE _y (AMS-I.C.)	<u>01/05/2021 to 31/12/2021</u> = 30,884 <u>01/01/2022 to 31/10/2022</u> = 38,861
PE _{y, ex-post}	Project emissions calculated as per paragraph ex post monitored values	For AMS-III.H COD approach & AMS-I.C <u>01/05/2021 to 31/12/2021</u> = 7,923 <u>01/01/2022 to 31/10/2022</u> = 9,773 For AMS-III.H MD_y approach & AMS-I.C <u>01/05/2021 to 31/12/2021</u> = 423 <u>01/01/2022 to 31/10/2022</u> = 482

Comparing the result of the emission reduction calculation as per requirement of AMS-III.H paragraph 46 is as follows.

- ER achieved from AMS-III.H COD approach is equal to 31,044 tCO₂e in 2021 and 35,541 tCO₂e in 2022.
- ER achieved from AMS-III.H MD approach is equal to 27,744 tCO₂e in 2021 and 35,104 tCO₂e in 2022.

The most conservative value of the ER under AMS-III.H is based on MD approach. Then the selected values are added with the emission reduction achieved under AMS-I.C which could be outlined as follows; 2,717 tCO₂e in 2021 and 3,275 tCO₂e in 2022. The total emission reduction project claims during this monitoring period; 01/05/2021 to 31/10/2022, is **68,840 tCO₂e**.

Vintage period	Baseline emissions (tCO ₂ e)	Project emissions (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Reduction VCU (tCO ₂ e)	Removal VCU (tCO ₂ e)	Total VCUs (tCO ₂ e)
01-May-2021 to 31-Dec-2021	30,884	423	0	30,461	0	30,461
01-Jan-2022 to 31-Oct-2022	38,861	482	0	38,379	0	38,379
Total	69,745	905	0	68,840	0	68,840

Vintage period	Ex-ante estimated reductions/removals	Achieved reductions/removals	Percent difference	Explanation for the difference
01-May-2021 to 31-Dec-2021	34,445	30,461	-11.57%	The reason of the lower emission reduction came from lower COD load for this vintage period which is 9,050.87 tCOD/year as compared to baseline estimation of 10,907.80 tCOD/year (-17.02%).
01-Jan-2022 to 31-Oct-2022	42,740	38,379	-10.20%	The reason of the lower emission reduction came from lower COD load for this vintage period which is 10,559.30 tCOD/year as compared to baseline estimation of 13,534.57 tCOD/year (-21.98%).
Total	77,185	68,840	-10.81%	During this monitoring period, the ex-ante calculation is equal to 77,185 tCO ₂ e, which is higher than the ex-post emission reduction. The operation days of this monitoring period is 245 days in year 2021 and 304 days in year 2022. Therefore, the ex-ante emission is based on 201.37 days in year 2021 ¹³ and 249.86 days in year 2022 ¹⁴ . The reason of the lower emission reduction came from lower COD load for this monitoring period ¹⁵ which is 9,820.46 tCOD/year as compared to baseline estimation ¹⁶ of 12,221.19 tCOD/year (-19.64%). It may also happen that in the future,

¹³ Operation days of ex-ante emission reductions in year 2021, 201.37 days, is based on [245 days*(300/365 days)].

¹⁴ Operation days of ex-ante emission reductions in year 2022, 249.86 days, is based on [304 days*(300/365 days)].

¹⁵ Average quantity of annual wastewater in the monitoring period is 316,272.00 m³ (average of 286,688 m³ in 2021 & 345,856 m³ in 2022). Average COD_{ww, untreated,y} is 31,050.69mg/l (average between 31,570.47mg/l in 2021 & 30,530.91mg/l in 2022). Annual COD load [(316,272.00*31,050.69mg)/1,000,000] = 9,820.46 tCOD/year.

¹⁶ Average quantity of annual wastewater in the baseline estimation is 532,003.56 m³ (average of 474,830.14 m³ in 2021 and 589,176.99 m³ in 2022), Average COD_{ww, untreated,y} is 22,972 mg/l Annual COD load [(532,003.56*22,972.00mg)/1,000,000] = 12,221.19 tCOD/year.

				the quantity and quality of wastewater entering the system may go up. Therefore, it can be concluded that the decrease in emission reductions is not permanent but dependent on various factors, which can neither be controlled nor predicted in advance.
--	--	--	--	--

APPENDIX 1: COMMERCIALY SENSITIVE INFORMATION

There is no commercially sensitive information within this monitoring report.