



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



Document Prepared by South Pole Carbon Asset Management Ltd.
Technoparkstrasse 1, 8005 Zurich Switzerland
Phone +41 43 501 35 50 Fax +41 43 501 35 99
info@southpole.com www.southpole.com

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

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

Chol Charoen Group Wastewater Treatment with Biogas System I (Cholburi), hereafter “the project activity”, involves the installation and operation of a biogas recovery and utilization system (an open anaerobic effluent treatment system) at Chol Charoen Co. Ltd., a tapioca starch factory in Cholburi, Thailand. The system has been in operation since 07/01/06 (the project start date).

This starch factory has a design daily production capacity of 240 tonnes of dried starch, generating 2,400 m³ of wastewater per operational day. Under the previous system, wastewater released from the plant was treated in 13 cascading, open anaerobic lagoons with a depth greater than 2 m from the water surface. This condition is a suitable anaerobic environment. Anaerobic bacteria in the ponds break down organic compounds in the wastewater, resulting in the release of biogas. The generated biogas is characterized by the chemical oxygen demand (COD) of the wastewater.

The project activity involves modification of the two existing open anaerobic lagoon-based process into a closed anaerobic system for the treatment of high organic matter wastewater. This is based on Anaerobic Fixed Film Reactor (AFFR) technology. Three open lagoons at the outlet of the AFFRs were redesigned and converted to covered lagoons in order to increase gas-storage capacity and serve as an emergency wastewater treatment system in case the AFFR system malfunctions.

The implementation of the AFFR system enables the recovery of biogas that would have been released to the atmosphere and the utilization of the recovered biogas for thermal and electricity generation. Excess biogas, if any, is sent to the enclosed flare system. Under the project activity, the burner is retrofitted with a combination fuel burner, which allows the boiler to be co-fired using both fuel oil and the biogas collected from the reactors. The power produced by the captured biogas augments the electricity requirement of the plant and is fed to the national grid, under the non-firmed power purchase agreement with the Provincial Electricity Authority (PEA). With such utilization of biogas, the project activity achieves greenhouse gas (GHG) emission reductions through the avoidance of methane being released to the atmosphere, and also through the reduction of fossil fuel consumption (with fuel oil and grid electricity being displaced).

In the absence of the project activity, the wastewater from the tapioca processing plant would have been treated in open anaerobic lagoons.

This is the fourth monitoring period of second crediting period. The monitoring period starts from 03-March-2020 to 30-April-2021. The total GHG emission reductions in this monitoring period is 50,383 tCO_{2e}

1.2 Sectoral Scope and Project Type

The project activity involves the recovery of biogas from the wastewater released from the tapioca starch processing plant. The recovered biogas is used in a boiler to generate heat for the starch drying process and generate electricity to meet the power requirements of the starch processing plant, which is then supplied to the nationally owned grid. After satisfying the above demands, surplus biogas is flared for safety purpose. The project has a total electricity generation capacity of less than 15 MW_{el} and a thermal generation capacity of less than 45 MW_{th}. It will generate emission reductions of less than 60 ktCO_{2e} per year. The type/category of the project is, according to Appendix B, Simplified Modalities and Procedures for Small-Scale CDM Project Activities, as follows:

Methane avoidance component:

Type III: Other project activities
Category III.H: Methane Recovery in Wastewater Treatment
Sectoral Scope 13: Waste handling and disposal
Version: 18

Electricity generation component:

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

Fuel replacement component

Type I: Renewable energy projects
Category I.C: Thermal energy production with or without electricity
Sectoral Scope 1: Energy industries (renewable/non-renewable sources)
Version: 20

The project is not a grouped project.

1.3 Project Proponent

Organization name	Chol Charoen Co., Ltd.
Contact person	(Project owner: Responsible for implementation and operation of the project activity)
Title	Mr. Ung Mengchua
Address	Managing Director
Telephone	1004/200 Rama3 Road, Bangpongpan, Yannawa, Bangkok, Thailand 10120
Email	+66 2 294 5315-6

1.4 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 Voluntary Carbon Standard
Contact person	Mr. Heuberger Renart
Title	CEO
Address	Technoparkstrasse 1, Zurich 8005 Switzerland
Telephone	+41 43 501 35 50
Email	registration@southpole.com

1.5 Project Start Date

The project activity starts on 07/01/2006, (the date when emission reduction began). This is the date on which retrofitted hot oil boiler became operational and began utilizing of biogas.

Crediting period start date: 01/07/2007. Due to insufficiency of monitoring equipments, the operational period in the year 2006 was neglected from the claim of emission reduction. This is in line with the principle of conservativeness as per VCS 2007.1 and complies with VCS program criteria for GHG projects and programs VCS Program Guide v.4.0.

1.6 Project Crediting Period

This is the second crediting period of the project activity which starts from 01/01/2017 to 31/12/2026 and the total crediting period is 10 years.

1.7 Project Location

The proposed project activity is located at Chol Charoen Co., Ltd., in Banbung district, Choburi province, approximately 250 km from Bangkok. The project activity location is depicted in **Figure 1** and **Figure 2**

Address: 204 Moo 3 Nongchak, Banbung, Choburi, 20170, Thailand
Geographic coordinates: Latitude 13° 17.736'N, Longitude 101° 09.108'E



Figure 1 : Project location



Figure 2 : Project boundary

1.8 Title and Reference of Methodology

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

Methane avoidance component:

Type III:	Other project activities
Category III.H:	Methane Recovery in Wastewater Treatment
Sectoral Scope 13:	Waste handling and disposal
Version:	18

Electricity generation component:

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

Fuel replacement component:

Type III:	Renewable energy projects
Category I.C:	Thermal energy production with or without electricity
Sectoral Scope 1:	Energy industries (renewable/non-renewable sources)
Version:	20

The above selected methodologies also refer to the latest approved versions of the following methodological tools:

- Project emissions from flaring, version 3.0;
- Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation, version 03.0;
- Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion, version 3;
- Determining the baseline efficiency of thermal or electric energy generation systems, version 2.0; and
- Tool to calculate the emission factor for an electricity system, version 7.0.

1.9 Participation under other GHG Programs

The project is not registered under any other GHG programs. This section is not applicable.

1.10 Other Forms of Credit

As per the justification under section 1.9, the project proponent will not claim the carbon credits under any other GHG emission reduction scheme. This section is not applicable.

1.11 Sustainable Development

The project activity contributes to sustainable development in more than one way.

Technical:

The advanced biogas reactor system, AFFR, is implemented for reusing biogas as fuel for heat and electricity generation. As compared to the baseline scenario, the installed wastewater treatment system consists of a highly efficient process for wastewater treatment based on well- researched technology from two very respectable institutions in Thailand (Biotech and KMUTT University), that promote new technologies in the country with replication options.

The anaerobic digester requires special training from skilled staff to operate and maintain the plant, creating employment and leading to knowledge transfer to the Eastern region of Thailand. The use of this technology in wastewater treatment by the project owner has enhanced the technological knowhow in the nearby areas and in plants looking for similar technologies in the country. Also, this locally produced equipment (as well as other associated technologies) may be used in other parts of Thailand for similar purposes.

Economic:

New jobs have been created during the construction and operational phases of the biogas reactor system. Regional economic development can also be fostered through contracts awarded to local firms. In addition, not only can partial reimbursement on the vast investment cost be achieved through utilization of captured biogas, but the additional revenue from the sale of VERs can also make the project financially feasible.

Sectoral:

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

Social:

The project activity has provided direct and indirect employment opportunities to the local community during the construction and operational phase of the project activity. During construction, employment was offered for a lot of local unskilled laborers contributing to social and economic well-being. The involvement of local employees in the project activity has helped to enhance the skill of the laborers in the region by training them in different technical competencies. In addition, the close collaboration between external experts and local counterparts is expected to promote long-term sustainable partnerships, benefiting the local stakeholders.

The substitution of fuel oil with biogas from the project activity has resulted in the increased availability of these fuels on the local market. The noise from pumps and blowers operating in the biogas plant, is insignificant. No other occupational health issues have been identified and the safety aspects of operating the biogas plant have been sufficiently addressed.

Environment

Due to higher efficiency and improved process controls, the quality of treated wastewater is expected to improve substantially with the implementation of the project activity. In fact, the biogas reactor system allows the starch factory to recycle the treated effluent in a starch production process; this ensures the sustainability of the water supply and that groundwater shortage will likely not be a problem for the local community. It must be mentioned that the project activity has zero discharge to the river or other natural sources such as soils and groundwater. Note that wastewater overflow might happen during the rainy season if the precipitation rate is higher than the outflow rate of the final pond for a sustained period of time. As can be seen from Figure 2, under Section 1.5, the starch plant and the pond systems are surrounded by agricultural land. Wastewater overflow can lead to a variety of problems that have significant environmental impacts. Excess nutrients in the wastewater have stimulated excessive plant growth that can disrupt the normal functioning of the ecosystem, known as eutrophication. Such a problem could lead to social conflicts within the community. While wastewater can overflow from any ponds in the old anaerobic lagoon, the overflow can only happen from the post-treatment ponds in the closed anaerobic

system. Since the average water quality at the outlet of the project activity is better than that in the anaerobic lagoon ponds, the environmental impacts from overflow of wastewater have been significantly reduced. Overall, the project has had positive impacts on the local environment by improving air quality through reduction in odor and cleaner emissions. This can in turn improve the standard of living of the local population. The capacity of this technological process to replace fuel oil and generate electricity can also be regarded as a potential for reducing dependency on fossil fuels and for promoting the diversification of energy resources. Ensuring energy security in this way can be seen as a contribution to sustainable development, particularly during this era of rising fuel prices.

Geographic/site specific:

The project has no barriers in terms of logistics. In addition, it is not located in sensitive areas such as protected areas or nearby fragile or vulnerable habitats close by. Thus, there are no issues preventing the eligibility of the project in this regard.

2 SAFEGUARDS

2.1 No Net Harm

The project activity does not have potential to create any negative environmental and socio-economic impacts.

2.2 Local Stakeholder Consultation

Place and date of meeting

Stakeholder consultation was held at a meeting room of Chol Charoen Co., Ltd. (in Cholburi) on 24 July 2008. Participants were able to examine the location where the proposed project would take place.

Meeting participants

Participants in this meeting are local residents who live within 5 km of the project location. They include local government officers, and local shopkeepers, among others.

Language

The meeting, and the material provided, was conducted in Thai (local language)

Meeting procedures

- Purpose of consultation
- Description of the project and its environmental impacts
- Description of VCS
- General feedback

Meeting documents and protocols

Registration was held prior to the meeting. During the meeting, relevant documents for project description, environmental impacts and the effects on sustainable development were delivered to all participants. On completion of the meeting, the following documents were collected and attested with signatures of the stakeholders attended:

- attendance list with names, addresses and occupations;
- non-technical description of the project; and
- documents on the environmental impacts of the project.

These documents are available in hard copies and can be shown to the Designated Operational Entity (DOE) during the validation process.

Summary of the comments received

After the presentations, participants were offered the opportunity to ask questions regarding the project activity. The overall response to the project was encouraging and positive to local environmental and social-economic conditions, i.e., the stakeholders appreciate the wastewater treatment in a more efficient way in which irritable odour can be avoided while creating new jobs. In all, no adverse reactions, comments, or clarifications were received during the Stakeholder Consultation process. The project participants did not recognize any need to make changes to the project design or monitoring plan.

Current Practice

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

2.3 AFOLU-Specific Safeguards

The project activity is not an AFOLU projects, this section is not required.

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

The monitoring period for this report is from 03-March-2020 to 30-April-2021, both days are included.

- As per the registered PD of the second crediting period, a new generator (Gen5, though was tagged as Gen 4 as per the 2nd CP registered PD) has been counted as a gas engine in the project activity. The validation team has checked and validated that the implementation of a new generator does not impact the baseline scenario and additionality. The installed capacity of all 4 generators is not exceeded the operation

license and is in-line with the (2nd CP) registered project description report. The Gen4 has been commissioning on 10 September 2018.

- There is no monitored data during the maintenance shutdown period in April 2020. The shutdown schedule depends on the availability of cassava roots.
- It was noted during the monitoring period, generator 4 (Gen 4) has stopped operation since 24/02/2021. No electricity has been generated from the generator. Supportive evidence has been prepared for verification.

Table 1 Summary of the technology implemented

Technology implemented	Capacity
Boiler	Dual fired boiler, capacity of 3.78 MW _{th}
Generator no. 1 & 2	Genset Type: 500GF-RZ
Generator3	Genset Type: 600GFZ1-RZ-ESM1
Generator4 ¹	Genset Type: 600GFZ1-PWZ-ESM1

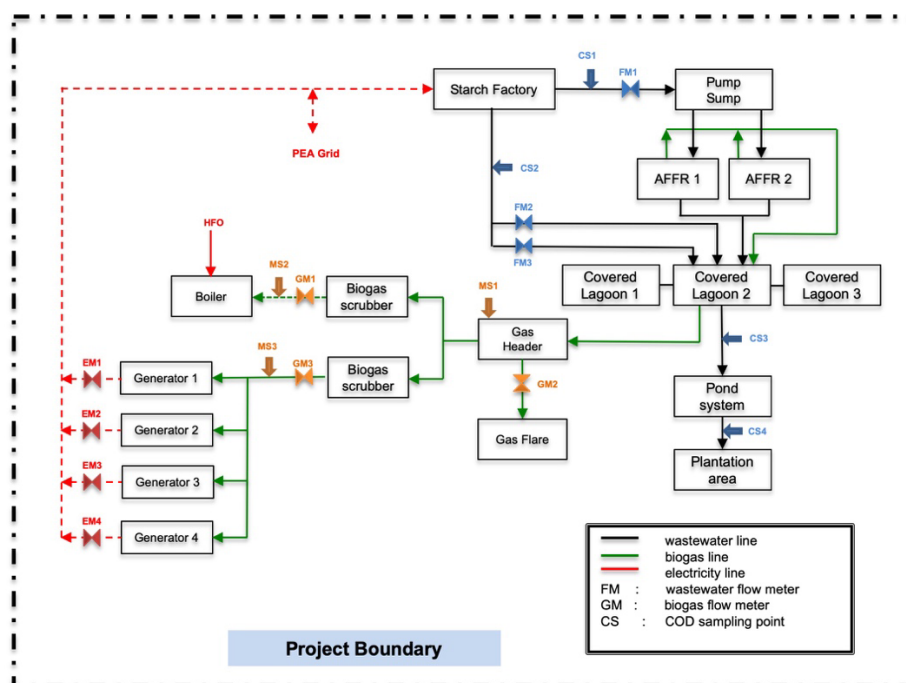


Figure 3: Monitoring diagram as project implementation

¹ Generator 4 stopped operation on 24/02/2021; technical information can be found as followed:
<https://www.tradeindia.com/products/biogas-genset-1430491.html>

3.2 Deviations

3.2.1 Methodology Deviations

There is methodology deviation applicable for the whole crediting period and has been validated during the second crediting period renewal.

Deviation

Baseline emissions for estimating the fossil fuel replaced. The latest version of methodology AMS I.C. requires monitoring of the fuel that would have been consumed in the absence of the project activity.

Deviated approach or formula

The project proponent uses a conservative approach, based on amount of heat required for starch drying, which in turn is estimated based on heat requirements per tonne of starch when only fuel oil was used. The approach compensates the fuel oil usage from the total fuel oil requirement (in baseline) and conservatively estimates the fuel oil replaced by methane, irrespective of the quantity of methane burnt.

Justification for deviation

Due to the incompleteness of the monitoring equipment, a deviation has been made to the approach specified in methodology AMS I.C. The deviated approach ensures that efficiency lost in system due to the dual fired system is conservatively adjusted in the baseline emissions. This means that if any efficiency loss happens due to dual fired system and the energy source is supplied by fuel oil, using the given approach the loss is accounted in biogas usage, thereby estimating lower fuel oil replacement for baseline emission estimation. In addition, the approach does not have any negative impact on the additionality of the project.

With reference to the clarification made by the SSC WG, this approach can be considered as not having a negative impact on the conservativeness of the applied methodology's criteria and procedures to quantify data leading to GHG emission reductions or removals. The clarification from EB, as referenced above, can be used to substantiate this statement.

The deviated approach has been adopted and accepted in the previous verifications and is still applicable for this verification.

3.2.2 Project Description Deviations

Deviation

It was found that source of data and description of measurement methods and procedure to be applied for parameter EG_{pj,y} were not consistent with the description of the parameter. This deviation was proposed and verified by the validation and verification body during the previous

verification of the project activity. The deviation was accepted, and the detail was addressed as follows.

Deviated approach

Source of data and description of measurement methods and procedure to be applied for $EG_{pj,y}$; quantity of electricity generation supplied by the project plant/unit to the grid in year y , have been revised to PEA meters and continuously monitored and monthly recorded. The readings are recorded monthly once in PEA joint meter reading reports, which are signed by the representatives of both parties i.e. the PP and PEA, respectively.

Justification for deviation

The deviated approach does not impact the applicability of the methodology, additionality or the appropriateness of the baseline scenario. The project remains in compliance with the VCS Program rules.

This project description deviation would be applicable for the whole second crediting period.

3.3 Grouped Projects

The project activity is not a grouped project - this section is not required.

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	Global warming potential for CH ₄ valid for the relevant commitment period	
Value applied	Monitoring period	Value Applied
	03/03/2020 to 31/12/2020	25
	01/01/2021 to 30/04/2021	28
Justification of choice of data or description of measurement methods and procedures applied	As per Annex 1 - clause 5 of VCS standard version 3.7, "Project shall transition to the updated GWP at their project crediting period renewal."	
Purpose of Data	Calculation of baseline and project emissions	
Comments	According to paragraph 3.14.4 of VCS standard 4.1 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). The GWP from AR4 (GWP-methane = 25) is applied for the emission reduction achieved from 03/03/2020 to 31/12/2020. However, the latest GWP from AR5 (GWP-methane = 28) has been applied for the emission reduction achieved from 01/01/2021 to 30/04/2021 which is comply with latest VCS standard.	

Data / Parameter	B _{0,ww}
Data unit	kg CH ₄ /kg COD
Description	Methane producing capacity of the wastewater
Source of data	IPCC default value as per methodology AMS III-H version 18
Value applied	0.25
Justification of choice of data or description of measurement methods and procedures applied	Default value

Purpose of Data	Calculation of baseline and project emissions
Comments	-

Data / Parameter	UF _{BL}
Data unit	-
Description	Model correction factor to account of model uncertainties
Source of data	AMS-III.H version18
Value applied	0.89
Justification of choice of data or description of measurement methods and procedures applied	Default value from AMS-III.H version 18
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	UF _{PJ}
Data unit	-
Description	Model correction factor to account of model uncertainties
Source of data	AMS-III.H version18
Value applied	1.12
Justification of choice of data or description of measurement methods and procedures applied	Default value from AMS-III.H version 18
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	MCF _{ww,treatment,BL,i}
Data unit	-
Description	Methane correction factor for the baseline anaerobic wastewater treatment system j
Source of data	Table 2 from AMS-III.H, Version 18, IPCC default values
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	The baseline wastewater treatment system consists of a succession of anaerobic deep lagoons (depth more than 2 meters) therefore the MCF value is chosen as 0.8
Purpose of Data	Calculation of baseline emissions

Comments	IPCC Default values from chapter 6 of volume 5. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
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Data / Parameter	$MCF_{ww,treatment,PJ,k}$
Data unit	-
Description	Methane correction factor for the project anaerobic wastewater treatment system k
Source of data	Table 2 from AMS-III.H, Version 18, IPCC default values
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	The project wastewater treatment system without biogas recovery (secondary treatment) consists in a succession of deep lagoons, with depth more than 2 metres, so the value of 0.8 has been chosen.
Purpose of Data	Calculation of project emissions
Comments	IPCC Default values from chapter 6 of volume 5. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

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

Data / Parameter	$\eta_{COD,BL,i}$
Data unit	%
Description	COD removal efficiency of the baseline system i
Source of data	Measurement campaign in the baseline wastewater system for 12 samples
Value applied	87%
Justification of choice of data or description of measurement methods and procedures applied	The COD removal efficiency is based, on COD values for the baseline system before project activity. The COD reduction across the baseline treatment system is multiplied by a factor of 0.89 for conservative

	estimation of baseline emissions. Actual reduction across the system is approximately 98.1% ² .
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	EF _{grid,CM,y}
Data unit	tCO ₂ e/MWh
Description	Combined margin CO ₂ emission factor for grid connected power generation in year y
Source of data	A Study on Thailand Grid Emission Factor by Thai DNA
Value applied	0.5637
Justification of choice of data or description of measurement methods and procedures applied	The study of the estimation of grid emission factor is carried out by Thai DNA in accordance with the Methodological Tool: Tool to calculate the emission factor for an electricity system. The choice of data has been detailed in the published study by Thai DNA. ³
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	FE
Data unit	%
Description	Flare efficiency
Source of data	Tool to determine project emissions from flaring gases containing methane.
Value applied	0%
Justification of choice of data or description of measurement methods and procedures applied	Default value for enclosed flare as per tool to determine project emissions from flaring gases containing methane has been applied.
Purpose of Data	Calculation of baseline emissions
Comments	-

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

² COD measurement records can be used to substantiate this value. Water analysis reports showing the quality of treated wastewater during pre-project scenario has been submitted to the DOE.

³ The latest study in 2017 is available at the time of validation for renewable of crediting period. <http://ghgreduction.tgo.or.th/24-t-ver/t-ver/t-ver-news-and-activities/292-thailand-grid-emission-factor-for-ghg-reduction-project-activity.html>

Justification of choice of data or description of measurement methods and procedures applied	According to clarification from SSC WG “in the case that the biogas is combusted for a gainful use of the released energy as in an engine or a power plant, a destruction efficiency of 100% can be used for the portion of biogas that is combusted when applying AMS III.H., i.e., using a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use”. ⁴
Purpose of Data	Calculation of baseline emissions
Comments	As per description of deviation 2.

Data / Parameter	EF _{CO2,i,y}
Data unit	tCO ₂ /TJ
Description	Emission factor of fossil fuel replaced – Residual Fuel oil
Source of data	IPCC 2006 default value for residual fuel oil, Volume 2, Chapter 1, 1.23
Value applied	77.4
Justification of choice of data or description of measurement methods and procedures applied	IPCC default values used for unavailability of national data. In the pre-project scenario, the residual fuel oil has been the main source of thermal energy for the processes.
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	$\rho_{CH_4,n}$
Data unit	kg/m ³
Description	Density of methane gas at reference conditions
Source of data	Methodological tool “Project emission from flaring” Version 3.0
Value applied	0.716
Justification of choice of data or description of measurement methods and procedures applied	<u>CDM EB as per EB28 Meeting report (Annex 13).</u>
Purpose of Data	Calculation of project emissions
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

⁴ <http://cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKEUHEF5LB07OICT1P>

Source of data	Default factor as per AMS.I.C
Value applied	100%
Justification of choice of data or description of measurement methods and procedures applied	Most conservative choice as per AMS I.C
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	NCV _{i,y}
Data unit	TJ/tonne
Description	NCV of fuel oil i.e. fossil fuel displaced by biogas
Source of data	IPCC default value
Value applied	0.0404
Justification of choice of data or description of measurement methods and procedures applied	IPCC default value for heavy fuel oil as per 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Table 1.2.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	Q _{FO,starch}
Data unit	L/tonne
Description	Liters of fossil fuel required per tonne of dry starch historically
Source of data	Historic data
Value applied	34.3
Justification of choice of data or description of measurement methods and procedures applied	Based on average values compiled from receipts in 2002, 2003, and 2005 2002 = 34.01 litres/tonne 2003 = 34.38 litres/tonne 2005 = 34.39 litres/tonne
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	D _{FO}
Data unit	Kg/litre
Description	Density of fuel oil
Source of data	http://www.engineeringtoolbox.com/fuels-densities-specific-volumes-d_166.html

Value applied	0.93
Justification of choice of data or description of measurement methods and procedures applied	Public available information
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	P_{el}
Data unit	kW
Description	Total electrical capacity of the equipment installed in the project activity
Source of data	Nameplate of the electrical equipment
Value applied	139.25 kW
Justification of choice of data or description of measurement methods and procedures applied	Extract from nameplate of the electrical equipment.
Purpose of Data	Calculation of project emissions
Comments	The rated power consumption of the equipment is updated according to the nameplate of the existing equipment.

4.2 Data and Parameters Monitored

Data / Parameter	Q _{ww,i,y}		
Data unit	m ³		
Description	Volume of wastewater treated in the year y		
Source of data	Measured continuously using volumetric flow meter FM1, FM2 and FM3		
Description of measurement methods and procedures to be applied	Measured continuously by flow meters installed before entering AFFR system.		
Frequency of monitoring/recording	Parameter monitored continuously but aggregated monthly and annually for calculations.		
Value monitored	Monitoring period	Value monitored (m ³)	
		Lower	Higher
	03/03/2020 to 31/12/2020	536,615	537,967
	01/01/2021 to 30/04/2021	277.118	278.302

Monitoring equipment	There were three flow meters (FM1, FM2 & FM3) in this monitoring period.														
	<table><tr><td>Tag/location</td><td>FM1</td></tr><tr><td>Brand</td><td>Euromag</td></tr><tr><td>Model</td><td>MC 608A</td></tr><tr><td>Serial number</td><td>KCA4726</td></tr><tr><td>Latest calibration</td><td>11/04/2019</td></tr><tr><td>Validity</td><td>10/04/2022</td></tr><tr><td>Implementation</td><td>27/11/2018 to 07/11/2020</td></tr></table>	Tag/location	FM1	Brand	Euromag	Model	MC 608A	Serial number	KCA4726	Latest calibration	11/04/2019	Validity	10/04/2022	Implementation	27/11/2018 to 07/11/2020
	Tag/location	FM1													
	Brand	Euromag													
	Model	MC 608A													
	Serial number	KCA4726													
	Latest calibration	11/04/2019													
	Validity	10/04/2022													
	Implementation	27/11/2018 to 07/11/2020													
	There was a replacement of the flowmeter FM1 on 07/11/2020. The detail of the replaced meter is as below.														
<table><tr><td>Tag/location</td><td>FM1</td></tr><tr><td>Brand</td><td>Siemens</td></tr><tr><td>Model</td><td>MAG500</td></tr><tr><td>Serial number</td><td>N1M7300330</td></tr><tr><td>Latest calibration</td><td>22/02/2021</td></tr><tr><td>Validity</td><td>21/02/2024</td></tr><tr><td>Implementation</td><td>07/11/2020 till date</td></tr></table>	Tag/location	FM1	Brand	Siemens	Model	MAG500	Serial number	N1M7300330	Latest calibration	22/02/2021	Validity	21/02/2024	Implementation	07/11/2020 till date	
Tag/location	FM1														
Brand	Siemens														
Model	MAG500														
Serial number	N1M7300330														
Latest calibration	22/02/2021														
Validity	21/02/2024														
Implementation	07/11/2020 till date														
Detail of FM2 is as follow:															
<table><tr><td>Tag/location</td><td>FM2</td></tr><tr><td>Brand</td><td>Euromag</td></tr><tr><td>Model</td><td>MUT1000EL</td></tr><tr><td>Serial number</td><td>YAL1624</td></tr><tr><td>Latest calibration</td><td>11/04/2019, 12/04/2020</td></tr><tr><td>Validity</td><td>11/04/2023</td></tr></table>	Tag/location	FM2	Brand	Euromag	Model	MUT1000EL	Serial number	YAL1624	Latest calibration	11/04/2019, 12/04/2020	Validity	11/04/2023			
Tag/location	FM2														
Brand	Euromag														
Model	MUT1000EL														
Serial number	YAL1624														
Latest calibration	11/04/2019, 12/04/2020														
Validity	11/04/2023														
Detail of FM3 is as follow:															
<table><tr><td>Tag/location</td><td>FM3</td></tr><tr><td>Brand</td><td>Euromag</td></tr><tr><td>Model</td><td>MUT1000EL</td></tr><tr><td>Serial number</td><td>YAL1625</td></tr><tr><td>Latest calibration</td><td>11/04/2019, 12/04/2020</td></tr><tr><td>Validity</td><td>11/04/2023</td></tr></table>	Tag/location	FM3	Brand	Euromag	Model	MUT1000EL	Serial number	YAL1625	Latest calibration	11/04/2019, 12/04/2020	Validity	11/04/2023			
Tag/location	FM3														
Brand	Euromag														
Model	MUT1000EL														
Serial number	YAL1625														
Latest calibration	11/04/2019, 12/04/2020														
Validity	11/04/2023														
QA/QC procedures to be applied	Flow meters underwent maintenance/calibration subject to appropriate industry standards, at least once every three years.														
Purpose of the data	Calculation of baseline and project emissions														
Calculation method	-														
Comments	The calibration certificate of new meter FM1 was not available from 07/11/2020 to 22/02/2021. The error found on the calibration certificate (1.37%) was applied to the monitored data. The conservative value has been selected for the calculation. Other two flow meters have been maintenance properly, so no adjustment to the monitoring data.														

Data / Parameter	COD _{ww,untreated,y}																								
Data unit	t COD/m³																								
Description	The chemical oxygen demand of the wastewater before the treatment system affected by the project activity.																								
Source of data	Measured as per colorimetric method CS1, CS2																								
Description of measurement methods and procedures to be applied	The COD content was analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The results should be logged in the plant operation report on a daily basis. In this monitoring period, the average value through sampling was used with a confidence/precision level of 90/10.																								
Frequency of monitoring/recording	Samples and measurements were ensured with a 90/10 confidence level																								
Value monitored	For AFFR system <table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value(tCOD/m³)</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>03/03/2020 to 31/12/2020</td><td>0.035</td><td>0.039</td></tr><tr><td>01/01/2021 to 30/04/2021</td><td>0.021</td><td>0.024</td></tr></table> For CL system <table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value(tCOD/m³)</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>03/03/2020 to 31/12/2020</td><td>0.021</td><td>0.025</td></tr><tr><td>01/01/2021 to 30/04/2021</td><td>0.023</td><td>0.027</td></tr></table>			Monitoring period	Value(tCOD/m³)		Lower	Higher	03/03/2020 to 31/12/2020	0.035	0.039	01/01/2021 to 30/04/2021	0.021	0.024	Monitoring period	Value(tCOD/m³)		Lower	Higher	03/03/2020 to 31/12/2020	0.021	0.025	01/01/2021 to 30/04/2021	0.023	0.027
Monitoring period	Value(tCOD/m³)																								
	Lower	Higher																							
03/03/2020 to 31/12/2020	0.035	0.039																							
01/01/2021 to 30/04/2021	0.021	0.024																							
Monitoring period	Value(tCOD/m³)																								
	Lower	Higher																							
03/03/2020 to 31/12/2020	0.021	0.025																							
01/01/2021 to 30/04/2021	0.023	0.027																							
Monitoring equipment	Colorimeter <table><tr><td>Brand</td><td>HACH</td></tr><tr><td>Model</td><td>DR900</td></tr><tr><td>Serial number</td><td>HAC160600001037</td></tr><tr><td>Latest calibration</td><td>29/02/2016, 09/04/2020</td></tr><tr><td>Validity</td><td>08/04/2023</td></tr></table>			Brand	HACH	Model	DR900	Serial number	HAC160600001037	Latest calibration	29/02/2016, 09/04/2020	Validity	08/04/2023												
Brand	HACH																								
Model	DR900																								
Serial number	HAC160600001037																								
Latest calibration	29/02/2016, 09/04/2020																								
Validity	08/04/2023																								
QA/QC procedures to be applied	Sampling and analysis were carried out adhering to internationally recognized procedures. The spectrophotometer is calibrated at least once every three years.																								
Purpose of the data	Calculation of baseline and project emissions																								
Calculation method	-																								
Comments	In the registered PD, the description of measurement methods and procedures to be applied mentioned that the results would be logged in the plant operation report on a daily basis. During this monitoring period, the COD has been measured through sampling, thus the average values were ensured with 90/10 confidence level. The																								

	calibration gap was found in this monitoring period; 03/03/2020 to 09/04/2020. The maximum error as found in the calibration certificate (2.1%) was selected and applied to the monitored value during the calibration gap.											
Data / Parameter	COD _{ww,treated,y}											
Data unit	t COD/m³											
Description	The chemical oxygen demand of the wastewater after the treatment system affected by the project activity.											
Source of data	Measured as per colorimetric method, CS3											
Description of measurement methods and procedures to be applied	The COD content was analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The results should be logged in the plant operation report. In this monitoring period, average value through sampling was used with the confidence/precision level 90/10.											
Frequency of monitoring/recording	Samples and measurements were ensured with a 90/10 confidence level											
Value monitored	<table><tr><th rowspan="2">Monitoring period</th><th colspan="2">Value(tCOD/m³)</th></tr><tr><th>Lower</th><th>Higher</th></tr><tr><td>03/03/2020 to 31/12/2020</td><td>0.0014</td><td>0.0017</td></tr><tr><td>01/01/2021 to 30/04/2021</td><td>0.0016</td><td>0.0018</td></tr></table>	Monitoring period	Value(tCOD/m³)		Lower	Higher	03/03/2020 to 31/12/2020	0.0014	0.0017	01/01/2021 to 30/04/2021	0.0016	0.0018
Monitoring period	Value(tCOD/m³)											
	Lower	Higher										
03/03/2020 to 31/12/2020	0.0014	0.0017										
01/01/2021 to 30/04/2021	0.0016	0.0018										
Monitoring equipment	Please see COD _{ww,untreated,y}											
QA/QC procedures to be applied	Sampling and analysis were carried out adhering to internationally recognized procedures. The spectrophotometer is calibrated at least once every 3 years.											
Purpose of the data	Calculation of baseline and project emissions											
Calculation method	-											
Comments	In the registered PD the description of measurement methods and procedures to be applied mentioned that the results would be logged in the plant operation report on a daily basis. During this monitoring period, the COD has been measured through sampling, and thus the average values were ensured with 90/10 confidence level. The calibration gap was found in this monitoring period; 03/03/2020 to 09/04/2020. The maximum error as found in the calibration certificate (2.1%) was selected and applied to the monitored value during the calibration gap.											
Data / Parameter	S _{final,PJ,y}											

Data unit	t												
Description	Amount of dry matter in the sludge												
Source of data	Measured – same weighbridge at starch plant for tapioca procuring												
Description of measurement methods and procedures to be applied	Measure the total quantity of sludge on a wet basis. The volume (m ³) and density or direct weighing may be used to determine the sludge amount (wet basis). Representative samples are taken to determine the moisture content to calculate the total sludge amount on dry basis. If the methane emissions from anaerobic decay of the final sludge were to be neglected because the sludge was controlled combusted, disposed of in a landfill with methane recovery, or used for soil application, then the end-use of the final sludge would be monitored during the crediting period.												
Frequency of monitoring/recording	Monitoring of 100 % of the sludge amount through continuous or batch measurements and moisture content through representative sampling to ensure the 90/10 confidence/precision level												
Value monitored	<table border="1"> <thead> <tr> <th>Monitoring period</th><th>Value monitored (tonnes)</th></tr> </thead> <tbody> <tr> <td>03/03/2020 to 31/12/2020</td><td>0</td></tr> <tr> <td>01/01/2021 to 30/04/2021</td><td>0</td></tr> </tbody> </table>	Monitoring period	Value monitored (tonnes)	03/03/2020 to 31/12/2020	0	01/01/2021 to 30/04/2021	0						
Monitoring period	Value monitored (tonnes)												
03/03/2020 to 31/12/2020	0												
01/01/2021 to 30/04/2021	0												
Monitoring equipment	Truck scale at starch plant <table border="1"> <thead> <tr> <th>Tag/location</th><th>Truck scale</th></tr> </thead> <tbody> <tr> <td>Brand</td><td>Linear</td></tr> <tr> <td>Model</td><td>PM02</td></tr> <tr> <td>Serial number</td><td>2006220</td></tr> <tr> <td>Latest calibration</td><td>30/05/2019</td></tr> <tr> <td>Validity</td><td>29/05/2021</td></tr> </tbody> </table>	Tag/location	Truck scale	Brand	Linear	Model	PM02	Serial number	2006220	Latest calibration	30/05/2019	Validity	29/05/2021
Tag/location	Truck scale												
Brand	Linear												
Model	PM02												
Serial number	2006220												
Latest calibration	30/05/2019												
Validity	29/05/2021												
QA/QC procedures to be applied	The plant manager's signature is required on the record. The calibration and the accuracy of truck scale is controlled and verified by Central Bureau of Weights and Measures. The calibration certificate is valid for 2 years.												
Purpose of the data	Calculation of project emissions												
Calculation method	-												
Comments	Since the truck scale has been maintenance properly, the adjustment of the monitoring data is not necessary.												

Data / Parameter	BG _{burnt, combusted, y}
Data unit	Nm ³
Description	Amount of biogas combusted for gainful use in the year y

Source of data	Measured using gas flow meter (GM1, GM3) Calculated from a summation of total biogas utilized in the boiler and generation sets.																						
Description of measurement methods and procedures to be applied	Thermal-mass type flow meters was automatically measure temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm ³)																						
Frequency of monitoring/recording	Monitored continuously but aggregated monthly and annually for calculations.																						
Value monitored	<table> <tr> <th>Monitoring period</th><th>Value applied (m³)</th></tr> <tr> <td>03/03/2020 to 31/12/2020</td><td>4,141,721</td></tr> <tr> <td>01/01/2021 to 30/04/2021</td><td>1,119,257</td></tr> </table>	Monitoring period	Value applied (m ³)	03/03/2020 to 31/12/2020	4,141,721	01/01/2021 to 30/04/2021	1,119,257																
Monitoring period	Value applied (m ³)																						
03/03/2020 to 31/12/2020	4,141,721																						
01/01/2021 to 30/04/2021	1,119,257																						
Monitoring equipment	There are two biogas flow meters implemented during this monitoring period. First gas meter is the meter monitoring biogas being sent to the hot oil boiler. <table> <tr> <td>Tag/location</td><td>GM1 - Boiler</td></tr> <tr> <td>Brand/ model/ serial number (detector)</td><td>VERIS/ C100-05-H-WCFS-CXXX/ V9107-03.1</td></tr> <tr> <td>Brand/ model/ serial number (transmitter)</td><td>Siemens/ 7MF4433-1BA22-1AC6-Z/ N1-8730-9470592</td></tr> <tr> <td>Latest calibration</td><td>17/04/2019, 10/04/2020</td></tr> <tr> <td>Validity</td><td>09/04/2023</td></tr> </table> Second gas meter is the meter monitoring biogas being sent to gas engine. <table> <tr> <td>Tag/location</td><td>GM3 - Generator</td></tr> <tr> <td>Brand</td><td>Fox</td></tr> <tr> <td>Model</td><td>FT2A-09ISSSTE3B0</td></tr> <tr> <td>Serial number</td><td>20880</td></tr> <tr> <td>Latest calibration</td><td>17/04/2019, 10/04/2020</td></tr> <tr> <td>Validity</td><td>09/04/2023</td></tr> </table>	Tag/location	GM1 - Boiler	Brand/ model/ serial number (detector)	VERIS/ C100-05-H-WCFS-CXXX/ V9107-03.1	Brand/ model/ serial number (transmitter)	Siemens/ 7MF4433-1BA22-1AC6-Z/ N1-8730-9470592	Latest calibration	17/04/2019, 10/04/2020	Validity	09/04/2023	Tag/location	GM3 - Generator	Brand	Fox	Model	FT2A-09ISSSTE3B0	Serial number	20880	Latest calibration	17/04/2019, 10/04/2020	Validity	09/04/2023
Tag/location	GM1 - Boiler																						
Brand/ model/ serial number (detector)	VERIS/ C100-05-H-WCFS-CXXX/ V9107-03.1																						
Brand/ model/ serial number (transmitter)	Siemens/ 7MF4433-1BA22-1AC6-Z/ N1-8730-9470592																						
Latest calibration	17/04/2019, 10/04/2020																						
Validity	09/04/2023																						
Tag/location	GM3 - Generator																						
Brand	Fox																						
Model	FT2A-09ISSSTE3B0																						
Serial number	20880																						
Latest calibration	17/04/2019, 10/04/2020																						
Validity	09/04/2023																						
QA/QC procedures to be applied	Flow meters should undergo maintenance/ calibration subject to appropriate industry standards, at least once every three years.																						
Purpose of the data	Calculation of baseline emissions																						
Calculation method	-																						
Comments	-																						
Data / Parameter	BG _{burnt,TOFlare,y} / VRG,m																						
Data unit	Nm ³																						
Description	Amount of biogas sent to flare system in the year y																						

Source of data	Measured using gas flow meter, GM2						
Description of measurement methods and procedures to be applied	Thermal-mass type flow meters would automatically measure temperature and pressure, expressing biogas volumes in normalized cubic meters (Nm ³)						
Frequency of monitoring/recording	Monitored continuously but aggregated monthly and annually for calculations.						
Value monitored	<table border="1"> <thead> <tr> <th>Monitoring period</th><th>Value monitored (m³)</th></tr> </thead> <tbody> <tr> <td>03/03/2020 to 31/12/2020</td><td>0</td></tr> <tr> <td>01/01/2021 to 30/04/2021</td><td>0</td></tr> </tbody> </table>	Monitoring period	Value monitored (m ³)	03/03/2020 to 31/12/2020	0	01/01/2021 to 30/04/2021	0
Monitoring period	Value monitored (m ³)						
03/03/2020 to 31/12/2020	0						
01/01/2021 to 30/04/2021	0						
Monitoring equipment	Please see comments below.						
QA/QC procedures to be applied	Flow meters underwent maintenance / calibration subject to appropriate industry standards, at least once every three years.						
Purpose of the data	Calculation of project emissions						
Calculation method	-						
Comments	During this monitoring period, there was no biogas sent for flaring, and no gas meter was being implemented at the project activity. The total biogas consumption rate and the biogas storage capacity were checked against the monitored biogas generation value. PP could ensure that no biogas have been sent to the flaring system during the monitoring period.						

Data / Parameter	WCH _{4,y}
Data unit	%
Description	Methane content in biogas in the year y
Source of data	Measured using a gas analyzer (MS1, MS2, MS3)
Description of measurement methods and procedures to be applied	The fraction of methane in the gas should be measured with a continuous analyzer or, alternatively, with periodical measurements at a 90/10 confidence/precision level. The methane content measurement was carried out close to a location in the system where a biogas flow measurement takes place. During this monitoring period, the methane was analyzed through the portable equipment, thus the confidence/precision level was applied to the monitoring value.
Frequency of monitoring/recording	Either with continuous analyzer or alternatively with periodical measurement at 90% confidence level.

Value monitored	Methane – header (from AFFR)		
	Monitoring period	Value monitored (%)	
		Lower	Higher
	03/03/2020 to 31/12/2020	51.15	52.40
	01/01/2021 to 30/04/2021	54.28	56.98
	Methane - biogas sent to boiler		
	Monitoring period	Value monitored (%)	
		Lower	Higher
	03/03/2020 to 31/12/2020	49.97	50.78
	01/01/2021 to 30/04/2021	53.50	54.46
	Methane – biogas sent to engines		
	Monitoring period	Value monitored (%)	
Lower		Higher	
03/03/2020 to 31/12/2020	47.68	48.45	
01/01/2021 to 30/04/2021	52.12	53.37	
Monitoring equipment	Methane gas analyzer		
	Brand	Gas Data	
	Model	GFM406	
	Serial number	12368	
	Latest calibration	12/03/2019	
	Validity	11/03/2022	
QA/QC procedures to be applied	The gas analyzer underwent maintenance/calibration subject to appropriate industry standards, at least once every three years.		
Purpose of the data	Calculation of baseline and project emissions		
Calculation method	The lowest value of 51.15% was chosen for baseline emission calculation, while highest value of 52.12% was chosen for project emission calculation in 2020. While 52.40% was chosen for baseline emission calculation, while highest value of 56.98% was chosen for the project emission calculation in 2021.		
Comments	The lower value was chosen for the baseline emission, while the higher value was selected for the project emission calculation. This is a conservative approach.		

Data / Parameter	$\eta_{\text{flare-m}}$
Data unit	%
Description	The flare efficiency
Source of data	Tool “Project emissions from flaring” version 02.0.0
Description of measurement methods	In the case of enclosed flares, the $\eta_{\text{flare,m}}$ is 0% without the complete flare monitoring system.

and procedures to be applied					
Frequency of monitoring/recording	Continuously monitored				
Value monitored	<table border="1"> <tr> <th>Monitoring period</th><th>Value monitored (%)</th></tr> <tr> <td>03/03/2020 to 31/12/2020</td><td>0</td></tr> </table> *conservative default value for enclosed flare	Monitoring period	Value monitored (%)	03/03/2020 to 31/12/2020	0
Monitoring period	Value monitored (%)				
03/03/2020 to 31/12/2020	0				
Monitoring equipment	-				
QA/QC procedures to be applied	-				
Purpose of the data	Calculation of project emissions				
Calculation method	-				
Comments	-				

Data / Parameter	EC _{PJ,j,y}						
Data unit	MWh						
Description	Electricity consumption by wastewater treatment system and biogas plant in year y						
Source of data	Maximum rated consumption						
Description of measurement methods and procedures to be applied	-						
Frequency of monitoring/recording	-						
Value monitored	<table border="1"> <tr> <th>Monitoring period</th><th>Value monitored (MWh)</th></tr> <tr> <td>03/03/2020 to 31/12/2020</td><td>2,261.60</td></tr> <tr> <td>01/01/2021 to 30/04/2021</td><td>447.27</td></tr> </table>	Monitoring period	Value monitored (MWh)	03/03/2020 to 31/12/2020	2,261.60	01/01/2021 to 30/04/2021	447.27
Monitoring period	Value monitored (MWh)						
03/03/2020 to 31/12/2020	2,261.60						
01/01/2021 to 30/04/2021	447.27						
Monitoring equipment	-						
QA/QC procedures to be applied	In the absence of an electric meter for the electricity consumption of project activity, the maximum rated consumption was used to calculate the emissions from PE_{power,y}. Since this approach has taken into account the distribution losses (TDL_{j,y}) which equals to 7.68%, and the calculation is based on an assumption that the electrical appliances were running at full capacity on the operating days for the entire year, the QA/QC aspect has already been assured.						

Purpose of the data	Calculation of project emissions
Calculation method	Plant load factor of 10% has been added to the calculation of the P_{el} . This approach is consistent with the estimation under second crediting period PD and would be applied for the whole second crediting period
Comments	-

Data / Parameter	$TDL_{j,y}$						
Data unit	%						
Description	Average technical transmission and distribution losses for providing electricity to the project activity (electricity import)						
Source of data	Recent data available for the host country						
Description of measurement methods and procedures to be applied	As per the guidance given in the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”, the most recent data available within the host country was used during monitoring and verification.						
Frequency of monitoring/recording	Annually In the absence of data from the relevant year, the most recent figures should be used, but not older than five years.						
Value monitored	<table border="1"> <thead> <tr> <th>Monitoring period</th><th>Value monitored (%)</th></tr> </thead> <tbody> <tr> <td>03/03/2020 to 31/12/2020</td><td>7.68</td></tr> <tr> <td>01/01/2021 to 30/04/2021</td><td>7.68</td></tr> </tbody> </table>	Monitoring period	Value monitored (%)	03/03/2020 to 31/12/2020	7.68	01/01/2021 to 30/04/2021	7.68
Monitoring period	Value monitored (%)						
03/03/2020 to 31/12/2020	7.68						
01/01/2021 to 30/04/2021	7.68						
Monitoring equipment	-						
QA/QC procedures to be applied	Not applicable						
Purpose of the data	Calculation of project emissions						
Calculation method	-						
Comments	During this monitoring period, Thailand Energy Balance 2020 published by Department of Alternative Energy Development and Efficiency (DEDE) has been selected for the calculation. ⁵						

Data / Parameter	$EG_{PJ,y}$
Data unit	MWh
Description	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y

⁵https://www.dede.go.th/ewt_news.php?nid=47341

Source of data	PEA meters												
Description of measurement methods and procedures to be applied	The power monitoring equipment is installed for continuous measuring of electricity produced from each generator. Since the net electricity generation supplied to the grid has been used in the calculation, the data from PEA meter was chosen.												
Frequency of monitoring/recording	Continuous monitoring and at least monthly recording												
Value monitored	<table border="1"> <thead> <tr> <th>Monitoring period</th><th>Value monitored (MWh)</th></tr> </thead> <tbody> <tr> <td>03/03/2020 to 31/12/2020</td><td>852.57</td></tr> <tr> <td>01/01/2021 to 30/04/2021</td><td>181.68</td></tr> </tbody> </table>	Monitoring period	Value monitored (MWh)	03/03/2020 to 31/12/2020	852.57	01/01/2021 to 30/04/2021	181.68						
Monitoring period	Value monitored (MWh)												
03/03/2020 to 31/12/2020	852.57												
01/01/2021 to 30/04/2021	181.68												
Monitoring equipment	Power export meter <table border="1"> <tbody> <tr> <td>Tag/location</td><td>PEA-export meter</td></tr> <tr> <td>Brand</td><td>EDMI</td></tr> <tr> <td>Model</td><td>Genius</td></tr> <tr> <td>PEA number</td><td>18324073</td></tr> <tr> <td>Latest calibration</td><td>N/A</td></tr> <tr> <td>Validity</td><td>N/A</td></tr> </tbody> </table> The meter is under PEA jurisdiction and calibration is not under project proponent control.	Tag/location	PEA-export meter	Brand	EDMI	Model	Genius	PEA number	18324073	Latest calibration	N/A	Validity	N/A
Tag/location	PEA-export meter												
Brand	EDMI												
Model	Genius												
PEA number	18324073												
Latest calibration	N/A												
Validity	N/A												
QA/QC procedures to be applied	The meter should be verified as per the manufacturer's recommendation. The meter used in the project activity is under PEA jurisdiction, thus the calibration/maintenance is out of project participants control.												
Purpose of the data	Calculation of baseline emissions												
Calculation method	-												
Comments	-												

Data / Parameter	$EG_{thermal,y}$
Data unit	TJ
Description	Net quantity of thermal energy supplied by the project activity during the year y
Source of data	Plant records
Description of measurement methods and procedures to be applied	As per the methodology deviated approach provided in section 2.6
Frequency of monitoring/recording	Continuous monitoring, aggregated annually
Value monitored	Historical data based on $Q_{starch,y}$

	<table><tr><th>Monitoring period</th><th>Value monitored (TJ)</th></tr><tr><td>03/03/2020 to 31/12/2020</td><td>65.76</td></tr><tr><td>01/01/2021 to 30/04/2021</td><td>28.73</td></tr></table>	Monitoring period	Value monitored (TJ)	03/03/2020 to 31/12/2020	65.76	01/01/2021 to 30/04/2021	28.73
	Monitoring period	Value monitored (TJ)					
	03/03/2020 to 31/12/2020	65.76					
	01/01/2021 to 30/04/2021	28.73					
Fuel Energy Input based on $FC_{i,j,y}$							
	<table><tr><th>Monitoring period</th><th>Value monitored (TJ)</th></tr><tr><td>03/03/2020 to 31/12/2020</td><td>17.53</td></tr><tr><td>01/01/2021 to 30/04/2021</td><td>6.12</td></tr></table>	Monitoring period	Value monitored (TJ)	03/03/2020 to 31/12/2020	17.53	01/01/2021 to 30/04/2021	6.12
Monitoring period	Value monitored (TJ)						
03/03/2020 to 31/12/2020	17.53						
01/01/2021 to 30/04/2021	6.12						
Monitoring equipment	For historical data basis – please see $Q_{starch,y}$ For fuel energy input – please see $FC_{i,j,y}$						
QA/QC procedures to be applied	The temperature and flow rate meters were subject to periodic calibration according to the equipment's specifications and applicable industry standards. In the absence of monitoring data, $EG_{thermal,y}$ can be estimated in a conservative manner with an energy balance calculation based on the energy inputs to the boiler system (biogas flow, HFO consumption), assuming a conservative value of 100% for the efficiency of the boiler. The amount of starch dried in a certain period can be used for crosschecking purposes. This approach was chosen for this monitoring period.						
Purpose of the data	Calculation of baseline emissions						
Calculation method	-						
Comments	Metering the energy produced by a sample of the systems where the simplified baseline is based on the energy produced multiplied by an emission coefficient						

Data / Parameter	$FC_{i,j,y}$						
Data unit	Litres						
Description	Quantity of fossil fuel used in the boiler in year y.						
Source of data	A flow meter is available at boiler to monitor the fuel oil usage at the project site.						
Description of measurement methods and procedures to be applied	A fuel oil meter is available at the hot oil boiler. In recording this parameter, the plant's operators would first manually archive the monitored data onto log sheets then transfer it to the computer for electronic storage. The archiving would be done on a daily basis.						
Frequency of monitoring/recording	Continuously monitoring with recording on daily basis						
Value monitored	<table> <tr> <th>Monitoring period</th><th>Value monitored (Litres)</th></tr> <tr> <td>03/03/2020 to 31/12/2020</td><td>25,038</td></tr> <tr> <td>01/01/2021 to 30/04/2021</td><td>22,000</td></tr> </table>	Monitoring period	Value monitored (Litres)	03/03/2020 to 31/12/2020	25,038	01/01/2021 to 30/04/2021	22,000
Monitoring period	Value monitored (Litres)						
03/03/2020 to 31/12/2020	25,038						
01/01/2021 to 30/04/2021	22,000						

Monitoring equipment	Flow meter for fuel oil	
	Tag/location	OM1 (at Boiler1)
	Brand	Contoil
	Model	VZF20
	Serial number	20320
	Latest calibration	23/06/2017, 09/04/2020
	Validity	08/04/2023
QA/QC procedures to be applied	Periodic calibrations (once in three years) for flow meter are ensured via an external agency.	
Purpose of the data	Calculation of project emissions	
Calculation method	-	
Comments	-	

Data / Parameter	$Q_{starch,y}$	
Data unit	Tonnes	
Description	Quantity of dry starch produced	
Source of data	Based on the operational log sheet at the plant	
Description of measurement methods and procedures to be applied	A proper record of all starch produced was maintained at the project site. This parameter is a component of regular monitoring for the starch industry as this is the main product and its revenues the core business relies from this product.	
Frequency of monitoring/recording	The monitored data was summarized annually.	
Value monitored	Monitoring period	Applied value (tonnes)
	03/03/2020 to 31/12/2020	51,758
	01/01/2021 to 30/04/2021	22,932
Monitoring equipment	Truck scale at starch factory	
	Tag/location	Weight bridge
	Brand	Metler Toledo
	Model	C1200-100
	Serial number	B70153544
	Accuracy	+ 30 g
	Latest calibration	06/12/2019, 30/10/2020
	Validity	29/10/2021
QA/QC procedures to be applied	Production data can be cross-checked with sales records if necessary.	
Purpose of the data	Calculation of baseline emissions	
Calculation method	-	
Comments	Since the weight bridge has been maintenance properly, the adjustment of the monitoring data is not necessary.	

4.3 Monitoring Plan

The monitoring plan is described in section 3.4 of the registered PD. The documented procedure for VCS monitoring program has been established and implemented. This document describes about the scope of the VCS project, the responsibilities of individuals involved, job descriptions and scope, and emergency preparedness and response measures.

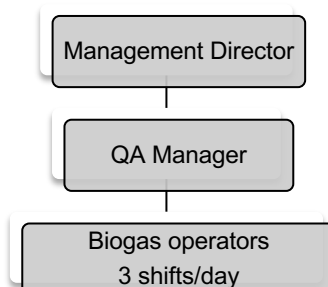
The daily operation data recording and laboratory analysis were carried out by the plant operator. The report was checked and approved by QA manager. The QA manager controls all equipment calibrations.

The QA manager collected all information and submitted to the consultant for the emission calculation.

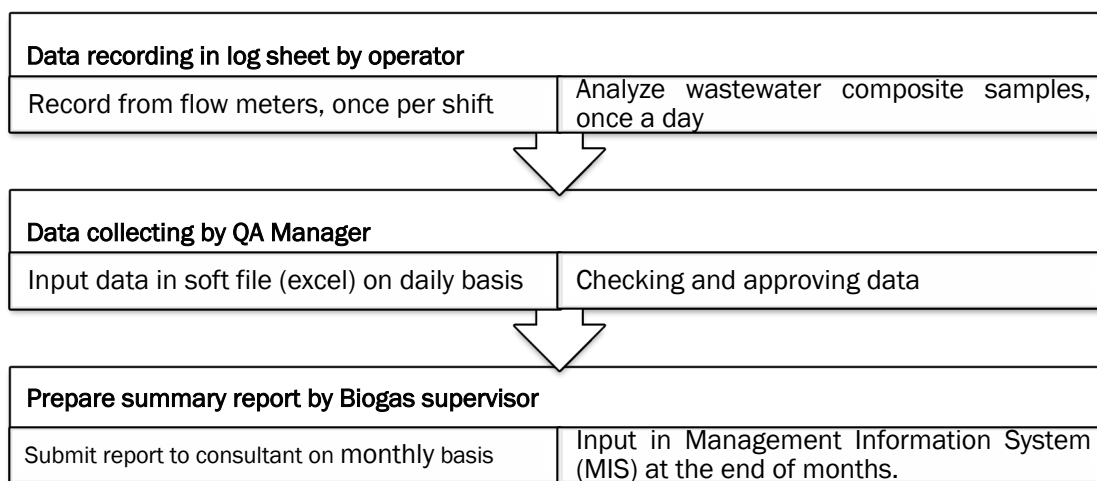
All monitoring data is available in an Excel spreadsheet. This spreadsheet consists of:

1. A summary worksheet containing the results of the monitoring for every day of the monitoring period on a yearly basis; and
2. The parameters monitored during the monitoring period

Organization structure



Data Collection and management system



Data storage and backup

- The original log sheets are collected and stored at the starch operation office by the QA Manager.
- The Excel spreadsheet is stored in the QA manager's computer and backed-up into an external or portable hard disk at least once a month.
- The data stored in MIS report is backup via Chol Charoen's server.
- The Excel spreadsheet submitted to consultant is stored and backed-up via the consultant's internal server on a monthly basis.

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

Baseline emissions calculation as per AMS III.H

Baseline emissions for the systems affected by the project activity can be calculated as per equation below.

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

Where:

Parameters	Details	Quantification
BE_y	Baseline emissions in year y (t CO ₂ e)	03/03/2020 to 31/12/2020 = 52,308 01/01/2021 to 30/04/2021 = 20,517
$BE_{power, y}$	Baseline emissions from electricity or fuel consumption in year y (t CO ₂ e)	03/03/2020 to 31/12/2020 = 0 01/01/2021 to 30/04/2021 = 0
$BE_{ww, treatment, y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (t CO ₂ e)	03/03/2020 to 31/12/2020 = 52,308 01/01/2021 to 30/04/2021 = 20,517
$BE_{s, treatment, y}$	Baseline emissions of the sludge treatment systems affected by the project activity in year y (t CO ₂ e)	03/03/2020 to 31/12/2020 = 0 01/01/2021 to 30/04/2021 = 0
$BE_{ww, discharge, y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into seas, rivers, and lakes in year y (t CO ₂ e). The value of this term is zero for the case 1(b)	03/03/2020 to 31/12/2020 = 0 01/01/2021 to 30/04/2021 = 0
$BE_{s, final, y}$	Baseline methane emissions from anaerobic decay of the final sludge produced in year y (t CO ₂ e). If the sludge is controlled combusted, disposed of in a landfill with biogas recovery, or used for soil application in the baseline scenario, this term was neglected	03/03/2020 to 31/12/2020 = 0 01/01/2021 to 30/04/2021 = 0

a) **Emissions on account of electricity or fossil fuel used ($BE_{power,y}$)**

The only electricity consumption devices used in the baseline wastewater treatment systems are pumps for pumping the starch wastewater into the open anaerobic lagoons. There is no consumption of fossil fuels for the operation of the baseline system.

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

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

b) **Methane emissions from baseline wastewater treatment systems ($BE_{ww,treatment,y}$);**

Methane emissions from the baseline wastewater treatment systems affected by the project ($BE_{ww,treatment,y}$) are determined using the COD removal efficiency of the baseline plant:

$$BE_{ww,treatment,y} = \sum Q_{ww,i,y} * COD_{inflow,i,y} * \eta_{COD,BL,i} * MCF_{ww,treatment,BL,i} * B_{o,ww} * UF_{BL} * GWP_{CH_4} \quad (2)$$

Where:

Parameter	Details	Quantification	
$BE_{ww,treatment,y}$	Methane emissions from the baseline wastewater treatment systems affected by the project	03/03/2020 to 31/12/2020=	52,308
		01/01/2021 to 30/04/2021=	20,517
$Q_{ww,i,y}$	Volume of wastewater treated in baseline wastewater treatment system i in year y (m^3).	03/03/2020 to 31/12/2020=	536,615
		01/01/2021 to 30/04/2021=	277,118
$COD_{inflow,i,y}$	COD of the wastewater inflow to the baseline treatment system i in year y (t/m^3). The average value was used through sampling with a confidence/precision level of 90/10	03/03/2020 to 31/12/2020=	$COD_{ww,untreated,lower(AFFR)} = 0.035$
			$COD_{ww,untreated,lower(CL)} = 0.021$
		01/01/2021 to 30/04/2021=	$COD_{ww,untreated,lower(AFFR)} = 0.021$
			$COD_{ww,untreated,lower(CL)} = 0.023$
$\eta_{COD,BL,i}$	COD removal efficiency of the baseline treatment system i , determined as per the paragraphs 38, 39 and 40 of the methodology	87%	
$MCF_{ww,treatment,BL,i}$	Methane correction factor for baseline wastewater treatment systems i	0.8	
i	Index for baseline wastewater treatment system		
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC value of 0.25 kg CH_4 /kg COD) ⁶	0.25	
UF_{BL}	Model correction factor to account for model uncertainties (0.89) ⁷	0.89	

⁶ Project activities may use the default value of 0.6 kg CH_4 /kg BOD, if 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 equations, 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.

⁷ Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

GWP _{CH4}	Global Warming Potential for methane	03/03/2020 to 31/12/2020 =	25
		01/01/2021 to 30/04/2021 =	28

c) **Methane emissions from baseline sludge treatment systems ($BE_{s,treatment,y}$)**

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.

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

d) **Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake ($BE_{ww,discharge,y}$)**

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

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

e) **Baseline methane emissions from anaerobic decay of the final sludge produced ($BE_{s,final,y}$)**

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 the anaerobic decay of the final sludge ($BE_{s,final,y}$) produced is also neglected.

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

As per the paragraph 46 AMS III.H., MD_y has been introduced under this methodology. The lowest emission reduction achieved in any year is the lowest value obtained from either MD_y approach or $BE_{y,expost}$ process:

$$MD_y = BG_{burnt,y} * W_{CH4,y} * D_{CH4} * FE * GWP_{CH4} \quad (3)$$

Where:

Parameters	Details	Quantification	
MD _y	Methane captured and destroyed/gainfully used by the project activity in the year y	03/03/2020 to 31/12/2020=	37,921
		01/01/2021 to 30/04/2021=	11,695
BG _{burnt,y}	Biogas flared/combusted in year y (m ³)	03/03/2020 to 31/12/2020=	BG _{burnt,combusted,y} = 4,141,721
			BG _{burnt,TOfiare,y} = 0
		01/01/2021 to 30/04/2021=	BG _{burnt,combusted,y} = 1,119,257
			BG _{burnt,TOfiare,y} = 0
W _{CH4}	Methane content of the biogas in the year y (volume fraction)	03/03/2020 to 31/12/2020=	51%
		01/01/2021 to 30/04/2021=	52%
D _{CH4}	Density of methane at the temperature and pressure of the biogas in the year y (t/m ³)	0.00072	

FE	Flare efficiency in year y (fraction)	0
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Baseline emissions calculation as per AMS I.C

For thermal energy produced using fossil fuels and/or grid electricity the baseline emissions are calculated as follows:

$$BE_{\text{thermal,CO}_2,y} = (EG_{\text{thermal,y}} / \eta_{\text{BL,thermal}}) * EF_{\text{FF,CO}_2} \quad (4)$$

As per the proposed methodology deviation explained in section 3.2.1 above, the baseline emissions were based on the minimum value between the amount of energy delivered by the dual fuel fired boiler and the historical specific consumption of fossil fuel oil per tonne of starch.

Where:

Parameter	Details	Quantification	
BE _{thermal,CO₂,y}	Baseline emissions from thermal energy displaced by the project activity during the year y (t CO ₂)	03/03/2020 to 31/12/2020=	1,357
		01/01/2021 to 30/04/2021=	473
EG _{thermal,y}	Net quantity of thermal energy supplied by the project activity during the year y (TJ)	03/03/2020 to 31/12/2020=	EG _{thermal,y} - Historical data = 65.76
			EG _{thermal,y} - Fuel energy input = 17.53
		01/01/2021 to 30/04/2021=	EG _{thermal,y} - Historical data = 28.73
			EG _{thermal,y} - Fuel energy input = 6.12
EF _{FF,CO₂}	CO ₂ emission factor of the fossil fuel that would have been used in the baseline plant. IPCC default emission factors can be used (t CO ₂ /TJ)	77.40	
Q _{starch,y}	Quantity of dry starch produced in year y (tonnes)	03/03/2020 to 31/12/2020=	51,758
		01/01/2021 to 30/04/2021=	22,932
q _{FO,starch}	Quantity of fossil fuel per unit of dry starch (liter/tonne)	34.30	
q _{FO,y}	Quantity of fossil fuel used in the project activity (litre)	03/03/2020 to 31/12/2020=	25,038
		01/01/2021 to 30/04/2021=	22,000
NCV _{FO}	Net calorific value of the fuel oil (TJ/tonne)	0.0404	
D _{FO}	Density of fuel oil in the year y (tonnes/m ³)	0.93	
η _{BL,thermal}	Efficiency of the plant using fossil fuel that would have been used in the absence of the project activity determined as per paragraph 39 or 40	78%	

Baseline emissions calculation as per AMS I.D

Baseline emissions include only CO₂ emissions from electricity generation in power plants that are displaced due to the project activity. The methodology assumes that all project electricity generation above baseline levels would have been generated by existing grid-connected power plants and the addition of new grid-connected power plants. The baseline emissions are to be calculated as follows:

$$BE_y = BE_{gen,y} = EF_{grid,y} * EG_{PJ,y}$$

(5)

Where:

Parameter	Details	Quantification	
BE _{gen,y}	Baseline emissions in year y (t CO ₂ e)	03/03/2020 to 31/12/2020=	480
		01/01/2021 to 30/04/2021=	102
EG _{PJ,y}	Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the project activity in year y (MWh)	03/03/2020 to 31/12/2020=	852.57
		01/01/2021 to 30/04/2021=	181.68
EF _{grid,y}	Combined margin CO ₂ emission factor for grid connected power generation in year y calculated using the latest version of the “Tool to calculate the emission factor for an electricity system” (t CO ₂ e/MWh)	0.5637	

5.2 Project Emissions

Project emissions calculation as per AMS III.H

The project emissions are calculated from

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

(6)

Where:

Parameters	Details	Quantification
PE _y	Project activity emissions in the year y (t CO ₂ e)	03/03/2020 to 31/12/2020 = 14,265 01/01/2021 to 30/04/2021 = 5,840
PE _{power,y}	Emissions from electricity or fuel consumption in the year y (t CO ₂ e).	03/03/2020 to 31/12/2020 = 1,373 01/01/2021 to 30/04/2021 = 272
PE _{ww,treatment,y}	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year y (t CO ₂ e).	03/03/2020 to 31/12/2020 = 4,698 01/01/2021 to 30/04/2021 = 2,877
PE _{s,treatment,y}	Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year y (t CO ₂ e).	03/03/2020 to 31/12/2020 = 0 01/01/2021 to 30/04/2021 = 0

PE _{ww, discharge, y}	Methane emissions from degradable organic carbon in treated wastewater in year y (tCO _{2e}).	03/03/2020 to 31/12/2020 = 0 01/01/2021 to 30/04/2021 = 0
PE _{s, final, y}	Methane emissions from anaerobic decay of the final sludge produced in year y (t CO _{2e}).	03/03/2020 to 31/12/2020 = 0 01/01/2021 to 30/04/2021 = 0
PE _{fugitive, y}	Methane emissions from biogas release in capture systems in year y (t CO _{2e})	03/03/2020 to 31/12/2020 = 8,194 01/01/2021 to 30/04/2021 = 2,691
PE _{biomass, y}	Methane emissions due to incomplete flaring in year y (t CO _{2e}).	03/03/2020 to 31/12/2020 = 0 01/01/2021 to 30/04/2021 = 0
PE _{flaring, y}	Methane emissions from biomass stored under anaerobic conditions. (t CO _{2e})	03/03/2020 to 31/12/2020 = 0 01/01/2021 to 30/04/2021 = 0

a) Emissions from electricity or fuel consumption in the year (PE_{Power, y})

This emission was calculated as per paragraph 28 of the methodology, by following the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

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

Where:

Parameter	Details	Quantification	
PE _{y, power}	Emissions from electricity consumption in the year y (tCO _{2e})	03/03/2020 to 31/12/2020=	1,373
		01/01/2021 to 30/04/2021=	272
EC _{PJ,j,y}	Electricity from the grid consumed by the project activity (wastewater treatment, biogas recovery and biogas utilization/flaring systems) (MWh) Plant load factor of 10% has been added on the maximum rated capacity, this approached is conservative and consistent with the estimation of registered PD.	03/03/2020 to 31/12/2020=	2,261.6
		01/01/2021 to 30/04/2021=	447.3
TDL _{j, y}	Average technical transmission and distribution losses for providing electricity to source j in year y	7.68%	
EF _y	Grid emission factor (tCO _{2e} /MWh)	0.5637	

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

$$PE_{Power, y} = \Sigma P_{el} * (100\% + TDL_{j, y}) * 8,760 \text{ hours} * EF_y * 10^{-3}$$

Where:

P_{el} Total electrical capacity of the equipment installed in the project activity (kW)

Determination of EF_y

Scenario A: Electricity consumption from the grid was chosen in this case and the combined margin emission factor of 0.5637 for a grid system was used.

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

These emissions were calculated as per equation (2) in the baseline emission calculation, using an uncertainty factor of 1.12 and data applicable to the project situation ($MCF_{ww,treatment,PJ,k}$) and with the following changed definition of parameters:

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

Where:

Parameter	Details	Quantification	
$PE_{ww,treatment,y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation (tCO ₂ e)	03/03/2020 to 31/12/2020=	4,698
		01/01/2021 to 30/04/2021=	2,877
$Q_{ww,i,y}$	Volume of wastewater treated in baseline wastewater treatment system <i>i</i> in year <i>y</i> (m ³). For ex post emissions reduction calculation was based on the actual monitored volume of treated wastewater	03/03/2020 to 31/12/2020=	537,967
		01/01/2021 to 30/04/2021=	278,302
$COD_{ww,treated,y}$	COD of the wastewater inflow to the baseline treatment system <i>i</i> in year <i>y</i> (t/m ³). An average value may be used through sampling with a confidence/precision level of 90/10	03/03/2020 to 31/12/2020=	0.0016
		01/01/2021 to 30/04/2021=	0.0016
$\eta_{PJ,k,y}$	COD removal efficiency of the project activity; 100% was used for conservative	100%	
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for project wastewater treatment system <i>k</i>	0.8	
<i>k</i>	Index for project activity wastewater treatment system	N/A	
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC value of 0.25 kg CH ₄ /kg COD) ⁸	0.25	
UF_{PJ}	Model correction factor to account for model uncertainties (1.12) ⁹	1.12	
GWP_{CH4}	Global Warming Potential for methane	03/03/2020 to 31/12/2020=	25
		01/01/2021 to 30/04/2021=	28

⁸ Project activities may use the default value of 0.6 kg CH₄/kg BOD, if 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 equations, 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.

⁹ Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

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

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

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

- d) **Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater ($PE_{ww, discharge, y}$)**

In the project activity the treated wastewater was discharged in existing open lagoons and there was no discharge into seas, rivers or lakes. Hence, emissions from this component have not been included in the assessment.

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

- e) **Methane emissions from the decay of the final sludge generated by the project activity treatment systems ($PE_{s, final, y}$)**

A relatively small amount of final sludge was removed from the digester. The project proponent would apply 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 emissions from the anaerobic decay of the final sludge produced can be omitted.

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

- f) **Methane fugitive emissions due to inefficiencies in capture systems ($PE_{fugitive, y}$)**

Project activity emissions from methane release in capture systems are determined as follows:

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

Where:

Parameter	Details	Quantification	
$PE_{fugitive, ww, y}$	Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year y (t CO ₂ e)	03/03/2020 to 31/12/2020=	8,194
		01/01/2021 to 30/04/2021=	2,691
$PE_{y, fugitive, s}$	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y (t CO ₂ e)	0	

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

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

Where:

Parameter	Details	Quantification
CFE_{ww}	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems (a default value of 0.9 was used)	0.9

MEP _{ww, treatment,y}	Methane emission potential of wastewater treatment systems equipped with biogas recovery system in year y (t)	03/03/2020 to 31/12/2020=	3,277
		01/01/2021 to 30/04/2021=	961

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

Where:

Parameter	Details	Quantification	
COD _{removed,PJ,k,y}	The chemical oxygen demand removed ¹⁰ by the treatment system k of the project activity equipped with biogas recovery in the year y (t/m ³)	03/03/2020 to 31/12/2020=	0.030
		01/01/2021 to 30/04/2021=	0.024
MCF _{ww,treatment,PJ,k}	Methane correction factor for the project wastewater treatment system k equipped with biogas recovery equipment	0.8	
UF _{PJ}	Model correction factor to account for model uncertainties (1.12)	1.12	

Since there is no anaerobic sludge treatment in the project activity, the PE_{fugitive,s,y} is considered as zero and excluded from the project emission calculation.

Thus, the fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems are given as:

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

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

If the project activity includes flaring of biogas, then the associated emissions (PE_{flare,y}) were estimated using the “Tool to determine project emissions from flaring gases containing methane” version 02.0.0 . The flare efficiency for the minute m (η_{flare,m}) is 0% , which was applied for this project for conservativeness.

Calculation of project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions for each minute m in year y, based on the methane mass flow in the residual gas (F_{CH4,RG,m}) and the flare efficiency (η_{flare,m}), as follows:

$$PE_{flare,y} = GWP_{CH4} * \sum F_{CH4,RG,m} * (1 - \eta_{flare}) * 10^{-3}$$

Where:

Parameter	Details	Quantification
PE _{flare,y}	Project emission from flaring of the residual gas stream in year y (tCO _{2e})	0
GWP _{CH4}	Global Warming Potential of methane valid for the commitment period (tCO _{2e} /tCH ₄)	03/03/2020 to 31/12/2020 = 25 01/01/2021 to 30/04/2021 = 28

¹⁰ Difference between the inflow COD and the outflow COD.

$F_{CH_4, RG, m}$	Mass flow of methane in the residual gas in the minute m (kg)	0
$\eta_{flare, m}$	Flare efficiency in minute m	0

h) Methane emissions from biomass stored under anaerobic conditions which would not have occurred 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 that do not take place in the baseline situation are not taken into consideration.

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

5.3 Leakage

The leakage predicted in the methodology employed is not applicable for this project activity as there was no transference of equipment - although new equipment had to be acquired.

5.4 Net GHG Emission Reductions and Removals

As per the AMS III.H, AMS I.C and AMS I.D, emission reductions were calculated using formulas mentioned in baseline, project, and leakage emissions sections above. Emission reductions were estimated as follows;

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

According to the AMS III.H, emission reduction achieved by the project activity is limited to the ex-post calculated baseline emissions minus project emissions using the actual monitored data for the project activity. Emission reductions achieved on any year are the lowest value of the following;

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

According to the equation above, the emission reduction as per AMS III.H, AMS I.C and AMS I.D. achieved during this monitoring period is as following;

Parameter	Details	Quantification
$ER_{y, ex-post}$	Emission reductions achieved by the project activity based on monitored values for year y (tCO ₂ e)	For AMS-III.H COD approach +AMS-I.C + AMS-I.D 03/03/2020 to 31/12/2020 = 39,880 01/01/2021 to 30/04/2021 = 15,252
$BE_{y, ex-post}$	Baseline emissions calculated as per paragraph ex post monitored values	For AMS-III.H COD approach +AMS-I.C + AMS-I.D 03/03/2020 to 31/12/2020 = 54,145 01/01/2021 to 30/04/2021 = 21,092
$PE_{y, ex-post}$	Project emissions calculated as per paragraph ex post monitored values	For AMS-III.H COD approach +AMS-I.C + AMS-I.D 03/03/2020 to 31/12/2020 = 14,265 01/01/2021 to 30/04/2021 = 5,840 For AMS-III.H MD_y approach +AMS-I.C + AMS-I.D 03/03/2020 to 31/12/2020 = 1,373 01/01/2021 to 30/04/2021 = 272

MD _y	Methane captured and destroyed/gainfully used by the project activity in the year y	For AMS-III.H MD_y approach +AMS-I.C + AMS-I.D 03/03/2020 to 31/12/2020 = 39,758 01/01/2021 to 30/04/2021 = 12,270
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The ex-post emission reductions during this monitoring period, from 03/03/2020 to 30/04/2021 was based on the MD approach. The emission reductions for this monitoring period as calculated, are equal to 50,383 tCO₂e. The ex-ante calculation is equal to 43,388 tCO₂e. The reason of higher emission reduction came from the higher COD load (quantity of wastewater and the COD value) for the monitoring period¹¹

From 03/03/2020 to 31/12/2020 it is 57,408 kg COD;

From 01/01/2021 to 30/04/2021 it is 67,247 kg COD.

As compared to baseline estimation of 55,200 kg COD¹².

The above factor could not be envisaged during the validation of the project activity. The project activity may achieve lower emission reduction in the future. It can be concluded that the increase in emission reductions is not permanent but dependent on various factors, which cannot be controlled or predicted in advance.

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)
03/03/2020 to 30/12/2020	39,758	1,373	0	38,385
01/01/2021 to 30/04/2021	12,270	272	0	11,998
Total	52,028	1,645	0	50,383

¹¹ In 2020 mp, average quantity of wastewater in the monitoring period is 2,522 m³/day, average COD_{inflow,i,y} are the average of 23,249 & 22,268 and the result is 22,758 mg/l, thus COD load [(2,522*22,758)/1000] = 57,408 kg COD.

In 2021 mp, average quantity of wastewater in the monitoring period is 2,834 m³/day, average COD_{inflow,i,y} are the average of 22,712 & 24,749 and the result is 23,731 mg/l, thus COD load [(2,834*23,731)/1000] = 67,247 kg COD.

¹² Average quantity of wastewater in the baseline estimation is 2,400 m³/day, Average COD_{inflow,i,y} is 23,000 mg/l COD load [(2,400*23,000)/1000] = 55,200 kg COD.