

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



Document Prepared By South Pole Carbon Asset Management Ltd.

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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 (Khonkaen), hereafter, 'the project activity', involves the installation and operation of a methane recovery and utilisation system (an open anaerobic effluent treatment system) at Kean Charoen (1) Co., Ltd., a tapioca starch factory in Khonkaen, Thailand. The system has been in operation since 2nd October 2006 (project start date). The starch factory has a mean daily production capacity of 175 tonnes¹ of dried starch, generating 2,000 m³ of wastewater per operational day.

Table 1: Summary of baseline and project conditions

Project/Baseline Component	Brief Description
Lagoon system	11 lagoons commissioned along with the operation start date of starch plant in 1988. The approximate retention time of the open lagoon system is around 200 days
Covered lagoons	Two covered lagoons have been converted from existing open lagoons. Typically, the COD removal efficiency of this system is around 80%. The hydraulic retention time is approximately 90 days. The covered lagoon system started operation in October 2006 (first month of biogas usage).
Boiler	There are two dual-fired boilers with a thermal capacity of 4.070 MW _{th} and 3.78 MW _{th} respectively. The first boiler, which previously capacity of 3.488 MW _{th} , was replaced by the new one with capacity 4.070 MW _{th} in year 2010 ² . The reason for replacement was to increase the biogas utilization capacity of boiler. The new burner can operate with only biogas (100%) instead of oil-biogas mixed fuel.
Gas engines	There are two electricity generation sets; the first set (no.1 st and 2 nd) with 2 generators capacity of 952 kW _e ³ each. The second generator set (no.3 rd and 4 th) with 2 generators capacity of 450 kW _e each are not included in this project boundary.
Flare	An open flare system is available at the plant. This is an automatic flare system that will operate when pressure is higher than 3 mbar. There is also a flame arrester to ensure the safe operation of the flare system.
Capacity of auxiliary drives	Total capacity of the auxiliary drives is 458 kW; the same can be referred in the GHG calculation sheet as well as in the document submitted during validation.

This monitoring report is for the second monitoring report of the first crediting period. The project has achieved 151,910 tCO₂e. Further background information on this project activity can be found in the VCS website:

<https://vcsprojectdatabase1.apx.com/mymodule/ProjectDoc/EditProjectDoc.asp?id1=427>

¹ Calculated by historical data

² This was occurred during the 1st verification

³ The technical specification document is provided.

1.2 Sectoral Scope and Project Type

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

Methane avoidance component:

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

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 : 14

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 : 15

1.3 Project Proponent

Organization name	Kean Charoen Co., Ltd.
Contact person	Ung Mengchua
Title	Mr.
Address	1004/201 Rama 3 Road, Bangpongpan, Yannawa, 10120
Telephone	+ 66 2 294 5315-6, 2945646
Email	sales@thaitapiocastarch.com

1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon Asset Management Ltd. (Responsible for development of emission reduction through the Voluntary Carbon Standard)
Contact person	Ladaporn Khunikakorn
Title	Regional Director Southeast Asia
Address	Technoparkstrasse 1, Zurich, Switzerland, 8005
Telephone	+41 43 501 35 50
Email	registration@southpole.com

1.5 Project Start Date

The project activity began on 2nd October 2006. On this date the hot oil boiler became operational and the biogas began to be utilized.

1.6 Project Crediting Period

Crediting period start date: 15th July 2009. Due to insufficiency of monitoring equipment, the operational period from 15th July 2009, which is the starting date mentioned in registered PD, till 2nd December 2009 was neglected from our claim of emission reduction.

The project activity is estimated to last 15 years⁴. After the initial crediting period of ten years, subsequent renewals of the crediting time may be considered depending on the status of the project activity and baseline revision at that time.

According to gas engine lifetime confirmations from individual technology providers, a lifetime of 15 years is assumed.

The lifetime of each boiler can be assumed as 25 years for the default value, and the boiler nameplates show the boiler manufacturing years as 1999 and 2002. It can be assumed that the boilers shall function normally during the first crediting period.⁵

1.7 Project Location

The proposed project activity is located at Kean Charoen Co., Ltd, in Kranuan district, Khonkaen province, situated in the northeast region of Thailand, approximately 450 km from Bangkok. The project activity location is depicted in Figure 1 and Figure 2.

Street address: 261 Moo 4, Huanakhum, Kranuan, Khonkaen, 40170, Thailand

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

⁴ Average operation period of a cover lagoon wastewater treatment system in Thailand is 15 years, <http://teenet.chiangmai.ac.th/btc/introbiogas02.php>

⁵ http://cdm.unfccc.int/EB/050/eb50_repan15.pdf - Tool to determine the remaining lifetime of equipment.



Figure 1: Location map



Figure 2: Project activity boundaries

1.8 Title and Reference of Methodology

AMS III.H., “Methane Recovery in Wastewater Treatment” (version 13), is applied to the proposed project activity for the methane avoidance components. The AMS I.C. “Thermal energy production with or without electricity” (version 15) and AMS I.D. “Grid connected renewable electricity

generation” (version 14) are applied for thermal energy and electricity components accordingly. These methodology choices have already been justified in section 2.2 of registered PD.

AMS. III.H. refers to:

- “Tool to determine project emissions from flaring gases containing methane”, Annex 13 of EB28

AMS.I.C. refers to:

- “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion” version 1.2
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” version 1.0

AMS.I.D., refers to:

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

These methodologies and tools can be found on the UNFCCC’s website at the following address:
<http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html>

1.9 Other Programs

1) Emission Trading Programs and Other Binding Limits

The project is registered under VCS and does not reduce GHG emissions from activities that are included in an emissions trading program or any other mechanism that included GHG allowance.

2) Other Forms of Environment Credit

The project does not seek or receive another form of GHG-related environmental credit including renewable energy certificates during this monitoring period.

3) Participation under Other GHG Programs

The project is registered under VCS and will not be registered under any other GHG programs.

1.10 Sustainable Development

Economic:

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

Sectoral:

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

Social:

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

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

Environment:

Due to higher efficiency and improved process control, the quality of treated wastewater is expected to improve substantially with the implementation of the project activity. In fact, the biogas reactor system allows the starch factory to recycle the treated effluent in a starch production process; this constitutes sustainability in water supply while ensuring that groundwater shortage should not be a problem for local community. It must be mentioned that the project activity has zero discharge to the river or other natural sources such as soils and groundwater. Note that wastewater overflow might happen during the rainy season if the precipitation rate is higher than the outflow rate of the final pond for a sustained period of time. As can be seen from Figure 2, under Section 1.7, 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 will stimulate excessive plant growth which can disrupt normal functioning of the ecosystem, known as Eutrophication. Such problem could lead to social conflicts within the community. While wastewater can overflow from any ponds in the old anaerobic lagoon, the overflow can only happen from the post-treatment ponds in the closed anaerobic system. Since the average water quality at the outlet of the project activity is better than that in the anaerobic lagoon ponds, the environmental impacts from overflow of wastewater will be significantly reduced. Overall, the project will have positive impacts on the local environment by improving air quality through reduction in 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 diversification of energy resources. Ensuring energy security in this way can be seen as a contribution to sustainable development, particularly during this era of growing fuel prices.

Geographic/site specific:

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

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The project was registered on 20/05/2010. The current monitoring period is from 01/01/2012 to 11/05/2016. The emission reductions for this period are 151,910 tCO₂e (VCUs). This is the second verification of project activity.

The implementation status of the project activity during this monitoring period and data management regarding particular events are provided in Table 3.

Table 2: Major timeline of the project activity

Date	Events
02/10/2006	Operation start date
15/07/2009	Crediting period start date
2010	Boiler 1 replacement
04/06/2012	Issuance of 1 st verification report for 1 st monitoring period (from 03/12/2009 to 31/12/2011)

Table 3: The implementation status of the project activity during this monitoring period

Major event	Period	Data management for ER calculation
Long holidays (> 3 days)	01/01/2012 – 05/01/2012 13/04/2012 – 18/04/2012 01/01/2013 – 04/01/2013 01/01/2015 – 05/01/2015 11/04/2015 – 18/04/2015 01/01/2016 – 03/01/2016	The starch plant and biogas were not operated, thus no data available for ER calculation.
Starch plant shutdown	01/06/2012 – 04/07/2012 16/11/2012 – 02/12/2012 07/04/2013 – 07/08/2013 18/11/2013 – 30/11/2013 11/04/2014 – 21/04/2014 01/06/2014 – 30/06/2014 02/11/2015 – 07/12/2015 11/04/2016 – 19/04/2016	The starch plant and biogas were not operated, thus no data available for ER calculation.

Malfunction of meter	Water flow meter at pump sump - 05/12/2012 – 31/12/2012 Water flow meter at CL1 - 19/11/2014 – 07/12/2014 Water flow meter at CL2 - 23/05/2014 – 10/07/2014 Gas flow meter to boiler 1 - 17/01/2013 – 20/02/2013 Gas flow meter to boiler 2 - 06/01/2012 – 21/01/2012 - 03/12/2012 – 28/12/2012	There was no meter replaced during the malfunction of each meter, thus no data available for ER calculation.
Installation of new meter	Water flow meter at pump sump (Brand: Endress Hauser, S/N: LA020720000) - 10/03/2013 (installed) - 23/09/2013 (moved from pump sump to CL1) Water flow meter at CL2 (Brand: Endress Hauser, S/N: M102F920000) - 22/09/2013	The last number was recorded before removing the old meter and the first number was taken from the new meter after installation, thus the data available for ER calculation.
Other main events	Unavailability of the logbooks for amount of biogas consumption at gas engines - 01/01/2012 – 14/03/2016 Unavailability of the logbooks for amount of wastewater at CL1 and CL2 - 14/02/2015 – 22/10/2015 Unavailability of the logbooks for amount of biogas consumption and quantity of fuel oil consumption at boiler 1 - 01/01/2012 – 31/12/2012 - 10/11/2014 – 31/12/2014 - 01/01/2015 – 09/08/2015 - 02/02/2016 – 23/02/2016 Unavailability of the logbooks for amount of biogas consumption and	Unavailability of the logbooks for amount of biogas consumption at gas engines - The data for biogas consumption at gas engine from 01/01/2012 – 31/12/2015 was taken from the Annual Report for Energy Management ⁶ of Kean Charoen Co.,Ltd. The report provided the details of energy consumption for the entire operation (starch and biogas plant) and included the table providing the monthly data of biogas consumption at gas engine. Unavailability of the logbooks for CL1 & CL2, boiler 1 and boiler 2 - Since the logbooks or other relevant documents as supportive evidence were not available, the data during the mentioned period was not claimed for ER calculation. Temporary relocation of GM4

⁶ According to section 7.9 of the [Energy Conservation Promotion Act \(No.2\) B.E. 2550 \(2007\)](#), the designated buildings and factories are mandatory for submission of the audited energy management to the Department of Alternative Energy Development and Efficiency, Ministry of Energy.

	quantity of fuel oil consumption at boiler 2 - 09/04/2016 – 19/06/2016 Temporary relocation of GM4 from boiler 2 to boiler 1 - 16/09/2013 – 12/11/2013 No calibration available for the power meters - 01/01/2012 – present	- Since no meter replaced at boiler 2 during the period, thus no data available for the ER calculation. No calibration - Since the calibration was not conducted, the data was excluded from ER calculation. This is conservative approach.
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2.2 Deviations

2.2.1 Methodology Deviations

Deviation 1

Background

This approach is deviated paragraph 15 of the methodology AMS I.C version 15. It was proposed and validated by the validation and verification body during the validation of the project activity. The deviation was accepted and the detail was addressed in section 4.1 of the registered PD.

Explanation of the deviation

Since the complete monitoring mechanism was not available for the measurement of baseline input/output thermal energy, a conservative approach has been adopted as explained in the registered PD.

Compliance with the deviation

For verification, with a quantity of dry starch that is produced during a particular year, a minimum required quantity of fossil fuel (fuel oil) can be estimated from quantity of fossil fuel used per unit of dry starch historically. For the same year, if the data for fossil fuel consumed is available, then the remaining energy must be supplied by biogas. This is a conservative approach to estimate the fuel oil that, in the absence of the project activity, would be used in the starch drying process.

The deviation takes into account the baseline efficiencies. A simplified approach is explained here to estimate the baseline emissions. The approach is based on historical consumption of fuel oil per tonne of starch generation. The deviation addresses the coherence with §15 and 10 of the methodology.

It must be noted that the efficiency of the boiler when used in dual-fuel mode is lower than at regular, single-fuel conditions (HFO only). This drop-in efficiency leads to a lower biogas to HFO displacement rate. Based on the arguments listed below (provided by technical experts on the subject) and energy balance comparisons based on data available before and after implementation of the dual-fuel mode in such boiler systems, an efficiency drop resulting in 10% less HFO displacement (than under theoretical conditions) is a conservative approximation. This can be substantiated based on following arguments:

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

The statements above can be confirmed through interview with technical experts and details of same can be provided. In addition, the energy balance for a particular year, considering amount of biogas and fossil fuel used, would easily justify the assumption that energy input required in a dual fuel system is higher than in the baseline system. Based on this, the deviation can be considered as justifiable as it conforms with the requirements of VCS version 3 that it does not impact negatively the conservativeness of the quantification of the emission reduction calculation or the additionality of the project.

Starch production are multiplied by this default factor (39.6 litres per tonne) to get minimum fuel oil consumption for each year. For the same year, subtracting actual amount of fuel oil used, the project estimates the amount of thermal energy supplied by biogas and consequently amount of GHG emission reductions made from the project as per AMS I.C., version 15, component.

Deviation 2

Background

This approach is deviated according to the answers to authors of query by the SSC WG⁷. It was proposed and validated by the validation and verification body during the validation of the project activity. The deviation was accepted and the detail was addressed in section 4.1 of the registered PD.

Explanation of the deviation

As per answers to authors of query by the SSC WG “*in the case that the biogas is combusted for a gainful use of the released energy as in an engine or a power plant, a destruction efficiency of 100% can be used for the portion of biogas that is combusted when applying AMS III. H. i.e. use a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use*”. Based on this, the calculation approach of MD_y has been deviated from the methodology as justified and accepted in the validation report.

Compliance with the deviation

A destruction efficiency of 100% is used for the portion of biogas that is combusted for gainful use i.e. in boiler and gas engines. For the portion of biogas that is sent to flare, a flare efficiency of 0% has been adopted for the current monitoring period to account for non-operation of the flare system due to unavailability of excess biogas.

2.2.2 Project Description Deviations

$$\bar{X}\bar{X} - \left(A * \frac{s}{\sqrt{n}}\right)\bar{X} + \left(A * \frac{s}{\sqrt{n}}\right)\bar{X} - \left(A * \frac{s}{\sqrt{n}}\right)\bar{X} + \left(A * \frac{s}{\sqrt{n}}\right)\frac{s}{\sqrt{n}}\bar{X} - \left(A * \frac{s}{\sqrt{n}}\right)\bar{X} + \left(A * \frac{s}{\sqrt{n}}\right)\text{Deviation 1}$$

Background

This approach is deviated according to the FAR M3 of the validation report. Since the replacement of first boiler (boiler 1) was addressed during the validation of the project activity, the FAR M3 was raised in the validation report. The first boiler was replaced during the first verification and has been used since then, therefore, the same deviation from the first verification is also applied for this verification.

Explanation of the deviation

The boiler 1 was replaced by the new bigger one. The capacity of thermal energy output was changed from 3.488 to 4.070 MW_{th}. As per description in FAR M3 of the validation report, if existing boiler is replaced with a new one during any verification no emission reduction shall be granted for heat displacement. Hence the heat displacement at this boiler was neglected from the emission reductions.

Compliance with the deviation

The deviated approach was adopted by considering only the thermal energy supplied from the second hot oil boiler (boiler 2) for the thermal energy displacement of AMS I.C.

⁷

https://cdm.unfccc.int/filestorage/V/NW/VNWAGY8MS92ZXDKUHEF5LB07QICT1P/Response%20WG%20provided.pdf?t=cU58cHNiNXZyfDD3-2TKKt_d5dRRvj16klhm

This is the conservative approach as per VCS guidelines because the emission reductions achieved from AMS I.C was reduced.

Description of deviation

The thermal energy supplied and displacement at the boiler 2 was calculated as per steps below;

1. Determine the fuel oil consumption of each boilers in litres

Fuel oil usage	2012	2013	2014	2015	2016
Boiler 1	0	84,680	49,050	76,170	69,190
Boiler 2	144,260	41,730	26,790	118,307	94,286

2. Determine the biogas consumption of each boilers in Nm³

Biogas usage	2012	2013	2014	2015	2016
Boiler 1	0	1,208,663	1,700,132	705,352	708,551
Boiler 2	1,739,295	805,869	1,158,079	1,435,053	580,787

3. Calculate the thermal energy supplied from each boiler in GJ

Thermal energy	2012	2013	2014	2015	2016
Boiler 1	0	28,665	37,534	17,792	17,581
Boiler 2	42,140	18,526	25,304	34,740	15,905
Total	42,140	47,191	62,838	52,532	33,487

4. Calculate the percentage of thermal energy supplied from each boiler

Percentage	2012	2013	2014	2015	2016
Boiler 1	0.00	0.61	0.60	0.34	0.53
Boiler 2	1.00	0.39	0.40	0.66	0.47

5. The BE_{thermal} calculation as per description in Deviation 1 of the registered PD was considered only the fuel oil displacement in the boiler 2. Then the equation for Deviation 1 was revised to,

$$BE_{thermal,CO2y} = (Q_{starch} * Q_{FO,starch} * \% B2 - q_{FO,y,Boiler2}) * D_{FO} * NCV_{FO} * EF_{CO2}/10^6$$

$$BE_{thermal,CO2y} = (Q_{starch} * Q_{FO,starch} * \% B2 - q_{FO,y,Boiler2}) * D_{FO} * NCV_{FO} * EF_{CO2}/10^6$$

Parameter	Description
Q _{starch,y}	Quantity of dry starch produced in year “y” (tonnes)
Q _{FO,starch}	Quantity of fossil fuel per unit of dry starch (liter/tonne)
q _{FO,y,boiler2}	Quantity of fossil fuel consumed by hot oil boiler no.2 in year “y” (litres)
D _{FO}	Density of fossil fuel (kg/litre)

NCV _{FO}	Net Calorific value of the fuel oil (TJ/ton)
%B2	The percentage of thermal energy supplied from the boiler 2 from step 4 above

2.3 Grouped Project

The project activity is not a grouped project.

2.4 Safeguards

2.4.1 No Net Harm

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

2.4.2 Local Stakeholder Consultation

Invitation procedure

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

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

Place and date of meeting

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

Meeting participants

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

1. Local residents
2. Local government representatives

There were 23 participants attended the meeting

Language

Documentation and meeting were conducted in Thai (local language)

Meeting procedures

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

Meeting documents and protocols

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

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

Compilation of comments received**Oral hearing for local stakeholders:**

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

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

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

Current Practice

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

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	GWP _{CH4}
Data unit	-
Description	Global warming potential for methane gas
Source of data	Default value from AMS III.H V13
Value applied	25
Justification of choice of data or description of measurement methods and procedures applied	Intergovernmental Panel on Climate Change, Climate Change 1995: The Science of Climate Change (Cambridge, UK: Cambridge University Press, 1996).
Purpose of the data	Calculation of baseline and project emissions
Comments	The default value is changed as per the VCS standard, version 3.7.

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 AMS-III.H version 13
Value applied	0.21
Justification of choice of data or description of measurement methods and procedures applied	IPCC adjusted value
Purpose of the data	Calculation of baseline 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 version 13
Value applied	0.94
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	UF_{PJ}
Data unit	Factor
Description	Model correction factor to account for model uncertainties
Source of data	AMS-III.H version 13
Value applied	1.06
Justification of choice of data or description of measurement methods and procedures applied	Default value
Purpose of the data	Calculation of project emissions
Comments	-

Data / Parameter	$MCF_{ww,treatment,BL,Lagoon}$
Data unit	Fraction
Description	Methane correction factor for baseline wastewater treatment systems i
Source of data	Table III.H 1 from AMS-III.H version 13
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	The baseline wastewater treatment system consists in a succession of deep lagoons (depth more than 2 metres) therefore MCF value is chosen as 0.8.
Purpose of the data	Calculation of baseline emissions
Comments	IPCC Default values from chapter 6 of volume 5 page no 6.21. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Data / Parameter	$MCF_{ww,treatment,PJ,CL}$
Data unit	Fraction
Description	Methane correction factor for project wastewater treatment system covered lagoon equipped with biogas recovery
Source of data	Table III.H 1 from AMS-III.H version 13
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	The project wastewater treatment system equipped with biogas recovery is a cover lagoon, therefore MCF value is chosen as 0.8.
Purpose of the data	Calculation of project emissions
Comments	-

Data / Parameter	$MCF_{ww,treatment,PJ,lagoon}$
Data unit	Fraction
Description	Methane correction factor for project secondary wastewater treatment system k
Source of data	Table III.H 1 from AMS-III.H version 13
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 m, so the value of 0.8 has been used.
Purpose of the data	Calculation of project emissions
Comments	IPCC Default values from chapter 6 of volume 5 page no 6.21. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Data / Parameter	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	87.16%
Justification of choice of data or description of measurement methods and procedures applied	The removal efficiency was based on a measurement campaign. The efficiency was 97.93% 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 87.16%.
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	CFE_{ww}
Data unit	-
Description	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems.
Source of data	Equation 10 in AMS-III.H, Version 13 methodology
Value applied	0.9
Justification of choice of data or description of measurement methods and procedures applied	A default value as per AMS III.H.
Purpose of the data	Calculation of project emissions
Comments	-

Data / Parameter	EF_y
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Data unit	tCO ₂ /MWh
Description	CO ₂ emission factor for grid power
Source of data	The calculation of emission factor for an electricity system in Thailand 2007, DEDE.
Value applied	0.5057
Justification of choice of data or description of measurement methods and procedures applied	EF _y is calculated according to the “Tool to calculate the emission factor for an electricity system” as determined in the respective small-scale methodology for grid connected electricity generation (AMS I.D. version 14).
Purpose of the data	Calculation of baseline and project emissions
Comments	-

Data / Parameter	EF _{CO2}
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 value used for unavailability of national data. Prior project activity, the residual fuel oil has been main source of thermal energy for the processes.
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	NCV _{Fo}
Data unit	GJ/tonne
Description	NCV of fuel oil i.e. fossil fuel displaced by biogas
Source of data	Thailand Energy situation 2005
Value applied	42.76
Justification of choice of data or description of measurement methods and procedures applied	Default value from official source in Thailand
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	NCV _{biogas}
Data unit	MJ/Nm ³
Description	NCV of biogas
Source of data	Thailand Energy situation 2005
Value applied	20.93
Justification of choice of data or description of measurement methods and procedures applied	Default value from official source in Thailand
Purpose of the 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	Historical data
Value applied	39.6
Justification of choice of data or description of measurement methods and procedures applied	Based on average values from 2005 and 2006 (January – October) 2005 = 40.0 litres/tonne 2006 (January – October) = 39.2 litres/tonne
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	D _{CH₄}
Data unit	kg/m ³
Description	Density of methane at normal conditions
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	CDM EB as per EB28 Meeting report (Annex 13)
Purpose of the data	Calculation of baseline emissions

Comments	-
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Data / Parameter	D _{FO}
Data unit	kg/liter
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	Publicly available information
Purpose of the 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	50%
Justification of choice of data or description of measurement methods and procedures applied	Default value for open flare as per Tool to determine project emissions from flaring gases containing methane has been applied.
Purpose of the data	Calculation of project emissions
Comments	-

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

measurement methods and procedures applied	used for the portion of biogas that is combusted when applying AMS III.H., i.e. use a value of 100% for FE in equation 16 in paragraph 32 for the portion of biogas that is combusted for a gainful use" ⁸
Purpose of the 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	List of electrical consumption from name plates of installed electrical equipment <table><tr><th>Tag</th><th>Description</th><th>Motor (HP)</th></tr><tr><td>ST1</td><td>Stirrer - NaOH Tank</td><td>3</td></tr><tr><td>ST2</td><td>Stirrer - Mixing tank</td><td>3</td></tr><tr><td>ST3</td><td>Stirrer - Pump sump</td><td>20</td></tr><tr><td>BI1</td><td>WW Feed pump</td><td>40</td></tr><tr><td>BI2</td><td>WW Feed pump</td><td>40</td></tr><tr><td>BI3</td><td>WW recycle pump</td><td>25</td></tr><tr><td>BI4</td><td>Sludge recycle pump 1</td><td>15</td></tr><tr><td>BI5</td><td>Sludge recycle pump 2</td><td>15</td></tr><tr><td>BI6</td><td>Reuse water pump</td><td>75</td></tr><tr><td>BI7</td><td>Reuse water pump</td><td>40</td></tr><tr><td>BI8</td><td>Reuse water pump</td><td>40</td></tr><tr><td>OG</td><td>Oxygen pump for Bio-scrubber</td><td>0.25</td></tr><tr><td>SP</td><td>Super pump for gas washer</td><td>1</td></tr><tr><td>FL</td><td>Flare</td><td>0.25</td></tr><tr><td>CH 1</td><td>Chiller No. 1</td><td>12.68</td></tr><tr><td>CH 2</td><td>Chiller No. 2</td><td>12.68</td></tr><tr><td>CH 3</td><td>Chiller No. 3</td><td>12.68</td></tr><tr><td>CH 4</td><td>Chiller No. 4</td><td>12.68</td></tr><tr><td>CH 5</td><td>Chiller No. 5</td><td>12.68</td></tr><tr><td>CLP1</td><td>Water pump - CT1</td><td>15</td></tr><tr><td>CLP2</td><td>Water pump - CT2</td><td>15</td></tr><tr><td>CLP3</td><td>Water pump - CT3</td><td>15</td></tr><tr><td>FBC1</td><td>Fan Blower of Cooling Tower 1</td><td>5</td></tr><tr><td>FBC2</td><td>Fan Blower of Cooling Tower 2</td><td>5</td></tr><tr><td>FB1</td><td>Fan Blower No. 1</td><td>0.5</td></tr><tr><td>FB2</td><td>Fan Blower No. 2</td><td>0.5</td></tr><tr><td>FB3</td><td>Fan Blower No. 3</td><td>1</td></tr><tr><td>FB4</td><td>Fan Blower No. 4</td><td>1</td></tr><tr><td>BA1</td><td>Blower air No. 1</td><td>5</td></tr><tr><td>BA2</td><td>Blower air No. 2</td><td>5</td></tr><tr><td>BL 1</td><td>Gas Blower No. 1</td><td>30</td></tr><tr><td>BL 2</td><td>Gas Blower No. 2</td><td>30</td></tr><tr><td>BL 3</td><td>Gas Blower No. 3</td><td>30</td></tr><tr><td>BL 4</td><td>Gas Blower No. 4</td><td>30</td></tr><tr><td>BL 5</td><td>Gas Blower No. 5</td><td>30</td></tr><tr><td>BP1</td><td>Spray pump</td><td>7.5</td></tr><tr><td>BP2</td><td>Spray pump</td><td>7.5</td></tr><tr><td colspan="2">Total - HP</td><td>614</td></tr><tr><td colspan="2">Total - kW</td><td>458</td></tr></table>	Tag	Description	Motor (HP)	ST1	Stirrer - NaOH Tank	3	ST2	Stirrer - Mixing tank	3	ST3	Stirrer - Pump sump	20	BI1	WW Feed pump	40	BI2	WW Feed pump	40	BI3	WW recycle pump	25	BI4	Sludge recycle pump 1	15	BI5	Sludge recycle pump 2	15	BI6	Reuse water pump	75	BI7	Reuse water pump	40	BI8	Reuse water pump	40	OG	Oxygen pump for Bio-scrubber	0.25	SP	Super pump for gas washer	1	FL	Flare	0.25	CH 1	Chiller No. 1	12.68	CH 2	Chiller No. 2	12.68	CH 3	Chiller No. 3	12.68	CH 4	Chiller No. 4	12.68	CH 5	Chiller No. 5	12.68	CLP1	Water pump - CT1	15	CLP2	Water pump - CT2	15	CLP3	Water pump - CT3	15	FBC1	Fan Blower of Cooling Tower 1	5	FBC2	Fan Blower of Cooling Tower 2	5	FB1	Fan Blower No. 1	0.5	FB2	Fan Blower No. 2	0.5	FB3	Fan Blower No. 3	1	FB4	Fan Blower No. 4	1	BA1	Blower air No. 1	5	BA2	Blower air No. 2	5	BL 1	Gas Blower No. 1	30	BL 2	Gas Blower No. 2	30	BL 3	Gas Blower No. 3	30	BL 4	Gas Blower No. 4	30	BL 5	Gas Blower No. 5	30	BP1	Spray pump	7.5	BP2	Spray pump	7.5	Total - HP		614	Total - kW		458
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⁸ Please refer to paragraph 29 SSC WG 22 external report, page 6. Please note that the respond to this query, F-CDM-SSCwg ver 01 SSC_324 dated 29/07/2009, can be accessed through the following link: <http://cdm.unfccc.int/UserManagement/FileStorage/VNWAGY8MS92ZXDKUHEF5LB07OICT1P>

Value applied	458
Justification of choice of data or description of measurement methods and procedures applied	Extract from nameplate of the electrical equipment.
Purpose of the data	Calculation of project emissions
Comments	-

3.2 Data and Parameters Monitored

Data / Parameter	Q _{y,ww}																												
Data unit	m ³																												
Description	Volume of wastewater treated in the year y																												
Source of data	Volumetric flow meter: FM1 and FM2																												
Description of measurement methods and procedures to be applied	The electromagnetic volumetric flow was installed before covered lagoons. In case the flow meter value was not available for a particular day, the value was estimated in a conservative manner by excluding from emission reduction estimation.																												
Frequency of monitoring/recording	Continuous monitoring with daily recording																												
Value monitored	FM1 at pump sump <table><tr><th>Monitoring Period</th><th colspan="2">Value (m³)</th></tr><tr><td>01/01/2012 to 31/12/2012</td><td colspan="2">1,077,712</td></tr><tr><td>01/01/2013 to 23/09/2013</td><td colspan="2">310,282</td></tr></table> FM1 and FM2 at covered lagoon 1 (CL1) and covered lagoon 2 (CL2) <table><tr><th rowspan="2">Monitoring Period</th><th colspan="2">Value (m³)</th></tr><tr><th>FM1</th><th>FM2</th></tr><tr><td>24/09/2013 to 31/12/2013</td><td>94,442</td><td>84,439</td></tr><tr><td>01/01/2014 to 31/12/2014</td><td>274,889</td><td>393,265</td></tr><tr><td>01/01/2015 to 31/12/2015</td><td>82,955</td><td>49,532</td></tr><tr><td>01/01/2016 to 11/05/2016</td><td>184,840</td><td>83,296</td></tr></table>			Monitoring Period	Value (m ³)		01/01/2012 to 31/12/2012	1,077,712		01/01/2013 to 23/09/2013	310,282		Monitoring Period	Value (m ³)		FM1	FM2	24/09/2013 to 31/12/2013	94,442	84,439	01/01/2014 to 31/12/2014	274,889	393,265	01/01/2015 to 31/12/2015	82,955	49,532	01/01/2016 to 11/05/2016	184,840	83,296
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Monitoring equipment	FM1 at pump sump <table><tr><th>Period of usage</th><td>Beginning – 10/03/2013</td></tr><tr><td>Meter name</td><td>FM1</td></tr></table>			Period of usage	Beginning – 10/03/2013	Meter name	FM1																						
Period of usage	Beginning – 10/03/2013																												
Meter name	FM1																												

	Serial Number	ZAP0573
	Brand	Euromag
	Type	MUT 1000EL
	Accuracy	±0.20%
	Calibration Frequency	Once in 3 years
	Calibration Date	29/11/2011
	Validity	28/11/2014
	Period of usage	11/03/2013 – 23/09/2013
	Serial Number	LA020720000
	Brand	Endress Hauser
	Type	PROMAG 10L
	Accuracy	±0.50%
	Calibration Frequency	Once in 3 years
	Calibration Date	23/10/2012 10/06/2014
	Validity	09/06/2017
	<u>From 24/09/2013 onwards, one additional meter (FM2) was installed at covered lagoon 2 (CL2) as well as FM1 was relocated from pump sump to covered lagoon 1 (CL1)</u>	
	Meter name	FM1
	Serial Number	LA020720000
	Brand	Endress Hauser
	Type	PROMAG 10L
	Accuracy	±0.50%
	Calibration Frequency	Once in 3 years
	Calibration Date	23/10/2012 10/06/2014
	Validity	09/06/2017
	Meter name	FM2
	Serial Number	M102FC20000
	Brand	Endress Hauser

	Type	PROMAG 10L
	Accuracy	±0.50%
	Calibration Frequency	Once in 3 years
	Calibration Date	30/01/2013 10/06/2014
	Validity	09/06/2017
QA/QC procedures to be applied	The flow meter was calibrated at least every 3 years.	
Purpose of the data	Calculation of baseline and project emissions	
Calculation method	Not applicable	
Comments	All the monitoring equipment were calibrated on time, thus no error was applied.	

Data / Parameter	COD _{ww,untreated,y}													
Data unit	mg/l													
Description	COD of wastewater entering the covered lagoon reactor system													
Source of data	Measured – Colorimetric analysis													
Description of measurement methods and procedures to be applied	The COD content is analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The COD sampling point was before covered lagoons. In case the COD value was not available for a particular day, the value was estimated in a conservative manner by excluding from emission reduction estimation.													
Frequency of monitoring/recording	The test was carried out in every operational day.													
Value monitored	<table><tr><th>Monitoring Period</th><th>Average value (mg/l)</th></tr><tr><td>01/01/2012 to 31/12/2012</td><td>20,236</td></tr><tr><td>01/01/2013 to 31/12/2013</td><td>18,417</td></tr><tr><td>01/01/2014 to 31/12/2014</td><td>17,211</td></tr><tr><td>01/01/2015 to 31/12/2015</td><td>22,685</td></tr><tr><td>01/01/2016 to 11/05/2016</td><td>30,824</td></tr></table>		Monitoring Period	Average value (mg/l)	01/01/2012 to 31/12/2012	20,236	01/01/2013 to 31/12/2013	18,417	01/01/2014 to 31/12/2014	17,211	01/01/2015 to 31/12/2015	22,685	01/01/2016 to 11/05/2016	30,824
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01/01/2014 to 31/12/2014	17,211													
01/01/2015 to 31/12/2015	22,685													
01/01/2016 to 11/05/2016	30,824													
Monitoring equipment	<table><tr><td>Meter name</td><td>Spectrophotometer</td></tr><tr><td>Serial Number</td><td>HI19945I</td></tr><tr><td>Brand</td><td>Hanna</td></tr><tr><td>Type</td><td>HI 83214</td></tr><tr><td>Accuracy</td><td>10 mg/l (HR) 1 mg/l (LR)</td></tr></table>		Meter name	Spectrophotometer	Serial Number	HI19945I	Brand	Hanna	Type	HI 83214	Accuracy	10 mg/l (HR) 1 mg/l (LR)		
Meter name	Spectrophotometer													
Serial Number	HI19945I													
Brand	Hanna													
Type	HI 83214													
Accuracy	10 mg/l (HR) 1 mg/l (LR)													

	Calibration Frequency	Once in 3 years
	Calibration Date	14/07/2010 16/08/2012 27/09/2013
	Validity	26/09/2016
QA/QC procedures to be applied	The spectrophotometer was calibrated at least once every 3 years.	
Purpose of the data	Calculation of project emissions	
Calculation method	Not applicable	
Comments	The monitoring equipment was calibrated on time, thus no error was applied.	

Data / Parameter	COD _{out,lagoon,PJ,y}													
Data unit	tonnes/m ³													
Description	COD of water coming out of the last lagoon													
Source of data	Measured – Colorimetric analysis													
Description of measurement methods and procedures to be applied	The COD content is analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The COD sampling point was after the last lagoons. In case the COD value was not available for a particular day, the value was estimated in a conservative manner by excluding from emission reduction estimation.													
Frequency of monitoring/recording	The tests are carried out in every operational day.													
Value monitored	<table><tr><th>Monitoring Period</th><th>Value (tonnes/m³)</th></tr><tr><td>01/01/2012 to 31/12/2012</td><td>0.000514</td></tr><tr><td>01/01/2013 to 31/12/2013</td><td>0.000518</td></tr><tr><td>01/01/2014 to 31/12/2014</td><td>0.000819</td></tr><tr><td>01/01/2015 to 31/12/2015</td><td>0.000875</td></tr><tr><td>01/01/2016 to 11/05/2016</td><td>0.000434</td></tr></table>		Monitoring Period	Value (tonnes/m ³)	01/01/2012 to 31/12/2012	0.000514	01/01/2013 to 31/12/2013	0.000518	01/01/2014 to 31/12/2014	0.000819	01/01/2015 to 31/12/2015	0.000875	01/01/2016 to 11/05/2016	0.000434
Monitoring Period	Value (tonnes/m ³)													
01/01/2012 to 31/12/2012	0.000514													
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01/01/2014 to 31/12/2014	0.000819													
01/01/2015 to 31/12/2015	0.000875													
01/01/2016 to 11/05/2016	0.000434													
Monitoring equipment	Please see COD _{ww,untreated,y}													
QA/QC procedures to be applied	Please see COD _{ww,untreated,y}													
Purpose of the data	Calculation of project emissions													
Calculation method	Not applicable													
Comments	Please see COD _{ww,untreated,y}													

Data / Parameter	COD _{out,CL,y}																						
Data unit	tonnes/m ³																						
Description	COD of water coming out of the covered lagoon																						
Source of data	Measured – Colorimetric analysis																						
Description of measurement methods and procedures to be applied	The COD content is analyzed using a colorimetric method in the on-site laboratory of the treatment plant. The COD sampling points are after covered lagoons. In case the COD value was not available for a particular day, the value was estimated in a conservative manner by excluding from emission reduction estimation.																						
Frequency of monitoring/recording	The tests are carried out in every operational day.																						
Value monitored	<table><tr><th rowspan="2">Monitoring Period</th><th colspan="2">Value (tonnes/m³)</th></tr><tr><th>CL1</th><th>CL2</th></tr><tr><td>01/01/2012 to 31/12/2012</td><td>0.001431</td><td>0.001704</td></tr><tr><td>01/01/2013 to 31/12/2013</td><td>0.001307</td><td>0.001691</td></tr><tr><td>01/01/2014 to 31/12/2014</td><td>0.001459</td><td>0.001730</td></tr><tr><td>01/01/2015 to 31/12/2015</td><td>0.001437</td><td>0.001876</td></tr><tr><td>01/01/2016 to 11/05/2016</td><td colspan="2">0.001446*</td></tr></table> *From 01/01/2016 to 12/05/2016, the collected samples from both CLs was mixed for conducting one analysis.			Monitoring Period	Value (tonnes/m ³)		CL1	CL2	01/01/2012 to 31/12/2012	0.001431	0.001704	01/01/2013 to 31/12/2013	0.001307	0.001691	01/01/2014 to 31/12/2014	0.001459	0.001730	01/01/2015 to 31/12/2015	0.001437	0.001876	01/01/2016 to 11/05/2016	0.001446*	
Monitoring Period	Value (tonnes/m ³)																						
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01/01/2015 to 31/12/2015	0.001437	0.001876																					
01/01/2016 to 11/05/2016	0.001446*																						
Monitoring equipment	Please see COD _{ww,untreated,y}																						
QA/QC procedures to be applied	Please see COD _{ww,untreated,y}																						
Purpose of the data	Calculation of project emissions																						
Calculation method	Not applicable																						
Comments	Please see COD _{ww,untreated,y}																						

Data / Parameter	BG _{combusted,y}
Data unit	Nm ³
Description	Amount of biogas combusted for gainful use
Source of data	Calculated from a summation of total biogas utilized in boilers, generation sets
Description of measurement methods and procedures to be applied	BG _{combusted,y} was estimated by summing the volume of biogas sent to the boiler and generation set.

	In case the flow meter value was not available for a particular day, the value was estimated in a conservative manner by excluding from emission reduction estimation.																														
Frequency of monitoring/recording	Continuous monitoring with daily recording																														
Value monitored	There are 3 gas meters installed for measurement of biogas combusted (GM1 – boiler1, GM4 – boiler 2, and GM3 - generator). However, as per the deviation 1 of the project description deviation, the biogas value from boiler 1 (GM1) was excluded from the biogas combusted for a conservative estimation of baseline emissions. <table border="1"> <thead> <tr> <th>Monitoring Period</th><th>Value (Nm³)</th></tr> </thead> <tbody> <tr> <td>01/01/2012 to 31/12/2012</td><td>8,286,814</td></tr> <tr> <td>01/01/2013 to 31/12/2013</td><td>4,392,271</td></tr> <tr> <td>01/01/2014 to 31/12/2014</td><td>5,931,050</td></tr> <tr> <td>01/01/2015 to 31/12/2015</td><td>9,214,407</td></tr> <tr> <td>01/01/2016 to 11/05/2016</td><td>1,478,273</td></tr> </tbody> </table>	Monitoring Period	Value (Nm ³)	01/01/2012 to 31/12/2012	8,286,814	01/01/2013 to 31/12/2013	4,392,271	01/01/2014 to 31/12/2014	5,931,050	01/01/2015 to 31/12/2015	9,214,407	01/01/2016 to 11/05/2016	1,478,273																		
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Monitoring equipment	<u>Boiler 1</u> <table border="1"> <tbody> <tr> <td>Meter name</td><td>GM1</td></tr> <tr> <td>Serial Number</td><td>N1-TD02-9544598</td></tr> <tr> <td>Brand</td><td>Siemens</td></tr> <tr> <td>Type</td><td>7MF4433-1BA22-1AC96-Z</td></tr> <tr> <td>Accuracy</td><td>±0.075%</td></tr> <tr> <td>Calibration Frequency</td><td>Once in 3 years</td></tr> <tr> <td>Calibration Date</td><td>30/11/2011 12/01/2014</td></tr> <tr> <td>Validity</td><td>11/01/2017</td></tr> </tbody> </table> <u>Boiler 2</u> <table border="1"> <tbody> <tr> <td>Meter name</td><td>GM4</td></tr> <tr> <td>Serial Number</td><td>N1-V905-9663007</td></tr> <tr> <td>Brand</td><td>Siemens</td></tr> <tr> <td>Type</td><td>7MF4433-1BA22-1AC96-Z</td></tr> <tr> <td>Accuracy</td><td>±0.075%</td></tr> <tr> <td>Calibration Frequency</td><td>Once in 3 years</td></tr> <tr> <td>Calibration Date</td><td>29/11/2011 11/01/2014</td></tr> </tbody> </table>	Meter name	GM1	Serial Number	N1-TD02-9544598	Brand	Siemens	Type	7MF4433-1BA22-1AC96-Z	Accuracy	±0.075%	Calibration Frequency	Once in 3 years	Calibration Date	30/11/2011 12/01/2014	Validity	11/01/2017	Meter name	GM4	Serial Number	N1-V905-9663007	Brand	Siemens	Type	7MF4433-1BA22-1AC96-Z	Accuracy	±0.075%	Calibration Frequency	Once in 3 years	Calibration Date	29/11/2011 11/01/2014
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Brand	Siemens																														
Type	7MF4433-1BA22-1AC96-Z																														
Accuracy	±0.075%																														
Calibration Frequency	Once in 3 years																														
Calibration Date	29/11/2011 11/01/2014																														

	Validity	10/01/2017
	Generator	
	Period of usage	Beginning – 25/07/2015
	Meter name	GM3
	Serial Number	7569
	Brand	FOX
	Type	FT2
	Accuracy	1%R + 0.2%FS
	Calibration Frequency	Once in 3 years
	Calibration Date	29/11/2011 22/01/2014
	Validity	21/01/2017
	Period of usage	26/07/2015 – present
	Meter name	GM3
	Serial Number	5314
	Brand	FOX
	Type	FT2
	Accuracy	1%R + 0.2%FS
	Calibration Frequency	Once in 3 years
	Calibration Date	13/05/2015
	Validity	12/05/2018
QA/QC procedures to be applied	The flow meters was calibrated at least once every 3 years.	
Purpose of the data	Calculation of baseline emissions	
Calculation method	The summation from GM3 and GM4 was calculated.	
Comments	All the monitoring equipment were calibrated on time, thus no error was applied.	

Data / Parameter	W _{CH4}
Data unit	%
Description	Methane content in biogas
Source of data	Measured – Gas analyzer system to monitor % of methane in biogas

Description of measurement methods and procedures to be applied	Online monitoring equipment is incorporated to increase the accuracy. Data from here is recorded and stored electronically on a continuous basis.																				
Frequency of monitoring/recording	The methane content in biogas is continuously measured. The average value is calculated on daily basis.																				
Value monitored	During the monitoring period, as the online monitoring equipment was not available for continuous measurement, the portable gas analyzer was used for periodic measurement and the measured values were applied 95% confidence level. The lower and upper values were used for calculation of baseline and project emissions in a conservative manner. <table><thead><tr><th rowspan="2">Monitoring Period</th><th colspan="2">Value (%)</th></tr><tr><th>Lower</th><th>Upper</th></tr></thead><tbody><tr><td>01/01/2012 to 31/12/2012</td><td>52.7</td><td>53.9</td></tr><tr><td>01/01/2013 to 31/12/2013</td><td>53.1</td><td>54.6</td></tr><tr><td>01/01/2014 to 31/12/2014</td><td>50.4</td><td>50.9</td></tr><tr><td>01/01/2015 to 31/12/2015</td><td>50.0</td><td>51.4</td></tr><tr><td>01/01/2015 to 11/05/2016</td><td>49.6</td><td>51.1</td></tr></tbody></table>	Monitoring Period	Value (%)		Lower	Upper	01/01/2012 to 31/12/2012	52.7	53.9	01/01/2013 to 31/12/2013	53.1	54.6	01/01/2014 to 31/12/2014	50.4	50.9	01/01/2015 to 31/12/2015	50.0	51.4	01/01/2015 to 11/05/2016	49.6	51.1
Monitoring Period	Value (%)																				
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Monitoring equipment	<table><tr><td>Period of usage</td><td>01/01/2012 – present</td></tr><tr><td>Meter name</td><td>MS</td></tr><tr><td>Serial Number</td><td>G503004</td></tr><tr><td>Brand</td><td>Geotech</td></tr><tr><td>Type</td><td>BIOGAS 5000</td></tr><tr><td>Accuracy</td><td>0.5%</td></tr><tr><td>Calibration Frequency</td><td>Once in 3 years</td></tr><tr><td>Calibration Date</td><td>16/11/2011 22/01/2014</td></tr><tr><td>Validity</td><td>21/01/2017</td></tr></table>	Period of usage	01/01/2012 – present	Meter name	MS	Serial Number	G503004	Brand	Geotech	Type	BIOGAS 5000	Accuracy	0.5%	Calibration Frequency	Once in 3 years	Calibration Date	16/11/2011 22/01/2014	Validity	21/01/2017		
Period of usage	01/01/2012 – present																				
Meter name	MS																				
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Brand	Geotech																				
Type	BIOGAS 5000																				
Accuracy	0.5%																				
Calibration Frequency	Once in 3 years																				
Calibration Date	16/11/2011 22/01/2014																				
Validity	21/01/2017																				
QA/QC procedures to be applied	The portable gas analyzer was calibrated at least once every 3 years. Since there was on online gas analyzer used during the monitoring period, the periodic measurement was conducted using portable gas analyzer at 95% confidence level.																				
Purpose of the data	Calculation of baseline emissions																				
Calculation method	Not applicable																				
Comments	The monitoring equipment was calibrated on time, thus no error was applied.																				

Data / Parameter	BG _{TOFlare,y}																
Data unit	Nm ³																
Description	Amount of biogas flared																
Source of data	Measured using biogas flow meter: GM2																
Description of measurement methods and procedures to be applied	The gas flow meter was installed at the plant.																
Frequency of monitoring/recording	Continuous monitoring with daily recording																
Value monitored	<table> <tr> <th>Monitoring Period</th><th>Value (Nm³)</th></tr> <tr> <td>01/01/2012 to 31/12/2012</td><td>0</td></tr> <tr> <td>01/01/2013 to 31/12/2013</td><td>0</td></tr> <tr> <td>01/01/2014 to 31/12/2014</td><td>0</td></tr> <tr> <td>01/01/2015 to 31/12/2015</td><td>0</td></tr> <tr> <td>01/01/2016 to 11/05/2016</td><td>0</td></tr> </table>	Monitoring Period	Value (Nm ³)	01/01/2012 to 31/12/2012	0	01/01/2013 to 31/12/2013	0	01/01/2014 to 31/12/2014	0	01/01/2015 to 31/12/2015	0	01/01/2016 to 11/05/2016	0				
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Monitoring equipment	<table> <tr> <td>Meter name</td><td>GM2</td></tr> <tr> <td>Serial Number</td><td>7568</td></tr> <tr> <td>Brand</td><td>FOX</td></tr> <tr> <td>Type</td><td>FT2-12I</td></tr> <tr> <td>Accuracy</td><td>1%R + 0.2%FS</td></tr> <tr> <td>Calibration Frequency</td><td>Once in 3 years</td></tr> <tr> <td>Calibration Date</td><td>29/11/2011 28/04/2016</td></tr> <tr> <td>Validity</td><td>27/04/2019</td></tr> </table>	Meter name	GM2	Serial Number	7568	Brand	FOX	Type	FT2-12I	Accuracy	1%R + 0.2%FS	Calibration Frequency	Once in 3 years	Calibration Date	29/11/2011 28/04/2016	Validity	27/04/2019
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Accuracy	1%R + 0.2%FS																
Calibration Frequency	Once in 3 years																
Calibration Date	29/11/2011 28/04/2016																
Validity	27/04/2019																
QA/QC procedures to be applied	The flow meter is calibrated at least once every 3 years.																
Purpose of the data	Calculation of baseline emissions																
Calculation method	Not applicable																
Comments	Though there were calibration gap during 28/11/2014 – 27/04/2016, there was no biogas flared during this monitoring period. Thus, no error had been applied to the emission reduction.																

Data / Parameter	q _{FO,y}
Data unit	Litres
Description	Quantity of fossil fuel used in boiler in year y.

Source of data	Usage data (monitored from boiler panel). Value was used for conservative estimation of biogas / methane used in replacement of fossil fuel during year y.																																
Description of measurement methods and procedures to be applied	Fuel oil meter was incorporated to the hot oil boiler. There are 2 boilers at the starch factory. However, as per the deviation 1 of the project description deviation, the oil meter value of boiler 1 was excluded in a conservative manner.																																
Frequency of monitoring/recording	Continuous monitoring with daily recording																																
Value monitored	There are 2 oil meters installed at boiler 1 and boiler 2 for measurement of fossil fuel consumption. However, as per the deviation 1 of the project description deviation, the oil meter value of boiler 1 was excluded for a conservative estimation. <table border="1"> <thead> <tr> <th>Monitoring Period</th><th>Value (litres)</th></tr> </thead> <tbody> <tr> <td>01/01/2012 to 31/12/2012</td><td>144,260</td></tr> <tr> <td>01/01/2013 to 31/12/2013</td><td>41,730</td></tr> <tr> <td>01/01/2014 to 31/12/2014</td><td>26,790</td></tr> <tr> <td>01/01/2015 to 31/12/2015</td><td>118,307</td></tr> <tr> <td>01/01/2016 to 11/05/2016</td><td>94,286</td></tr> </tbody> </table>	Monitoring Period	Value (litres)	01/01/2012 to 31/12/2012	144,260	01/01/2013 to 31/12/2013	41,730	01/01/2014 to 31/12/2014	26,790	01/01/2015 to 31/12/2015	118,307	01/01/2016 to 11/05/2016	94,286																				
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Monitoring equipment	<u>Boiler 1</u> <table border="1"> <tbody> <tr> <td>Meter name</td><td>OM1</td></tr> <tr> <td>Serial Number</td><td>4546871</td></tr> <tr> <td>Brand</td><td>CONTOIL</td></tr> <tr> <td>Type</td><td>VZO 20FL 130/25</td></tr> <tr> <td>Accuracy</td><td>1%</td></tr> <tr> <td>Calibration Frequency</td><td>Once in 3 years</td></tr> <tr> <td>Calibration Date</td><td>29/11/2011 22/01/2014</td></tr> <tr> <td>Validity</td><td>21/01/2017</td></tr> </tbody> </table> <u>Boiler 2</u> <table border="1"> <thead> <tr> <th>Period of usage</th><th>Beginning – 31/07/2015</th></tr> </thead> <tbody> <tr> <td>Meter name</td><td>OM2</td></tr> <tr> <td>Serial Number</td><td>4126168</td></tr> <tr> <td>Brand</td><td>CONTOIL</td></tr> <tr> <td>Type</td><td>VZO 20FL 130/25</td></tr> <tr> <td>Accuracy</td><td>1%</td></tr> <tr> <td>Calibration Frequency</td><td>Once in 3 years</td></tr> <tr> <td>Calibration Date</td><td>29/11/2011</td></tr> </tbody> </table>	Meter name	OM1	Serial Number	4546871	Brand	CONTOIL	Type	VZO 20FL 130/25	Accuracy	1%	Calibration Frequency	Once in 3 years	Calibration Date	29/11/2011 22/01/2014	Validity	21/01/2017	Period of usage	Beginning – 31/07/2015	Meter name	OM2	Serial Number	4126168	Brand	CONTOIL	Type	VZO 20FL 130/25	Accuracy	1%	Calibration Frequency	Once in 3 years	Calibration Date	29/11/2011
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		26/08/2014
	Validity	25/08/2017
	Period of usage	01/08/2015 - present
	Meter name	OM2
	Serial Number	5449943
	Brand	CONTOIL
	Type	VZF20RC 130/16
	Accuracy	1%
	Calibration Frequency	Once in 3 years
	Calibration Date	05/05/2015 07/05/2016
	Validity	06/05/2019
QA/QC procedures to be applied	The liquid flow meter was calibrated at least once every 3 years.	
Purpose of the data	Calculation of project emissions	
Calculation method	Not applicable	
Comments	- As per the deviation 1 of the project description deviation, the oil meter value of boiler 1 was excluded in a conservative manner. - All the monitoring equipment were calibrated on time, thus no error was applied.	

Data / Parameter	Q _{starch,y}													
Data unit	Tonnes													
Description	Quantity of dry starch produced													
Source of data	Based on operational log sheet at the plant													
Description of measurement methods and procedures to be applied	A proper record of all starch produced was maintained at the project site.													
Frequency of monitoring/recording	Daily recording													
Value monitored	<table><tr><th>Monitoring Period</th><th>Value (tonnes)</th></tr><tr><td>01/01/2012 to 31/12/2012</td><td>63,670</td></tr><tr><td>01/01/2013 to 31/12/2013</td><td>52,634</td></tr><tr><td>01/01/2014 to 31/12/2014</td><td>75,978</td></tr><tr><td>01/01/2015 to 31/12/2015</td><td>73,239</td></tr><tr><td>01/01/2016 to 11/05/2016</td><td>34,388</td></tr></table>		Monitoring Period	Value (tonnes)	01/01/2012 to 31/12/2012	63,670	01/01/2013 to 31/12/2013	52,634	01/01/2014 to 31/12/2014	75,978	01/01/2015 to 31/12/2015	73,239	01/01/2016 to 11/05/2016	34,388
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Monitoring equipment	<table><tr><td>Meter name</td><td>Indicators for floor scale</td></tr></table>		Meter name	Indicators for floor scale										
Meter name	Indicators for floor scale													

	Serial Number	B406274156 B406274200 B301690263 B315226070 B316230849
	Brand	Ohaus
	Model	T32XW
	Accuracy	±2%
	Calibration Frequency	Once a year
	Calibration Date	06/09/2011 02/09/2012 29/08/2013 29/08/2014 15/08/2015
	Validity	15/08/2016
QA/QC procedures to be applied	The production data was cross-checked with sales records, if necessary.	
Purpose of the data	Calculation of baseline emissions	
Calculation method	Not applicable	
Comments	All the monitoring equipment were calibrated on time, thus no error was applied.	

Data / Parameter	EG _y											
Data unit	MWh/y											
Description	Net electricity production by the generators during year y											
Source of data	Measured – Electricity meters installed at the generation sets											
Description of measurement methods and procedures to be applied	Measured electronically on a continuous basis. The power meters are installed after generators.											
Frequency of monitoring/recording	Continuous monitoring with daily recording											
Value monitored	The monitoring data was excluded during the monitoring period due to no calibration of the electricity meters.											
Monitoring equipment	<table><tr><td>Meter name</td><td>EM1</td></tr><tr><td>Serial Number</td><td>62560 1 00N0030</td></tr><tr><td>Brand</td><td>CARLO GAVAZZI</td></tr><tr><td>Type</td><td>WM3-06</td></tr><tr><td>Accuracy</td><td>±0.5%</td></tr></table>		Meter name	EM1	Serial Number	62560 1 00N0030	Brand	CARLO GAVAZZI	Type	WM3-06	Accuracy	±0.5%
Meter name	EM1											
Serial Number	62560 1 00N0030											
Brand	CARLO GAVAZZI											
Type	WM3-06											
Accuracy	±0.5%											

	Calibration Frequency	Once in 3 years
	Calibration Date	Not available
	Meter name	EM2
	Serial Number	62560 1 00N0034
	Brand	CARLO GAVAZZI
	Type	WM3-06
	Accuracy	±0.5%
	Calibration Frequency	Once in 3 years
	Calibration Date	Not available
QA/QC procedures to be applied	The power meters shall be calibrated at least once in three years.	
Purpose of the data	Calculation of baseline emissions	
Calculation method	Not applicable	
Comments	- As there was no calibration conducted for the electricity meters, the values were not included in baseline emission calculation ($BE_{gen,y}$) for conservative. - The electricity supplied from new generators (no.3 and 4) were not included in this calculation since they were the additional equipment installed after project implementation	

Data / Parameter	EC _y											
Data unit	MWh/y											
Description	Electricity consumption by wastewater treatment plant in year y											
Source of data	Maximum rated consumption was calculated by multiplying total electrical capacity with operational hours with 10% additional factor to be conservative.											
Description of measurement methods and procedures to be applied	Calculation based on maximum rated consumption was conducted in a conservative manner (as per paragraph 35 in AMS III. H., version 13).											
Frequency of monitoring/recording	Not applicable. This was based on the calculation mentioned above.											
Value monitored	<table><tr><th>Monitoring Period</th><th>Value (MWh)</th></tr><tr><td>01/01/2012 to 31/12/2012</td><td>4,413</td></tr><tr><td>01/01/2013 to 31/12/2013</td><td>4,413</td></tr><tr><td>01/01/2014 to 31/12/2014</td><td>4,413</td></tr><tr><td>01/01/2015 to 31/12/2015</td><td>4,413</td></tr></table>		Monitoring Period	Value (MWh)	01/01/2012 to 31/12/2012	4,413	01/01/2013 to 31/12/2013	4,413	01/01/2014 to 31/12/2014	4,413	01/01/2015 to 31/12/2015	4,413
Monitoring Period	Value (MWh)											
01/01/2012 to 31/12/2012	4,413											
01/01/2013 to 31/12/2013	4,413											
01/01/2014 to 31/12/2014	4,413											
01/01/2015 to 31/12/2015	4,413											

	01/01/2016 to 11/05/2016	1,826	
Monitoring equipment	Not applicable		
QA/QC procedures to be applied	-		
Purpose of the data	Calculation of project emissions		
Calculation method	Not applicable		
Comments	The project only consumed the electricity generated by the generators using biogas		

Data / Parameter	Sludge removed and its application																	
Data unit	Tonnes and type of application																	
Description	The quantity of organic material / sludge removed from treatment plant and its application																	
Source of data	Weighing equipment available at the site was used.																	
Description of measurement methods and procedures to be applied	Proper log records were maintained for sludge removal and disposal at the project site.																	
Frequency of monitoring/recording	Recorded every time sludge was removed from the system																	
Value monitored	<table><tr><th>Monitoring Period</th><th>Value (tonnes)</th></tr><tr><td>01/01/2012 to 31/12/2012</td><td>0</td></tr><tr><td>01/01/2013 to 31/12/2013</td><td>0</td></tr><tr><td>01/01/2014 to 31/12/2014</td><td>0</td></tr><tr><td>01/01/2015 to 31/12/2015</td><td>0</td></tr><tr><td>01/01/2016 to 11/05/2016</td><td>0</td></tr></table>		Monitoring Period	Value (tonnes)	01/01/2012 to 31/12/2012	0	01/01/2013 to 31/12/2013	0	01/01/2014 to 31/12/2014	0	01/01/2015 to 31/12/2015	0	01/01/2016 to 11/05/2016	0				
Monitoring Period	Value (tonnes)																	
01/01/2012 to 31/12/2012	0																	
01/01/2013 to 31/12/2013	0																	
01/01/2014 to 31/12/2014	0																	
01/01/2015 to 31/12/2015	0																	
01/01/2016 to 11/05/2016	0																	
Monitoring equipment	<table><tr><td>Meter name</td><td>Weighbridge</td></tr><tr><td>Serial Number</td><td>0001648</td></tr><tr><td>Brand</td><td>Commandor</td></tr><tr><td>Type</td><td>HP-06</td></tr><tr><td>Accuracy</td><td>±20 kg</td></tr><tr><td>Calibration Frequency</td><td>Every two years</td></tr><tr><td>Calibration Date</td><td>12/01/2012 03/06/2014</td></tr><tr><td>Validity</td><td>02/06/2016</td></tr></table>		Meter name	Weighbridge	Serial Number	0001648	Brand	Commandor	Type	HP-06	Accuracy	±20 kg	Calibration Frequency	Every two years	Calibration Date	12/01/2012 03/06/2014	Validity	02/06/2016
Meter name	Weighbridge																	
Serial Number	0001648																	
Brand	Commandor																	
Type	HP-06																	
Accuracy	±20 kg																	
Calibration Frequency	Every two years																	
Calibration Date	12/01/2012 03/06/2014																	
Validity	02/06/2016																	
QA/QC procedures to be applied	The plant manager's signature shall be required on the record.																	
Purpose of the data	Calculation of project emissions																	
Calculation method	Not applicable																	

Comments	Though there were calibration gap during 01/01/2012 to 11/01/2012 and 12/01/2014 to 02/06/2014, the sludge was not removed during this monitoring period. Thus, no error had been applied to the emission reduction.
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Data / Parameter	Q _{biogas,flare,h}													
Data unit	Nm ³ /hr													
Description	Biogas sent to flare during a particular hour h													
Source of data	Biogas flow meter, GM2 is used.													
Description of measurement methods and procedures to be applied	Log record was maintained on an hourly basis to ascertain net amount of biogas has gone to flare unit during a particular hour.													
Frequency of monitoring/recording	-													
Value monitored	<table><tr><th>Monitoring Period</th><th>Value (Nm³/hr)</th></tr><tr><td>01/01/2012 to 31/12/2012</td><td>0</td></tr><tr><td>01/01/2013 to 31/12/2013</td><td>0</td></tr><tr><td>01/01/2014 to 31/12/2014</td><td>0</td></tr><tr><td>01/01/2015 to 31/12/2015</td><td>0</td></tr><tr><td>01/01/2016 to 11/05/2016</td><td>0</td></tr></table>		Monitoring Period	Value (Nm ³ /hr)	01/01/2012 to 31/12/2012	0	01/01/2013 to 31/12/2013	0	01/01/2014 to 31/12/2014	0	01/01/2015 to 31/12/2015	0	01/01/2016 to 11/05/2016	0
Monitoring Period	Value (Nm ³ /hr)													
01/01/2012 to 31/12/2012	0													
01/01/2013 to 31/12/2013	0													
01/01/2014 to 31/12/2014	0													
01/01/2015 to 31/12/2015	0													
01/01/2016 to 11/05/2016	0													
Monitoring equipment	Same gas flow meter for the parameter BG _{TOFlare,y}													
QA/QC procedures to be applied	Same gas flow meter for the parameter BG _{TOFlare,y}													
Purpose of the data	Calculation of project emissions													
Calculation method	Not applicable													
Comments	There was no record since no biogas was flared during the monitoring period.													

Data / Parameter	$\eta_{\text{flare,h}}$			
Data unit	%			
Description	Flare efficiency			
Source of data	“Tool to determine project emissions from flaring gases containing methane”			
Description of measurement methods and procedures to be applied	The efficiency of the flaring process was defined as 50% based on the default factor for open flares.			
Frequency of monitoring/recording	Continuous monitoring, record on the daily basis			
Value monitored	<table><tr><th>Monitoring Period</th><th>Value (%)</th></tr></table>		Monitoring Period	Value (%)
Monitoring Period	Value (%)			

	01/01/2012 to 31/12/2012	0
	01/01/2013 to 31/12/2013	0
	01/01/2014 to 31/12/2014	0
	01/01/2015 to 31/12/2015	0
	01/01/2016 to 11/05/2016	0
Monitoring equipment	Flame detector	
QA/QC procedures to be applied	Maintenance of flare system shall be conducted periodically as per supplier's specifications to ensure optimal operation.	
Purpose of the data	Calculation of project emissions	
Calculation method	Not applicable	
Comments	The condition was not met as per the monitoring plan. To be conservative on the project emission calculation, the flare efficiency of 0% default was taken into account. However, there was no record of flame detection since no biogas was flared during the monitoring period.	

3.3 Monitoring Plan

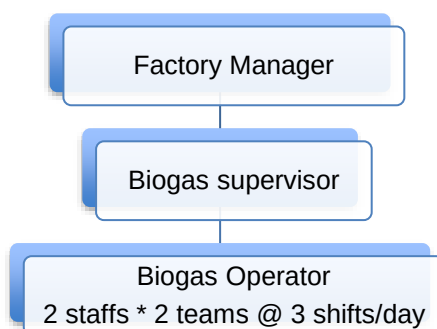
The monitoring plan is as described in section 3.4 of the registered PD. The daily operation data recording and laboratory analysis is carried out by plant operators. The reports are checked and approved by the biogas plant supervisor. All equipment calibrations are controlled by the biogas plant supervisor.

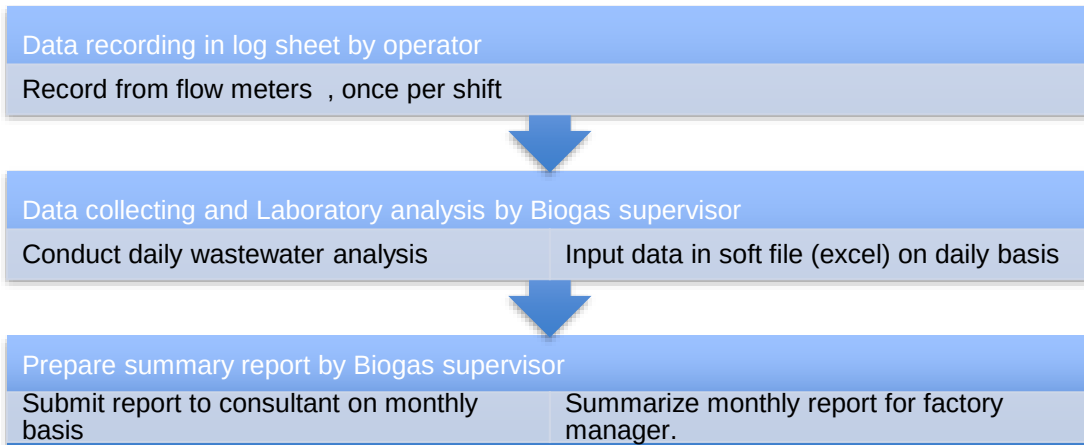
The biogas plant supervisor collects all information and submit it to a consultant for emission calculation.

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;
2. The monitored parameters during the monitoring period.

Organization structure



Data Collection and management system

The monitoring diagram for the second verification of project activity has been changed during the monitoring period of 01/01/2012 to 11/05/2016. The previous monitoring diagram (Figure 3) was implemented until 23/09/2013 and the current monitoring diagram (Figure 4) has started using from 24/09/2013 onwards.

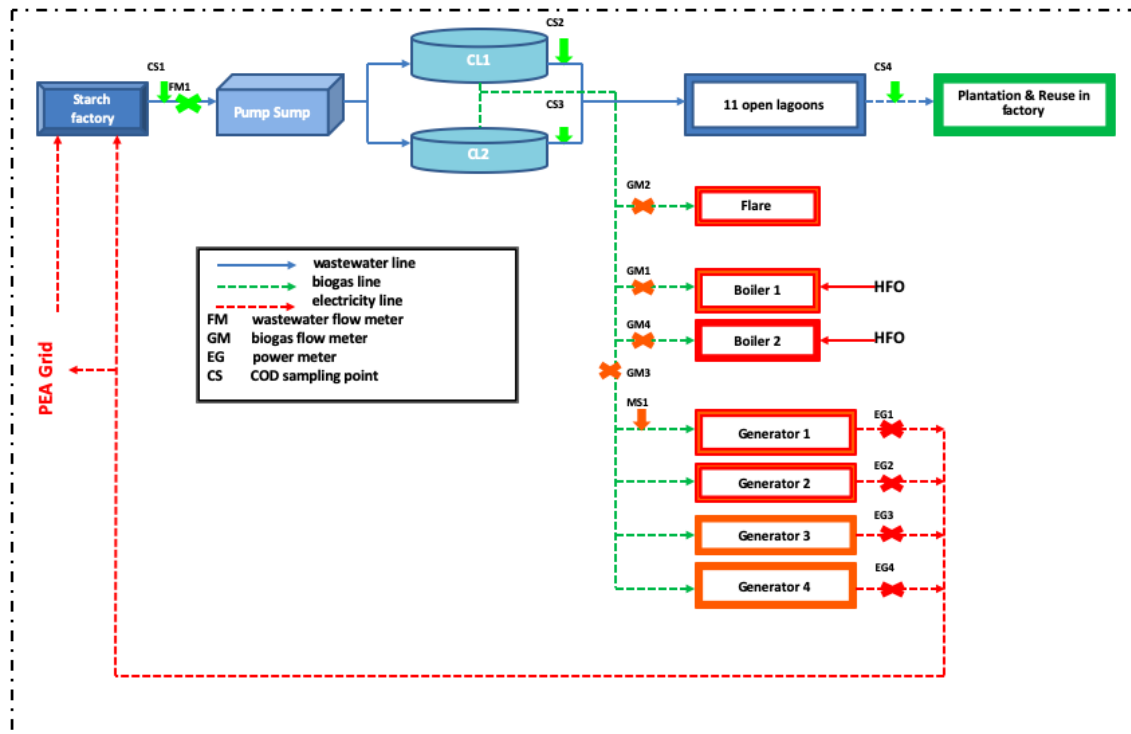


Figure 3: The monitoring diagram from 01/01/2012 to 23/09/2013

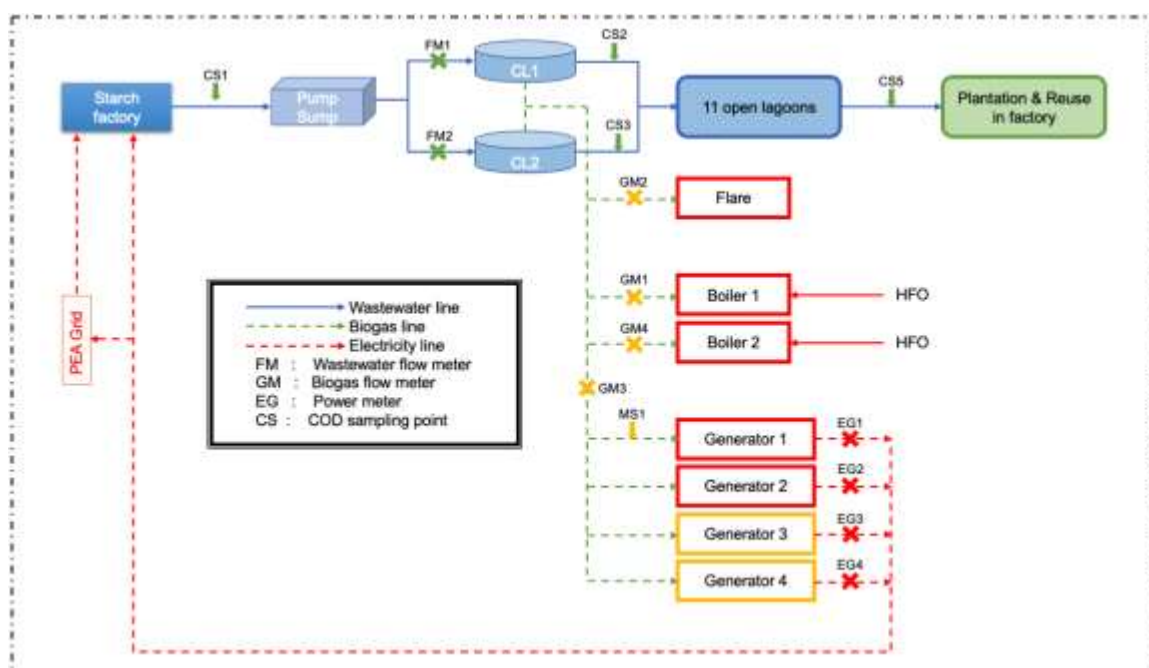


Figure 4: The monitoring diagram from 24/09/2013 onwards

Data storage and backup

- The original log sheets are collected and stored in the starch production office by biogas supervisor.
- The data in excel format is saved in computer at biogas control room and backup into computer at production office every month by biogas supervisor.

The excel spreadsheet submitted to consultant is stored and backup via consultant's internal server on monthly basis.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

Baseline Emissions for AMS III.H

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

Where:

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

$BE_{ww, discharge, y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y (tCO _{2e}).
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In the baseline scenario, treated wastewater is not discharged into sea/lake/river, therefore methane emissions from degradable organic carbon in treated wastewater discharged ($BE_{ww, discharge, y}$) is taken as zero.

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

Baseline Emissions for AMS ID

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

As per AMS I. D., paragraph 10, the baseline is the MWh produced by the renewable generating unit multiplied by an emission coefficient as follows:

$$BE_y = BE_{gen, y} = EF_y * EG_y \quad (\text{Equation 2})$$

Where:

Parameter	Details
EG_y	The quantity of electricity supplied by the project activity during the year “y” (MWh)
EF_y	Thailand National Grid emission factor (tCO _{2e} /MWh)

Since the calibration of the monitoring equipment for measurement of the parameter EG_y was not conducted in line with the registered monitoring plan, the data was excluded from the calculation of baseline emission from electricity generation. This is conservative approach.

Therefore, $BE_y = BE_{gen, y} = 0$.

Baseline Emissions for AMS IC

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

According to paragraph 15 of AMS I.C., the baseline emissions are estimated based on the amount of heat/steam delivered by the equipment (as per equation below).

The deviation explained in later section of the PD takes into account the baseline efficiencies and a simplified approach is explained here to estimate the baseline emissions, the approach is based on historical consumption of fuel oil per tonne of starch generation. The deviation addresses the coherence with §15 and 10 of the methodology.

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

Where:

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

Since the boiler no.1 was replaced and the thermal capacity has been increased. The deviation 1 as per the registered PD is established based on conservative approach for the emission reduction of heat component.

Baseline emissions

AMS III. H.						
Parameter	Unit	2012	2013	2014	2015	2016
$Q_{ww,y}$	m ³	1,077,712	489,163	668,154	132,487	268,136
$COD_{removed,i,y}$	tonnes /m ³	0.018	0.016	0.014	0.020	0.026
$B_{o,ww}$	kg CH ₄ /kg COD	0.21	0.21	0.21	0.21	0.21
$MCF_{ww,treatment,BL,lagoon}$		0.8	0.8	0.8	0.8	0.8
GWP_{CH_4}		25	25	25	25	25
UF_{BL}		0.94	0.94	0.94	0.94	0.94
$BE_{ww,treatment,y} \text{ (COD approach)}$	tCO ₂ e	76,721	30,421	37,869	10,602	27,993

Parameter	Unit	2012	2013	2014	2015	2016
$BG_{combusted,y} \text{ (boiler2)}$	Nm ³	1,739,295	805,869	1,158,079	1,435,053	580,787
$BG_{combusted,y} \text{ (gas engines)}$	Nm ³	6,547,519	3,586,402	4,772,971	7,779,354	897,486
$BG_{ToFlare,y}$	Nm ³	0	0	0	0	0
$W_{CH_4,y} - \text{lower}$	%	52.7%	53.1%	50.4%	50.0%	49.6%
D_{CH_4}	kg/m ³	0.716	0.716	0.716	0.716	0.716
$Q_{biogas,flare,y}$	Nm ³	0	0	0	0	0
$\eta_{flare-h}$	%	0%	0%	0%	0%	0%
$BE_{ww,y} \text{ (MD approach)}$	tCO ₂ e	78,227	41,715	53,484	82,536	13,125

AMS I. C.						
Parameter	Unit	2012	2013	2014	2015	2016
$Q_{FO,boiler\ 2}$	litres	144,260	41,730	26,790	118,307	94,286
$Q_{starch,y}$	tonnes	63,670	52,634	75,978	73,239	34,388
EF_{CO_2}	t CO ₂ /MWh	77.4	77.4	77.4	77.4	77.4
NCV_{FO}	t CO ₂ /TJ	42.76	42.76	42.76	42.76	42.76
$Q_{FO,starch}$	liters/tonne	39.6	39.6	39.6	39.6	39.6
D_{FO}	kg/m ³	0.93	0.93	0.93	0.93	0.93
$BE_{thermal,CO_2,y} = ER_{heat,y}$	tCO ₂ e	7,316	2,390	3,646	5,539	1,700

AMS I. D.						
Parameter	Unit	2012	2013	2014	2015	2016
EG_y	MWh					
EF_y	tCO ₂ /MWh					
$BE_{gen,y} = ER_{power,y}$	tCO ₂ e	Since the meters were not calibrated, the data was excluded in baseline emission calculation.				

4.2 Project Emissions

Project activity emissions for AMS III.H

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

Where:

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

Project emissions

Parameter	Unit	2012	2013	2014	2015	2016
EC _y	MWh	4,413	4,413	4,413	4,413	1,826
EF _y	tCO ₂ /MWh	0.5057	0.5057	0.5057	0.5057	0.5057
PE _{power,y}	tCO ₂ e	2,232	2,232	2,232	2,232	924

Parameter	Unit	2012	2013	2014	2015	2016
Q _{ww,y}	m ³	1,077,712	489,163	668,154	132,487	268,136
COD _{removed,PJ,k,y}	mg/l	0.00116	0.00095	0.00077	0.00028	0.00099
B _{o,ww}	kg CH ₄ /kg COD	0.21	0.21	0.21	0.21	0.21
MCF _{ww,treatment,PJ,lagoon}	Fraction	0.8	0.8	0.8	0.8	0.8
GWP _{CH4}		25	25	25	25	25
UF _{PJ}	Fractor	1.06	1.06	1.06	1.06	1.06
PE _{ww,treatment,y}	tCO ₂ e	5,580	2,076	2,306	166	1,177

Parameter	Unit	2012	2013	2014	2015	2016
PE _{s,treatment,y}	tCO ₂ e	0	0	0	0	0
PE _{ww,discharge,y}	tCO ₂ e	0	0	0	0	0
PE _{s,final,y}	tCO ₂ e	0	0	0	0	0
PE _{biomass,y}	tCO ₂ e	0	0	0	0	0

Parameter	Unit	2012	2013	2014	2015	2016
MCF _{ww,treatment,PJ,CL}		0.8	0.8	0.8	0.8	0.8
COD _{removed,PJ,CL,y}	mg/l	0.019	0.017	0.015	0.022	0.029
MEP _{ww,treatment,y}	tonnes	3,441	1,366	1,673	493	1,304
PE _{fugitive,ww,y}	tCO ₂ e	8,603	3,415	4,183	1,232	3,260
PE _{fugitive,s,y}	tCO ₂ e	0.00	1.00	2.00	3.00	1.00
PE _{fugitive,y}	tCO ₂ e	8,603	3,416	4,185	1,235	3,261

PE _{flaring,y}	tCO ₂ e	0	0	0	0	0
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PE _{y,ex post}	tCO ₂ e	16,415	7,724	8,723	3,633	5,362
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4.3 Leakage

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

4.4 Net GHG Emission Reductions and Removals

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)
01/01/2012 to 31/12/2012	84,037	16,415	0	67,622
01/01/2013 to 31/12/2013	32,811	7,724	0	25,087
01/01/2014 to 31/12/2014	41,515	8,723	0	32,792
01/01/2015 to 31/12/2015	16,141	3,633	0	12,508
01/01/2016 to 11/06/2016	14,825	924	0	13,901
Total	189,329	37,419	0	151,910

Remarks on increase in achieved emission reductions

The actual emission reductions during this monitoring period has been higher than ex-ante figure (71,225 tCO₂e). The justification has been provided as follows.

- 1) Change in default parameter of GWP_{CH4}
According to the VCS standard, version 3.7, the GWP_{CH4} value of 25 has been applied for the emission calculation. This caused the overall ERs to increase around 14.87%⁹.
- 2) When comparing the actual monitored data with the ex-ante figures, most of figures were increased. The explanation for the main figures has been provided as follows:
 - Ton of starch production: The starch production capacity has not been changed. The higher amount was from the higher utilization of starch factory.
 - Uncertainty of wastewater volume: The generated wastewater per tonne starch¹⁰ was in range of 7.80 – 16.93 m³ which was 11.4 assumed for ex-ante calculation. However, this was regarding the starch operation and the highest figure (16.93) was still lower than the average figure from starch factory in Thailand of 23 m³/t.¹¹
 - Biogas production volume: The actual COD removal efficiency for the covered lagoon system was more than 90%, while the figure of 80% was applied in ex-ante calculation. This further explains the increased biogas production.
 - Quantity of fossil fuel used: The actual quantity of fossil fuel consumed at two boilers was much lower than the ex-ante figure.

At the time of PD development and validation, conservative values were used and verified by the validating DOE. The quality of raw material had also impact on the starch output and resulting wastewater generation. This was dependent on the crop and is subject to seasonal variations. Therefore, the assumptions made at the time of validation were based on sound judgment and sources and may change during the course of operation of the project. It may happen that due to the variation in the raw material, the wastewater generation volume may change again in the future.

⁹ GWP_{CH4} 21 – The total ERs was 129,324 tCO₂e.

¹⁰ The range was not included the 2015 data as the record was not available from 14/02/2015 – 22/10/2015.

¹¹ <http://www.kmutt.ac.th/rippc/best73e.htm>

APPENDIX X: <TITLE OF APPENDIX>

N/A