Project design document form for small-scale CDM project activities

(Version 06.0)

PROJECT DESIGN DOCUMENT (PDD)	
Title of the project activity	UPOIC Wastewater Treatment for Energy Generation, Krabi
Version number of the PDD	12
Completion date of the PDD	08/07/2015
Project participant(s)	1. United Palm Oil Industry Public Company Limited (UPOIC) 2. Swiss Carbon Asset Ltd. (Switzerland)
Host Party	Thailand
Sectoral scope and selected methodology(ies), and where applicable, selected standardized baseline(s)	Sectoral scope 1: Energy Industries Sectoral Scope 13: Waste handling and disposal Methodology applied: AMS-I.D. version 16 AMS-III.H. version 15
Estimated amount of annual average GHG emission reductions	18,001 tCO2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

Purpose of the project activity, reduction of greenhouse gases
United Palm Oil Industry Public Company Limited (UPOIC) has a crude palm oil mill located in Krabi Province, Thailand at approximately 814 km south of Bangkok. The mill produces Crude Palm Oil (CPO) from the Fresh Fruit Bunches (FFB) at capacity of 175,200 tonnes FFB /year, 300 days per year of operation. From the production processes, there is high organic content wastewater called Palm Oil Mill Effluent (POME) generated at approximately 0.59 m^3/ton FFB[1]. This POME has Chemical Oxygen Demand (COD) of 60,000-80,000 mg/L which was treated in an open lagoon system using anaerobic, facultative and polishing ponds, with a depth greater than 2 meters, without aeration (for more details please refer to Section B.2, Table 4 and Figure 4-5). Methane was formed during the anaerobic conditions in the open ponds and emitted directly to the atmosphere.

The purpose of 'UPOIC Wastewater Treatment for Energy Generation, Krabi' is to shift from traditional wastewater treatment in opened anaerobic ponds with uncontrolled release of methane to the atmosphere to a closed digester system with biogas capture using Completely Stirred Tank Reactors (CSTR) to extract and capture the methane gas from the high organic laden waste water. The captured gas is produced electricity which is utilized in the palm oil factory. Surplus electricity is fed into the national grid. Hence, the ultimate purpose of the project activity is to reduce greenhouse gases (GHGs) emissions to the atmosphere, produce electricity, and contribute to an environmentally and socially sustainable development of wastewater treatment at UPOIC.

How the project reduce greenhouse gas emission
The project involves technology know-how transfer to local communities. The CSTR system for this project is developed by the Energy Research and Development Institute (ERDI) of Chiang Mai University in the north of Thailand to enhance the treatment efficiency for POME which has special characteristics, containing oil and other ingredients different from other industries (details of the technology shown in section A 4.2). The know-how transfer has been done by technicians from ERDI during a training program. The training includes technical, environmental and safety knowledge and operational and maintenance instructions.

The CSTR creates an enclosed anaerobic environment, which enables bacteria to digest and convert the organic matter in wastewater into biogas. As per the design, the captured biogas is approximately 2,622,256 m3/year is supplied to the 2 sets of 952 kW-generator, to produce electricity which is self-utilized in the palm oil factory and fed into the electricity grid. Any excess biogas will be flared.

The baseline scenario of the project;

- POME is treated in the existing opened anaerobic lagoons of the factory. This anaerobic process generates and emits biogas-containing methane into the atmosphere.
- The Thai electricity grid generates and emits GHGs from a combination of natural gas, coal, oil, and other fuel sources.

The project scenario;

- POME is treated in CSTR system. The produced biogas is captured and utilized for electricity generation. The produced methane is, thus, not emit into the atmosphere.
- The generated electricity is partly used in the factory and partly fed into the grid. The GHGs emission is reduced due to the replacement of fossil fuel that generally is required for generation of grid electricity with this renewable resource.

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[1] 10-day measuring data at UPOIC, Krabi, June-July 2009

The view of the project participants of the contribution of the project activity to sustainable development

The project activities can fulfill the CDM project eligibility criteria set by Thai DNA 'Thai Greenhouse Gas Organization (TGO)'. This sustainable development criteria for CDM project in Thailand focuses on four major aspects as described below and summarized in Table 1.

National Resources and Environment: The gas produced from POME by anaerobic digestion process will be captured and utilized for electricity generation. Thus, the GHG emission and the offensive smells from the POME will be minimized. The COD of the treated wastewater will be reduced by approximately 90 percent[2] and will be further used for irrigation in their own factory and not contributed to additional smell or harmful discharge to open water bodies. The produced biogas will be used to generate electricity for self-utilizing (biogas system and Palm Oil Factory) at approximately 895 MWh/year and feed into the grid at approximately 4,784 MWh/year that would otherwise produced from fossil fuels with high green house gas emission. This substitution would lower the emission of other air pollutants i.e. dust, sulfur dioxide, etc. as well. Since the project will modify the existing anaerobic ponds and available space in the existing pond area to serve the new system, the new land will not be used thus, the natural resource indicator will not be disturbed by the proposed project activities.

Social: As a result of methane emissions reduction, offensive smells from the POME will be minimized. The project activity will thus improve working standards of employees and living standards of the local community. In addition, the project owner has set up a budget in order to share benefit from CERs revenue to local stakeholder for social contribution such as support local activity, support education of the poor, etc.

Development and/or technology transfer: This project will involve technology and know how transferred from institutional to local people. The local staff will be trained for the operations and maintenance of the technology. The technology is replicable and will induce more installations in similar agricultural sectors or wastewater treatment conditions.

Economics: The construction, operation and maintenance of the anaerobic wastewater and biogas system will create additional employment opportunities. During construction within 18 months a total of approximately 40 temporary jobs and during operation 5 permanent jobs (technicians, engineers) will be created. Moreover, the project activity helps to reduce the dependency on fossil fuels by implementing a modern technology that produces biogas fuel (autonomous renewable energy).

[2] Wastewater analysis of the Lamsoon (Thailand) PLC which used the digester developed by the Energy Research and Development Institute, 2009

Table 1: Sustainable Development Criteria/Indicator for CDM Projects in Thailand

	Sustainable Development Criteria/Indicator	Criterion met by project activity
1	Natural Resources and Environment Indicators	
1.1	Environment Indicators	
-	Reduction of greenhouse gases emission as specified the Kyoto Protocol	YES
-	Reduction of air pollutant emission in compliance with air quality standards	YES
-	Noise pollution (in compliance with government standards)	YES
-	Odor pollution (in compliance with government standards)	YES
-	BOD Loading in wastewater (in compliance with government standards)	YES
-	Waste management	YES
-	Soil pollution (in compliance with government standards)	YES
-	Groundwater contamination	YES
-	Reduction of hazardous waste	YES
1.2	Natural Resource Indicators	
-	Water demand and efficiency of water usage	YES
-	Soil, coastal and river bank erosion	YES
-	Increase green areas under the project's initiative(in accordance with provincial green areas statistics)	YES
-	Ecosystem diversity	YES
-	Species diversity	YES
-	Use/import of GMO and/or alien species to the project site	YES
2	Social	
-	People's participation (assessed by the level of participation being organized)	YES
-	Activities promoting social development, culture, and 'sufficiency economy' philosophy	YES
-	Workers health and surround community health	YES
3	Development and/or technology transfer indicators	
-	Technological development	YES
-	Post Project Implementation Plan or Post Crediting Period Plan as outlined by the project	YES
-	Capacity-building	YES
4	Economic indicators	
4.1	Increasing income of stakeholders	
-	Increasing income of the workers	YES
-	Increasing income of other stakeholders, such as increases in income of farmers through selling raw materials to the project	YES
4.2	Energy	
-	Use of alternative energy	YES
-	Energy efficiency	YES
-	Increase in using local content	YES

A.2. Location of project activity

A.2.1. Host Party
Thailand

A.2.2. Region/State/Province etc.
South, Krabi Province

A.2.3. City/Town/Community etc.
District Nua Klong, Sub-district Huay Yoong

A.2.4. Physical/Geographical location
The United Palm Oil Industry Company Limited factory is located 814 km. South of Bangkok in the Krabi Province. The complete address is as follows (see Figure 1):

96 Moo 6 , Nua Klong-Kao Panom Rd., Huay Yoong Sub-district, NuaKlong District, Krabi Province, 81130 Thailand Tel. +6675 621 919 Fax. +6675 621 922

The coordinates are as follows: 8°9’2382’’ N; 99°1’4009’’ E.

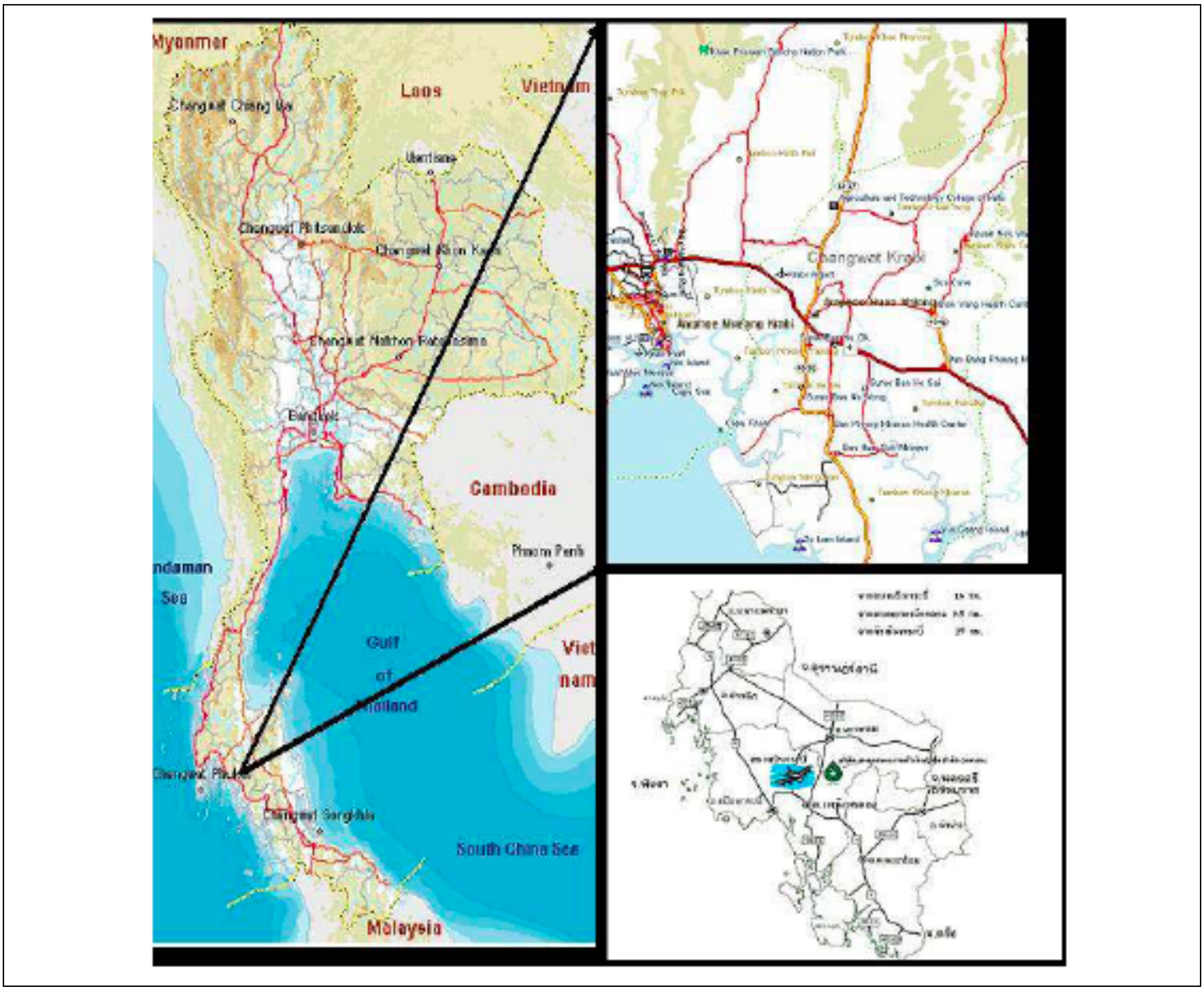


Figure 1: Location of the project activity

A.3. Technologies and/or measures

At present, UPOIC factory has daily average production rates of 175,200 tonnes of FFB (fresh fruit bunches) per year. Currently the factory is operating a conventional open pond waste water treatment system with several open ponds. (The existing open pond system and the biogas system master plan is shown in **Figure 2**). A digester treatment technology is implemented at UPOIC to treat the wastewater generated in the production processes. An average of 0.59 m^3 wastewater per ton of FFB is generated during 10-day campaign and this result is cross-checked with the benchmarking implementation report for United Palm Oil Industry Public Co., Ltd. studied by Thai-German Program for Enterprise Competitiveness which indicates the specific waste water generation rate of UPOIC is between 0.45-0.76 m^3 wastewater per ton of FFB[3], therefore the wastewater generation rate of 0.59 m^3 wastewater per ton of FFB obtained during the 10-day campaign can be applied for estimating the volume of wastewater. Thus approximately 350 m^3 wastewater is generated per day. This digester system recovers methane and produce biogas. The latter is utilized for electricity generation for self-utilized for palm oil factory use and feeding into the grid.

Technical Data for Developing CDM Project

Item	**Amount**
Production Rate per day	175,200 tonnes (historical data)
Operation days	300 days (UPOIC)
Wastewater Generation Rate	0.59 m^3/t FFB (10-day campaign)
Wastewater Flow Rate	102,730 m3/yr
COD (mg/l)	60,000 – 80,000 mg/l (10-day campaign)
Estimated biogas production rate through biogas reactor	2,622,256 m^3/year (calculated)
Biogas Utilization	~ 5,770 MWh/year electricity for self-utilized and grid feed
Methane (CH4) content in Biogas	65 % (ERDI)
Expected Technology Lifetime	>10 yrs (ERDI)

The discharge from organic fractions of the palm oil production process, primarily FFB, from palm oil mill has high chemical oxygen demand (COD). Referring to research reports and Chiang Mai University (CMU) laboratory tests results, the discharged effluent from Palm Oil Mill has approximately 120 g COD/liter of which about 90% is biodegradable. The biogas production rate is ranging around 25-30 m^3 of biogas per 1 m^3 of wastewater. The effective retention time is 20 days. These results give strategic guidelines to design appropriate functions for biogas systems to cope with the characteristics of the wastewater, such as enhancing of the mixing, returning and retaining the microbes.

From the study, a hybrid system has been chosen as it is the best suited for the underlying situation by combining the advantages of completely stirred tank reactor (CSTR) and Plug-Flow digester. Because the wastewater is characterized not only by a high COD, but also by a high load of suspended solids (SS) with low separation ability, an adoption of traditional tank reactors to the specific site characteristics is necessary. Thus, a **CMU Plug Flow - CSTR Based System** is implemented by ERDI. This system gives biogas operators different necessary functions, such as flexible mixing strategy to minimize energy consumption and maximize biogas efficiency. The system is designed based on a zero downtime operation mode which reduces operation cost in comparison to normal operation mode in which machineries and process need warm up phase before coming into full efficient operation. Moreover, COD content in the effluent is reduced by about 90% and enter the conventional opened pond post treatment process. Thus, the project

[3] Eco-Efficiency Benchmarking in the Palm Oil Industry, Benchmarking Implementation Report for United palm Oil Industry Co., Ltd. period of December 2005 - February 2006.Thai-German Program for Enterprise Competitiveness, 23 March 2006.

activity does not only reduce GHG emissions, but also enhance the quality of effluent from the palm oil plant through a significant reduction of COD. The digested effluent is used for irrigation purposes at surrounding palm plantations. A small amount of sludge is collected in a sand bed filter and applied to the palm plantations as fertilizer next to the pond system. The hybrid system ensures a continuous high contact rate of bacteria in the reactor. The top of the digester is equipped with a plastic sheet system to collect all the generated biogas to be stored and utilized as a renewable energy source.

Besides the tank reactor, being the central element of the improved treatment process, the following components will be installed

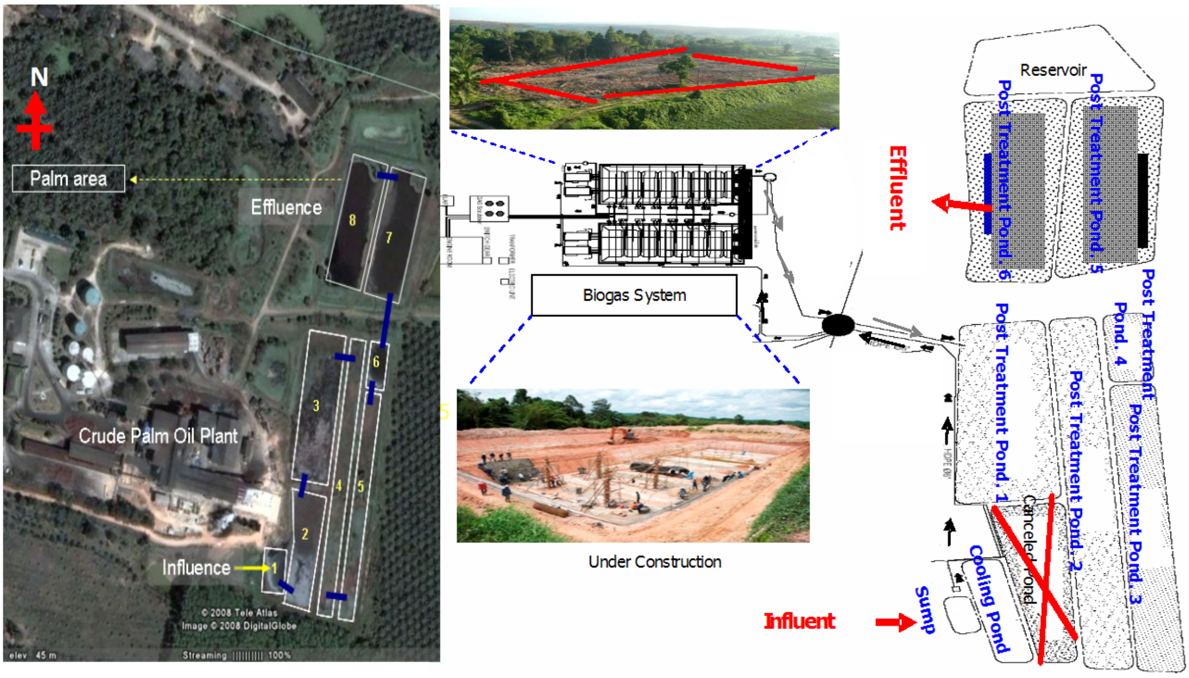
- **Pretreatment Pond** The pond allows temperature adjustment of wastewater leaving the production process as well as a first sedimentation of solid components;
- **Distribution Tank** The distribution tank continuously pumps screened effluent to the hybrid system;
- **Sand Bed Filter** The filter separates the solid and liquid parts of collected sludge from the bottom of the digester;
- **Post Treatment and storage pond** Overflow effluent of the hybrid digester and effluent from the sand bed filter will be further treated in the existing open pond system.
- **Biogas Filter** Retained gas will be firstly channeled through a biogas filter in order to remove hydrogen sulphide (H_2S).

The capacity of the biogas system at UPOIC, Krabi province is 12,000 m^3, including the two 6,000 m^3 reactors. This system can support 550 m^3 of wastewater per day (estimated wastewater of the project is 345 m/day) and it can yield 13,750 m^3 of biogas (estimated produced biogas of the project is 8,741 m^3/day). The effluent after post treatment is applied as fertilization for palm fields according to the zero discharge policy. The sludge from the anaerobic reactors, collected at the sand bed filter, is applied to the palm plantation beside the pond system. As soon as the sludge is entering the sand bed filter it is coming into aerobic conditions in which any methane production will stop, thus the sludge emissions can be neglected (see also Section B.6.1 ***Explanation of methodological choices,*** Project Activity Emissions, p 25). The flow diagram in **Figure 3** summarizes the described process.

The captured biogas is pumped through a pipeline delivery system to 2 sets of generator of 952 kW each. The electricity generated by the gas engines replaces the power purchased from the grid and sell the surplus electricity to the grid. The generator manufactured by Guascor (Spain), model GUASCOR SFGLD 560, is applied for this project. The maximum biogas consumption rate of the generator is 400 m^3 biogas/hour. The technical data of the electricity generator is shown in **Table 2**.

In case there is any excess biogas left from the generator, it is flared by the 500 m^3/hr-enclosed flare manufactured by BKE, local manufacturer, installed at site. The flare is designed for 0.7 second (700 ms) retention time at temperature 1,000℃ (lower temperature has more retention time) whereas the methane ignition delay time is less than 50 ms. It is certified[4] that the methane destruction efficiency is higher than 90% as long as the biogas burning rate is not more than 500 m^3/hr and the flue gas temperature inside the enclosed is above 700 ºC or more than 100℃ above the biogas auto ignition temperature. The expected technology lifetime is approximately 20 years.

[4] The certify document from technology provider, BKE Combustion Control Co., Ltd, issued on May 12, 2009.



Existing Open Pond Wastewater Treatment System

Biogas Master Plan

Figure 2: Existing open pond wastewater treatment system and biogas system master plan

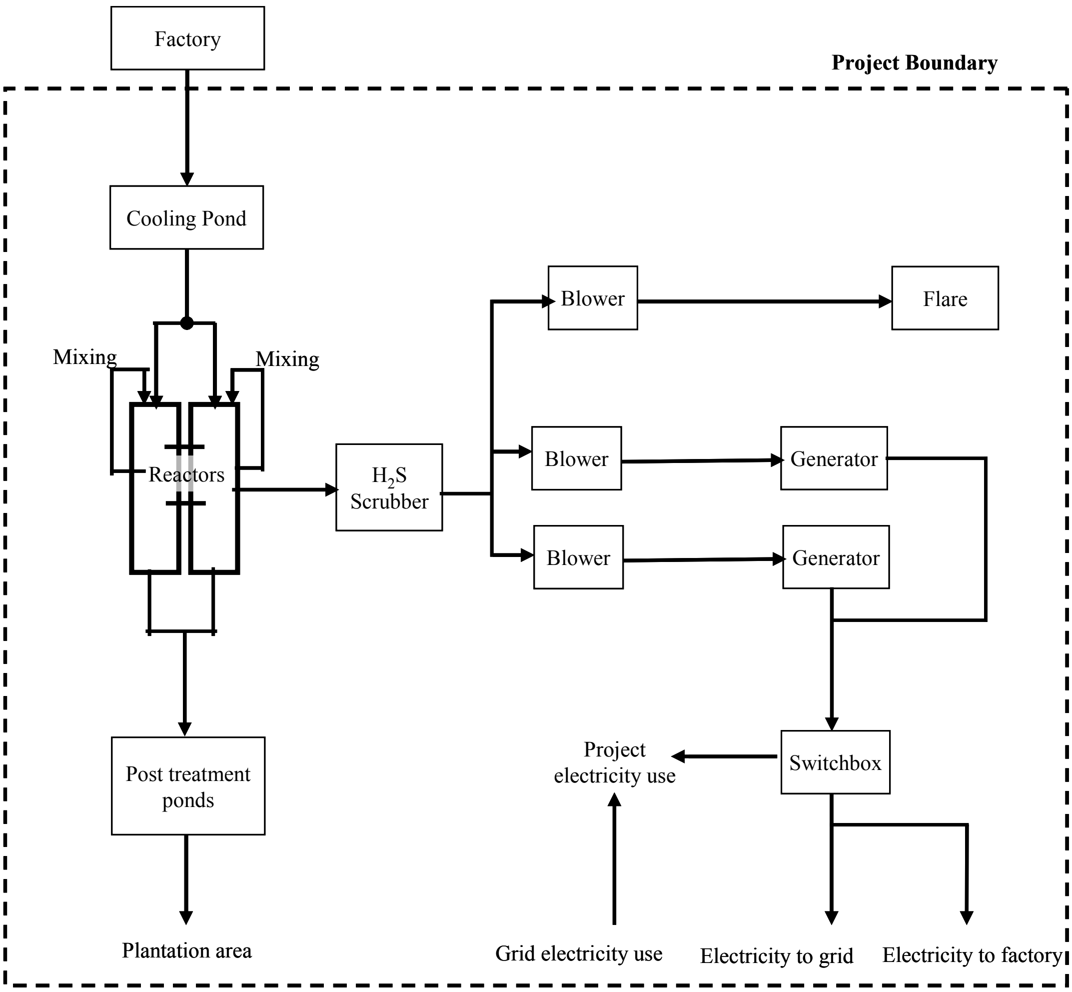


Figure 3: Flow diagram of UPOIC's wastewater treatment process and biogas system

Table 2: Electricity generator specification applied in the proposed project activity

Manufacturer	Guascor
Engine type	SFGLD560
Cycle	4 strokes
Cylinder number	16
Disposition	“V” form 60”
Aspiration	Turbocharged-after-cooled
Rotation (from flywheel end)	Counter clockwise
Bore	160 mm
Stroke	175 mm
Displacement	56,30 Liters
Speed	1,500 r.p.m
Compression ratio	11,7 to 1
Mechanical power 24h/24 (continuous duty) ISO3046/1	kwb
Electrical power 24/24 (continuous duty) @cosφ=1	952 kWe
Total available power deducting the parasitic loses	938 kWe
Maximum intake back pressure	450 mm we
Expected Technology Lifetime	>15 years

Technology Transfer
Biogas system is developed by the Energy Research and Development Institute of Chiang Mai University. The biogas gensets is provided by a European equipment supplier (Gauscor) and the flaring equipments are designed and manufactured by the technology provider of the host country (BKE Combustion Controls Co., Ltd.). One year follow-up and training is fixed in the contract with Chiang Mai University to support the factory. The work instruction has been set up and the respective documentation is included in existing ISO 9001:2000/ISO 14001:2004 system. Technical training for genset operation is also contracted. Maintenance of all equipment is performed inline with the supplier specifications.

Environmentally Safe and Sound Technology
The technology is expected to be environmentally safe. The project got approved by Thai DNA on Sustainable Development, which is a criteria checking on environmental, social, and economic impacts. The parameters that are controlled to ensure the systems proper operation, for example, are pH, volatile fatty acids and alkalinity. Analysis is conducted by the factory laboratory and external accredited laboratory.

A.4. Parties and project participants

Party involved (host) indicates host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Thailand (host)	United Palm Oil Industry PCL. (private entity)	No
Switzerland	Swiss Carbon Asset Ltd. (private entity)	No

A.5. Public funding of project activity

No loans from international financial institutions (IFIs) are included. The financing has been realized by United Palm Oil Public Public Company Limited with own capital, as well as the sale of generated CERs to private investors and funding from the Ministry of Energy through their Biogas technology promotion scheme. An official letter from the Energy Policy and Planning Office is included in the Appendix 2 confirming that no ODA funding is involved in the program.

A.6. Debundling for project activity

As defined in paragraph 2 of Appendix C of the SSC M&P, a proposed small-scale project activity shall be deemed to be a debundled component of a large project activity if there is a registered small-scale CDM project activity or a request for registration by another small-scale project activity:

- By the same project participants;
- In the same project category and technology/measure; and
- Registered within the previous 2 years; and
- Project boundary is within 1 km of the project boundary of the proposed small-scale activity at the closest point. The proposed project activity is not a debundled component of any larger project activity as there is no other small-scale project activity that fulfills the above-mentioned criteria.

SECTION B. Application of selected approved baseline and monitoring methodology and standardized baseline

B.1. Reference of methodology and standardized baseline

The approved methodology, AMS III.H. "***Methane Recovery in Wastewater Treatment***", Version 15 (EB55, 2010), valid from 10/08/2010 is applied. This methodology is based on the baseline approach from paragraph 48 of the CDM modalities and procedures "*Existing actual or historical emissions as applicable*".

Due to incomplete flaring in line with methodology AMS III.H, the *"Tool to determine project emissions from flaring gases containing Methane"* Version 01 (EB28, Annex 13) is applied in order to calculate project emissions.

Due to the project will utilize the captured biogas for electricity generation purpose thus, AMS I D. *"Grid connected renewable electricity generation"*, Version 16 (EB54, 2010) as valid from 11/06/2010 is applied to the electricity generation component of the project.

To apply AMS I.D., the "*Tool to calculate the emission factor for an electricity system*" Version 02.1.0 (EB60, Annex 8) is required to complete the calculation of emission from electricity generation.

B.2. Project activity eligibility

1. The project activity involves the introduction of treatment in an anaerobic reactor with biogas recovery as a sequential treatment step for the wastewater that is presently being treated in an anaerobic lagoon without methane recovery. And the captured methane will be used as fuel source for electricity generation feeding to the grid. The project activity falls into the AMS III.H and AMS

I.D. To justify the choice of project category, the section 'technology/measure' of AMS III.H is considered as described;

a) Substitution of aerobic wastewater or sludge treatment systems with anaerobic systems with biogas recovery and combustion; ***N/A***
b) *(*Introduction of anaerobic sludge treatment system with biogas recovery and combustion to a wastewater treatment plant without sludge treatment; ***N/A***
c) Introduction of biogas recovery and combustion to a sludge treatment system; ***N/A***
d) Introduction of biogas recovery and combustion to an anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an on site industrial plant; ***YES*** *(introduction of biogas recovery and combustion to an anaerobic open lagoon system)*
e) Introduction of anaerobic wastewater treatment with biogas recovery and combustion, with or without anaerobic sludge treatment, to an untreated wastewater stream; ***N/A***
f) Introduction of a sequential stage of wastewater treatment with biogas recovery and combustion, with or without sludge treatment, to a wastewater treatment system without biogas recovery (e.g. introduction of treatment in an anaerobic reactor with biogas recovery as a sequential treatment step for the wastewater that is presently being treated in an anaerobic lagoon without biogas recovery). ***N/A***)

2. In cases where baseline system is anaerobic lagoon the methodology is applicable if:
   a) The lagoons are ponds with a depth greater than two meters, without aeration. The value for depth is obtained from engineering design documents, or through direct measurement, or by dividing the surface area by the total volume. If the lagoon filling level varies seasonally, the average of the highest and lowest levels may be taken ***YES*** ;
   b) Ambient temperature above 15°C, at least during part of the year, on a monthly average basis ***YES***;
   c) The minimum interval between two consecutive sludge removal events shall be 30 days ***YES .***

3. The recovered biogas from the above measures is utilized for the following applications instead of combustion/flaring;

   a) Thermal or electrical energy generation directly; *Yes, biogas is used for electricity generation for self-utilized and grid feed. The flaring is foreseen for emergency cases only.*
   b) Thermal or electrical energy generation after bottling of upgraded biogas; *N/A*
   c) Thermal or electrical energy generation after upgrading and distribution: *N/A*
      i. Upgrading and injection of biogas into a natural gas distribution grid with no significant transmission constraints;
      ii. Upgrading and transportation of biogas via a dedicated piped network to a group of end users;
   d) Hydrogen production. N/A

In conclusion, the project falls into measures 1 (d) and 2 (a) to 2(c) and 3(a). The applicability conditions of AMS III.H compared to the project activity is shown in Table 3.1 to 3.2

Table 3.1: The applicability conditions of AMS.III.H version 15 compared to the project activity

No.	Applicability Criteria	Project Conditions
1	As the project activities are covered under paragraph 3(a), that component of the project activities can use a corresponding methodology under type I.	The project generates electricity then, AMS I.D is applied. The project is not a cogeneration system and the installed capacity is below 15 MW thresholds (total maximum generator capacity is 952 kWe x 2 sets = approx. 2MW).
2	New facilities (Greenfield projects) and project activities involving a change of equipment resulting in a capacity addition of the wastewater or sludge treatment system	• The project activity takes place at an existing wastewater treatment system. An additional sequential wastewater stage is included. The

	compared to the designed capacity of the baseline treatment system are only eligible to apply this methodology if they comply with the requirements in the General Guidance for SSC methodologies3 concerning these topics. In addition the requirements for demonstration of the remaining lifetime of the equipment replaced as described in the general guidance shall be followed.	existing wastewater pond treatment system was designed for a capacity of 75 ton FFB/hour in 2004 and the wastewater flow rate of 1,000 m3/day. • Historical FFB processing rates show that this capacity was not achieved within the last 5 years up to March 2009. • The new system has a design capacity of 350 m^3/day according to the historical wastewater and thus it can be concluded that the project activity is not resulting in a capacity addition.
3	Measurement is limit to those that result in aggregated emission reductions of less than or equal to 60 kt CO_2 equivalent annually form all type III components of the project activity.	The project has CO2 emission reduction about 18,002 tonnes per year.
4	In cases where baseline system is anaerobic lagoon the methodology is applicable if: a) The lagoons are ponds deeper than 2 meters, without aeration. The value for depth is obtained from engineering design documents, or through direct measurement, or by dividing the surface area by the total volume. If the lagoon filling level varies seasonally, the average of the highest and lowest levels may be taken. b) The ambient temperature is above 15℃, at least during part of the year, on a monthly average basis, c) The minimum interval between two consecutive sludge removal events shall be 30 days	UPOIC wastewater treatment system consists of series of open lagoons which are anaerobic ponds, facultative ponds and polishing pond. (see detail in **Figures 4 and 5**). The existing pond system are identified as followed; a) Anaerobic pond consists of pond named 'anaerobic ponds no 1-4' and 'facultative ponds no. 1-2'. According to engineering design the depth is 5 meters. b) The monthly average temperature over the year of Krabi Province is above 15℃ (base on the temperature record at Trang Meteorological Department years 1999- 2003 which is the closest station to project site). c) The interval between two consecutive sludge removal events is about 2-3 years

Table 3.2: The applicability conditions of AMS I.D compared to the project activity

No.	Applicability Criteria	Project Conditions
1	This category comprises renewable energy generation units, such as photovoltaic, hydro, tidal/wave, wind, geothermal and renewable that supply electricity to a national or a regional grid.	The project uses biogas recovered from the wastewater treatment system to generate electricity and export to the national grid.
2	This methodology is applicable to project activities that (a) Install a new power plant at a site where there was no renewable energy power plant operating prior to the implementation of the project activity (Greenfield plant);	The project involves the installation of new gas engines at site where there was no renewable energy power plant operating prior to the implementation of the project activity.

	(b) Involve a capacity addition1; (c) Involve a retrofit of (an) existing plant(s); or (d) Involve a replacement of (an) existing plant(s).	
3	If the new unit has both renewable and non-renewable components (e.g.,. a wind/diesel unit), the eligibility limit of 15 MW for a small scale CDM project activity applies only to the renewable component. If the unit added co fires fossil fuel, the capacity of the entire unit shall not exceed the limit of 15 MW.	Two gas engines with a capacity of 952 kW each have been installed by the project activity. The project is within the 15 MW thresholds.

B.3. Project boundary

From the paragraph 13 of AMS III.H "The project boundary is the physical, geographical site where the wastewater and sludge treatment takes place in baseline and project situation. It covers all facilities affected by the project activity including sites where the processing, transportation and application or disposal of waste products as well as biogas takes place." Thus, the project boundary covers the wastewater treatment facilities (cooling ponds, reactors, post-treatment ponds and storage pond) as well as the facilities for the combustion of the biogas and electricity generation as indicated in, Figure 3 in section A.3. Figure 4 represents the boundaries of baseline and proposed project activities;

- Baseline area and activity: covers the existing open pond system from the first storage pond to the last aerated lagoon, the electricity consumption of equipment of the pond system and the grass area where the treated wastewater is applicable for agricultural purpose.
- Project area and activity: covers the project digester facilities, post treatment pond system which is adjusted from the existing pond system, electricity consumption of the new system, combustion of biogas, electricity generation and the factory's grass area where the treated wastewater and small amounts of sludge are applied. No transport would be required in the project scenario.

Since the series of existing open ponds were changed in function after project development thus, these ponds have been considered as 'affected' from the CDM project (see Figure 5). The electricity generated from biogas is firstly supplied to the palm oil factory to meet the in-house demand and the surplus electricity is fed to the national grid system. Regarding electricity generation, the newly installed electricity generation equipment and the combustion components is included in the project but the palm oil plant is considered as 'not affected' since its process is not changed due to the project activities whether the source of electricity used is supplied from national grid or project electricity generation system.

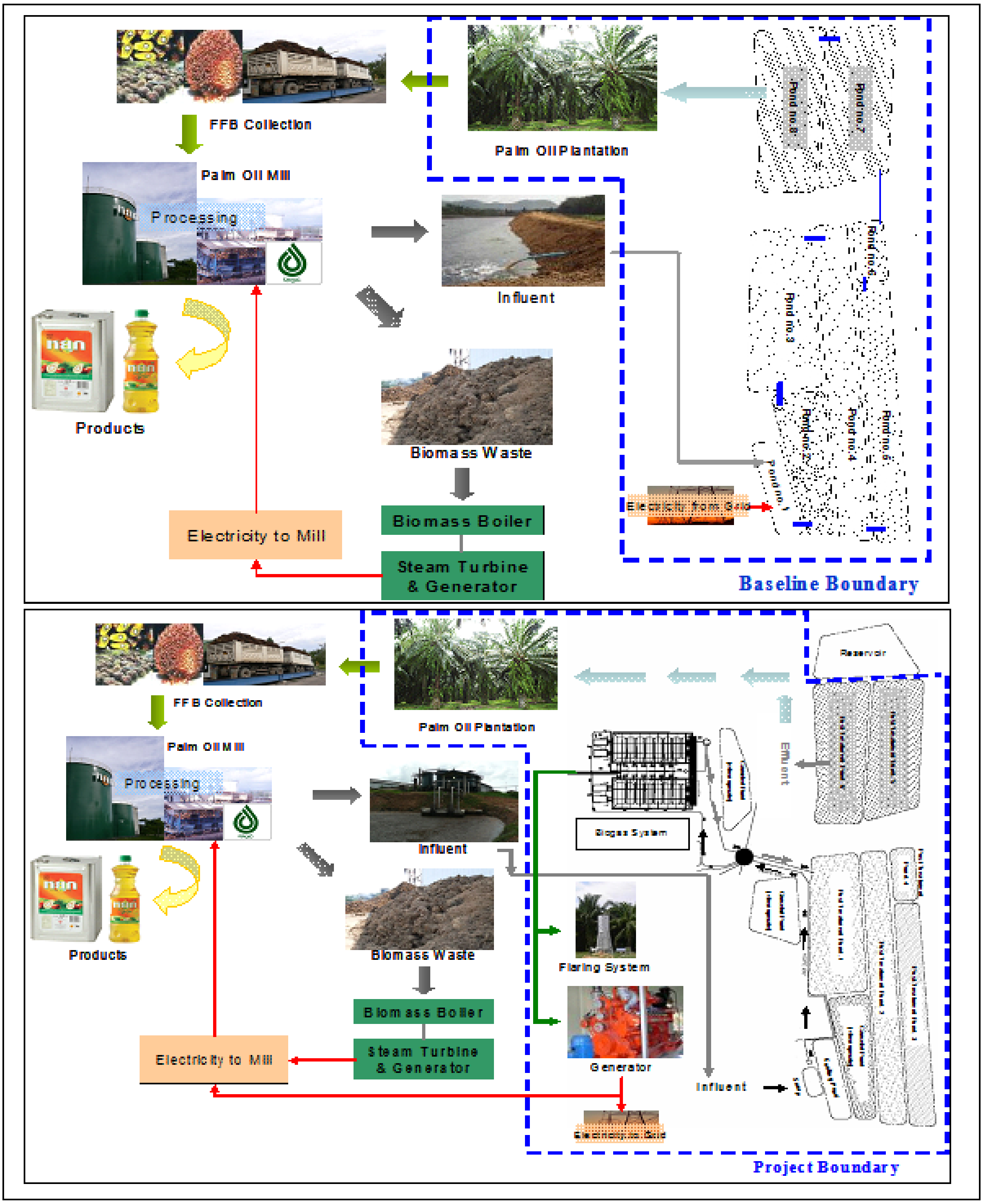
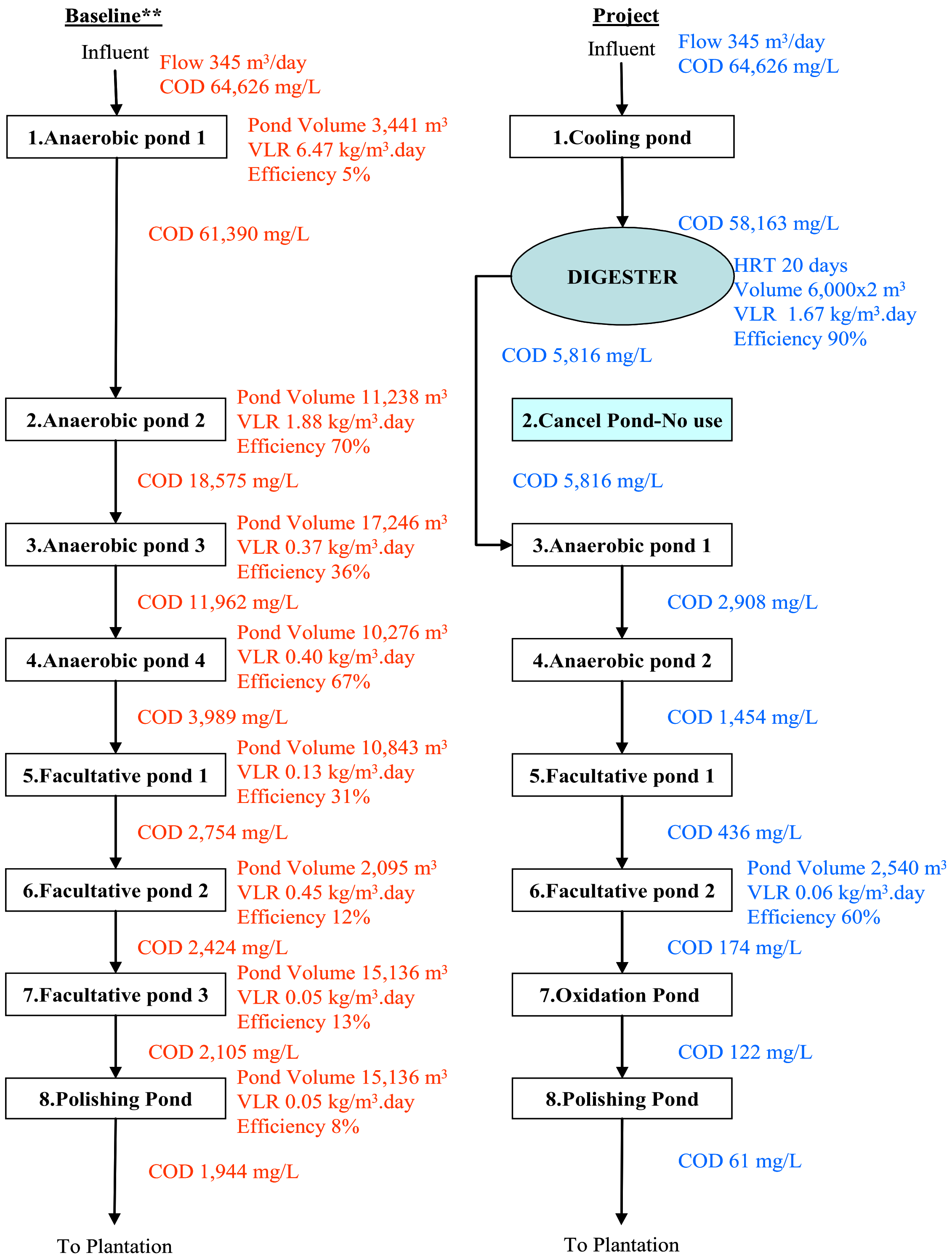


Figure 4: Baseline and project boundary of UPOIC Wastewater Treatment for Energy Generation, Krabi



Note: ** Baseline wastewater data obtained from 10 days measurement of the existing open pond system

Figure 5: Changing in function of baseline wastewater treatment system due to the project development

B.4. Establishment and description of baseline scenario

The POME was discharged to the open ponds system located in the factory area without discharging to the public water body. Anyway, the wastewater was treated to meet the national standard in order to reduce the effect of odour on nearby community and for using in the project grass area. The Factory Act B.E.2535 states that the factory, which the wastewater is discharged to public water body, must treat their wastewater to meet the standard before discharge out. Since UPOIC palm oil mill does not discharge wastewater to public water body thus, the factory is not against any law/regulation. The small-scale methodology assumes the continuation of current practice to be the most likely baseline scenario. Since it has been verified that there are no legal or regulatory restrictions to the continuation of current practice and thus it is considered as being complete.

As project activities involve two components, wastewater treatment and electricity generation, the data used for the two components of the project are summarized as followed;

<u>Recovery of methane in wastewater treatment</u>
The baseline scenario in the absence of the project activity at UPOIC Palm Oil Mill is the continuation of the existing anaerobic wastewater treatment system for the palm oil mill effluent (POME) without methane recovery and combustion. The existing POME treatment system was based on the common open lagoon treatment method widely adopted by the palm oil industry in Thailand. Parameters used for baseline calculation taken from the pond design and historical data records such as production capacity of the factory (to calculate wastewater quantity), pond electricity consumption, etc. The COD is determined by 10 days continuous baseline measurement during June-July 2009 in ambient conditions of the site. Average values from the measurement campaign are used and multiplied by 0.89 to account for the uncertainty of the data. These data are used to calculate baseline emission on account of power used, and methane released from the existing system. The treatment system includes 8 deep open lagoons with the different purposes as shown in Figure 5 but according to the 10 days measurement, it was found that the functions of ponds are different from the original design. The system consists of 6 anaerobic ponds and 2 aerobic poor managed ponds (as describe in Table 3.1). Sludge removed is applied on soil in the plantation as fertilizer supplement. No baseline emissions are expected from this source since the sludge normally would have been applied in a thin layer.

<u>Electricity Generation</u>
The biomass power plant and grid system provide electricity for the factory; to supply the mill, the office building and the open pond system. During the palm oil mill operation period, UPOIC utilizes the by- product (empty fruit bunch-EFB, fibers and shells) from the production process as raw material to generate steam for the palm oil mill. This steam is supplied to the steam turbine to obtain optimum pressure for the palm oil production process and as the steam has enough high pressure to generate electricity, the steam pressure runs the turbine to supply to the factory with electricity. Consequently, when the palm oil mill is not in operation, there is no electricity generation from the process as well. Hence, no electricity was available to supply the office building and open pond system and UPOIC has to import electricity from the grid to support these demands by that time. The proposed project utilizes the captured biogas as electricity, which is the office building during non-operation of the palm oil mill instead of grid electricity. The amount of electricity generated by the biomass power plant will not be affected by the electricity generated by the biogas plant since it depends on the palm oil production rate only and the electricity from biogas will be fed to the office during non-operation period as the details below:

		Source of Electricity		
		Grid	Biomass	Biogas
Baseline				
Mill operation	Factory	-	✓	-
	Office & Open pond	-	✓	-
Non-operation	Factory	-	-	-
	Office & Open pond	✓	-	-
Project				
Mill operation	Factory	-	✓	-
	Office	-	✓	-
Non-operation	Factory	-	-	-
	Office	-	-	✓

The relevant baseline information and specific data used to determine the baseline emissions are shown in section B.6.1.

B.5. Demonstration of additionality

The following description is to demonstrated project additionality by applying the (c) Investment Barrier: a financially more viable alternative to the project activity would have led to higher emissions of the "Attachment A to Appendix B of the simplified modalities and procedures for small-scale CDM project activities" that the proposed project activity would not have happened in the absence of the CDM and thus effectively reduces anthropogenic emissions of greenhouse gases.

UPOIC has considered applying CDM with the intended biogas project and called technology providers for proposals. In their request for proposals to the engineering companies UPOIC asked for consideration of estimated CDM revenues. After evaluation of the proposals UPOIC recognized the financial benefit and requested a proposal from ENVIMA (Thailand) Co., Ltd. for CDM consulting services. This is clearly showed that UPOIC would not have implemented the biogas project without CDM. Implementation of the project activity requires significant higher investment, operation, and maintenance cost in comparison to the absence of the CDM project activity and further operating the existing open lagoons. Consequently the CDM project activity appears uneconomic besides the environmental improvements. The existing anaerobic open pond system is in compliance with applicable legislation and regulations. This system is a common practice in Thailand palm oil industry[5], needs no investment and requires low maintenance costs. Thus there is no driving force to change from the existing open pond system to the more expensive project activity.

With the benefit of CDM revenue, the project activity could become economic viable. The details will be described under "investment analysis".

<u>Investment Analysis</u>
The project activity without CDM is not financially attractive. The purpose of undertaking an investment analysis is to determine whether or not the project activity would be financially viable without the incentive of the CDM. A financial analysis is based on the project Internal Rate of Return (IRR) calculation follow option III "Benchmark analysis" of the "Tool for the demonstration and assessment of additionality", version 05.2 (EB39). The identified IRR benchmark without taking into account the associate risk (due to new technology applied) at the time of BoD decision is the 15% IRR benchmark[6] of the Independent Power Producer (IPP), which is a private entity

[5] The study from ERDI for biogas potential in different industries, www.thaibiogas.com
[6] http://www.ays.co.th/Uploadeds/Research/eng/Energy_071119_U.pdf

who owns facilities to generate electric power for sale to the grid system the same as LS , from "IPP Bidding" by Ayudhya Securities Public company limited. This 15% benchmark is also supported by the Palm Oil Crushing Mill Association, which recommends that the IRR for biogas investments should not be lower than 15%. As reference a more conservative approach the default value from EB 62 Annex 5 'Guidelines on the Assessment of Investment Analysis' (Version 05) has been taken into account. The appendix of Annex 5 includes a table, providing default values for the approximate expected return on equity for different project types and host countries. For Thailand under Group1 the benchmark of 11.2% has been calculated. This value, without adding an inflation rate, is additional considered as reference in the Investment Analysis.

The input data, used in the financial analysis are summarized in Table 4. The financial calculation below considers the investment and O&M costs from the Biotech Thai proposal, available at the time of the investment decision (called: financial feasibility BoD decision). The design in this proposal is based on the yearly capacity of 200,000 t FFB per year and the 'worst case' output of 1m3 wastewater per t FBB with a COD of 70,000 mg/l. In this 'financial feasibility BoD calculation' the produced electricity is calculated with 5,547,790 kWh/year. Later a second financial calculation (called financial feasibility update) was accomplished, considering the results of the '10 days campaign' and the actual investment costs. This 'financial feasibility update calculation' takes account of the yearly capacity of 175,200 t FBB (3 years average production rate 2006-2008) and the COD and wastewater generation rate measured in the 10 days campaign, resulting in 5,768,963 kWh electricity per year. The values in this second financial calculation comply to the emission reduction calculation and are mentioned throughout the PDD.

Table 4: The project data input for the financial analysis at the time of the investment decision

Investment		Source of data
- Construction cost	60,000,000 THB	Biotech Thai Proposal
- Equipment	20,000,000 THB	Biotech Thai Proposal
- Contingency (5%)	4,000,000 THB	Biotech Thai Proposal
Income		
Electricity selling tariff	2.1216 THB/KWh, with annual increase 3%	Calculated mixed electricity tariff rate, based on peak and off peak time PEA, no adder (details see 'financial feasibility BoD decision)
Adder 0.3 THB/Unit for 7 years	1,562,676 THB	EPPO agreement 02.02.2007.
Electricity supplied to the grid	5,208,919 kWh/yr= 11,051,056 THB	Electricity Production Rate, Biotech Thai Corporation proposal and Tariff Rate Electricity Authority Thailand – calculated mixed rate.
Savings on account of avoiding import of grid electricity (2.3876 THB/Unit)	432,855 kWh/yr= 1,033,485 THB	PEA rate 1.7034 THB for companies buying electricity + Ft value of 0.6842 THB (details see 'financial feasibility BoD decision') & Electricity Consump. Baseline
Average Annual Expenditure		
Chemical cost	500,000 THB	Biotech Thai Proposal
Cost of electricity for biogas system	300,000 THB	Biotech Thai Proposal
Maintenance cost of biogas system	1,800,000 THB	Biotech Thai Proposal
Maintenance cost of gas engine	2,633,040 THB	Biotech Thai Proposal

system		
Employee cost for engineering system	310,250 THB	Biotech Thai Proposal
Inflation rate	5.9%	Biotech Thai Proposal
Increasing rate of labour cost	2.8%	Biotech Thai Proposal
Increasing rate of energy cost	3.0%	Biotech Thai Proposal

The results of the financial feasibility study of the project activity show that without CDM, the project IRR is 5.85%. The sensitivity analysis illustrates that the project IRR decreases to 2.75%, when the income is 10% less than calculated and increases up to 8.47%, if the income raises up to 10%. Variations on operation & maintenance costs ± 10% cause IRR deviations between 4.1 and 7.39%. When decreasing or increasing the project costs by 10%, the IRR value fluctuates between 4.62 and 7.30% (Table 6). Since all values are far below the benchmark of 15%, as well as below the conservative default value of 11.2%, the project is considered as non attractive, further considering that wastewater activities are not the core competence of the project owner. Due to high investment and risks of system failure, UPOIC has been skeptical to invest in such a new and untraditional approach and would have continued the treatment with the existing open pond system without CDM. The financial feasibility study considers the investment of the biodigester system, the power generator, construction and instruments as an initial investment cost, the maintenance and operation costs of the system as expenditure and the revenue from electricity selling as well as the savings from avoiding grid electricity import as income. The variations for the factors project costs, O&M costs, and income in which the project IRR would approach the benchmark of 15% are demonstrated in Table 7. The variation level of the different factors, necessary for the project IRR to be equal to the benchmark, is high and unlikely to occur. With CDM the project IRR would increase to 20%, and is considered as financial viable.

Table 5: Sensitivity analysis of the project IRR

Factor	Variation (IRR) %		
	10	0	-10
Project cost	7.30%	5.85%	4.62%
O&M cost	7.39%	5.85%	4.10%
Income	2.75%	5.85%	8.47%

Table 6: Assumption in which the Project IRR will be in range of the benchmark IRR

Factor	Variation %	IRR (%)
Project cost	-43.40%	15%
O&M cost	-75.10%	15%
Income	40.70%	15%

Referring to the Guidelines on the demonstration and assessment of prior consideration of the CDM version 03, EB 49, Annex 22, the project is considered as ‘Existing project activity as its start date is prior to 2.August 2008, prior to the date of publication of the PDD for the global stakeholder consultation. Therefore it is necessary to demonstrate that CDM was seriously considered in the decision to implement the project activity. Thus demonstrating awareness and consideration of CDM prior to the project activity start date and indicating that CDM benefits have been a decisive factor in the decision to proceed with the project. The descriptions No. 1–5 in Table 7 demonstrate that UPOIC considered CDM since 2006 by visiting a palm oil mill which started implementing a biodigester and applied for CDM, by requesting proposals from different technology providers including CDM revenues in their financial calculation and by requesting a proposal from a CDM consulting company to receive an overview of cost and revenue of their intended planning All this has been done before the Board of Directors decided to implement the project under CDM and before the starting date of the project activity (year 2008). The Minutes of Meeting of the Board of Directors reflects that CDM revenue has been considered as a major decisive factor for the approval of the project. Since then UPOIC implemented the technical project in parallel with the CDM development as shown in the timeline in Table 7.

Table 7: UPOIC Project Timeline

No.	Company	Description	Date	Remark
1	UPOIC	UPOIC visited other biogas plant	20/06/2006	UPOIC visited the other biogas plant to collect more information about biogas system.
2	Smart Energy - UPOIC	Smart Energy Co., Ltd proved biogas proposal to UPOIC	23/02/2007	Proposals contain CDM revenue calculations in the financial part based on estimated methane capture potential.
3	Biotech Thai Corporation-UPOIC	Biotech Thai Corporation provided biogas proposal to UPOIC	11/06/2007	Proposals contain CDM revenue calculations in the financial part based on estimated methane capture potential.
4	Papop - UPOIC	Papop provide biogas proposal to UPOIC	27/07/2007	Proposals contain CDM revenue calculations in the financial part based on estimated methane capture potential.
5	Envima - UPOIC	Proposal Envima	03/08/2007	Proposal for consulting services for CDM application
6	UPOIC	Board approval	10/08/2007	Board approve budget for biogas and CDM consultant
7	EPPO	ENCON fund	19/11/2007	EPPO announce fund
8	UPOIC	ENCON fund	26/12/2007	UPOIC applied for the ENCON fund
9	UPOIC-TGO	Submit LOI to TGO to introduce the project	26/02/2008	
10	Envima-UPOIC	UPOIC approved first payment to Envima	28/02/2008	UPOIC approved first payment to Envima confirm that Envima is contracted for CDM advisory service. During that time the contract preparation was started by LS and finished in July, 2008
11	UPOIC-TÜV SÜD	Validation contact	05/03/2008	UPOIC contacted TÜV SÜD for proposal to be the validation DOE.
12	UPOIC-Contractor "Know-How Transfer Co., Ltd."	UPOIC signed contract with contractor for construction on 10.03 and started construction on 11.03.	10/03/2008	The agreement was signed on 10.03.the purchase order from UPOIC was issued on 13/03/2008, the construction on site started on 11.03.2008
13	UPOIC-ERDI	UPOIC signed contract with ERDI for Biogas system design and construction	01/04/2008	ERDI started biogas system design.
14	UPOIC-Envima-ERDI	The first stakeholder consultation and construction	26/05/2008	The first stakeholder consultation was conducted without any objection of the stakeholder. Thus since this date ERDI finalized digester design and start construction of the biogas system. (it was considered as start of project construction at site)
15	UPOIC-Envima- ERDI	The second stakeholder consultation meeting	09/07/2008	After public documents, UPOIC arrange the meeting again and invited more stakeholder to participate.

No.	Company	Description	Date	Remark
16	UPOIC-EPPO	Date of receiving ENCON Fund	30/05/2008	-
17	UPOIC - Tricorona	Date of signing EPRA	29/09/2008	ERPA is under re-negotiation since June 2010. Buyer might be changed
18	Envima	Uploaded GS documents to GS website	03/03/2009	Due to the change of the Gold Standard (GS) requirements from version 1 to 2. Envima prepared GS passport and GS stakeholder consultation report which was uploaded under Tricorona's registry account at the beginning of year 2009.
19	UPOIC-TÜV SÜD - Envima	Validation	20-24/04/2009	1 day site visit, 1 day document review
20	UPOIC	The third stakeholder meeting	22/04/2009	As per local stakeholder consultation report
21	UPOIC-PEA	Start selling electricity	24/10/2009	As per commissioning test report

B.6. Emission reductions

B.6.1. Explanation of methodological choices

The baseline scenario for wastewater treatment corresponds with the scenario given in paragraph 1 (d) of AMS-III.H, "introduction of biogas recovery and combustion to an anaerobic lagoon system". The emission reduction due to the wastewater treatment (ERy) is calculated as the difference between the baseline emissions from wastewater (BEy) and sum of the project emission activity (PEy) and leakage (LEy).

Baseline emissions

As per paragraph 16 of AMS III.H, baseline emissions for the systems affected by the project activity may consist of:

$$BE_{y,ex\ ante} = BE_{power,\ y} + BE_{ww,treatement,y} + BE_{s,discharge,y} + BE_{s,\ final,y} \qquad \text{Eq (1.)}$$

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

(i) is considered since the existing treatment pond system consumes electricity for feed-in & out pumps and aerator. (ii) is considered since the existing ponds system is the series of open lagoons consisting of anaerobic, facultative and aerated conditions. (iii) is not considered as there is no sludge treatment system in the baseline and the sludge normally would have been applied in thin layer to land for agricultural purpose. (iv) is considered on account of inefficiencies of the treatment system and (v) is not considered because, as per AMS III.H, if the sludge is controlled combusted, disposed in a landfill with biogas recovery, or used for soil application in the baseline scenario, this term shall be neglected.

The baseline is therefore calculated as follows:

$BE_{y,ex\ ante} = BE_{power,\ y} + BE_{ww,treatement,y} + BE_{s,discharge,y}$

Project activity emissions

As per paragraph 26 of AMS III.H, project activity emissions from the systems affected by the project activity may consist of:

$PE_{y,ex\ ante} = PE_{power,\ y} + PE_{ww,treatement,y} + PE_{s,treatement,y} + PE_{s,discharge,y} + PE_{s,\ final,y} + PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y}$ Eq (2.)

I. CO_2 emissions on account of power and fuel used by the project activity facilities ($PE_{power,y}$);
II. Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{ww,treatment,y}$);
III. Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{s,treatment,y}$);
IV. Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater ($PE_{ww,discharge,y}$);
V. Methane emissions from the decay of the final sludge generated by the project activity treatment systems ($PE_{s,final,y}$);
VI. Methane fugitive emissions on account of inefficiencies in capture systems ($PE_{fugitive,y}$);
VII. Methane emissions due to incomplete flaring ($PE_{flaring,y}$);
VIII. Methane emissions from biomass stored under anaerobic conditions which would not have occurred in the baseline situation ($PE_{biomass,y}$)

As for (i), CO2 emissions on account of power and fuel used by the project activity facilities, the project will not consume fossil fuels, therefore only the electricity component is taken into account. However, as all electricity used by the project is expected to be provided by the on-site power generation with biogas, no emissions from project electricity consumption are calculated for the ex-ante estimations. Potential grid electricity use due to generator downtime will be monitored and associated emissions accounted for during the project's crediting period. (ii) is considered even there is no anaerobic treatment condition that affected by the project activity and not equipped with biogas recovery but there are the series of ponds defined as 'aerobic poor manage' which has a potential to emit methane to the atmosphere. (iii) is not considered as no sludge treatment takes place. (iv) is considered since the discharged wastewater still contains organic matters that would be degraded after treated by the digester. (v) is not considered because as per AMS III.H, if the sludge is controlled combusted, disposed in a landfill with biogas recovery, or used for soil application in aerobic conditions in the project activity, this term shall be neglected, and the sludge treatment and/or use and/or final disposal shall be monitored during the crediting period. (vi) is considered as the biogas capture system might be inefficiency. (vii) is considered since the access biogas will be flared and (viii) is not considered as no biomass is stored under anaerobic conditions which would not have occurred in the baseline situation.

Therefore, project activity emissions are calculated as follows:

$PE_{y,ex\ ante} = PE_{power,\ y} + PE_{ww,treatement,y} + PE_{s,discharge,y} + PE_{s,\ final,y} + PE_{fugitive,y} + PE_{flaring,y}$

Leakage emissions

As the project activity does not involve the transfer of used technology to another activity, there are no leakage effects ($LE_{y,ex\ ante} = 0$).

Emission reductions

According to AMS III.H paragraph 29, for all scenarios in paragraph 1, emission reductions shall be estimated ex-ante as follows:

$ER_{y,ex\ ante} = BE_{y,ex\ ante} – (PE_{y,ex\ ante} + LE_{y,ex\ ante})$ Eq (3.)

As per the methodology for cases 1 (vi), ex post emission reductions shall be based on the lowest value of a) the amount of biogas recovered and flared during the crediting period, that is monitored ex post or b) ex post calculated baseline, project and leakage emissions as per formula:

$ER_{y,ex\ ante} =\min(BE_{y,ex\ ante} – (PE_{y,ex\ ante} + LE_{y,ex\ ante})),(MD_y – PE_{power,y} – PE_{biomass,y} – LE_{y,ex\ post}))$ Eq (4.)

MD_y = Methane captured and destroyed/gainfully used by the project activity in the year y (tCO2e). In case of flaring/fuelling it shall be measured using the conditions of the flaring process as follows;

$MD_y = BG_{burnt,y} \times W_{CH4,y} \times D_{CH4} \times FE \times GWP_{CH4}$ Eq (5.)

Parameters and input values for emission calculation detailed as follows:
Baseline emissions:
$BE_{y,ex\ ante} = BE_{power,\ y} + BE_{ww,treatement,y} + BE_{s,discharge,y}$
(i) Emissions from electricity or fossil fuel used (BEpower,y); determined as per the procedures described in AMS- I.D. This is consistent with paragraph 9 of AMS I.D., which stated that "the baseline emissions is the product of electrical energy baseline *EGBL*, *y* expressed in kWh of electricity produced by the renewable generating unit multiplied by an emission factor ... (a) A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the 'Tool to calculate the Emission Factor for an electricity system'. Since the project supplies the produced electricity to palm oil plant in case the existing biomass plant is not operated to substitute electricity imported from grid, thus the baseline is considered on the net electricity generation (total electricity generated minus self-consumption of biogas system). The details of project electricity consumption are as follows:

1) Total electricity generated from produced biogas = **approx. 5,769 MWh/y**
2) The amount of electricity used in biogas system (from the electricity required of the equipment) **= approx.646 MWh/y;**
3) The amount of electricity supplied to palm oil plant (estimated from 3-year historical data of electricity imported from grid to palm oil plant during non-plant operating) = **approx. 433 MWh/year;**
4) The amount of electricity fed to the national grid (determined from the total electricity generation minus self- consumption and electricity supplied to palm oil plant) = **4,690 MWh/yr.**

Thus, electricity substitutes grid is 5,123 MWh/y.

$\mathbf{BE_{power,y} = EG_{y,exported} \times EF_{y,grid}}$

Parameter	Description	Value	Source
$EG_{y,exported}$	Electricity supplied to the grid by the Project in year "y" (MWh)	5,123	Calculated
$EF_{y,grid}$	Emission factor for grid electricity for year *y* (tCO2/MWh)	0.52	Calculated as per 'tool' (details in Appendix 4)

(ii) Methane emissions from baseline wastewater treatment systems; the baseline wastewater treatment system consists of anaerobic ponds, facultative ponds and aerated lagoons thus, the MFC will be varied depends on the type of ponds. Data of flow rate is obtained from average of 10-day measurement multiply with 0.89 to account for the uncertainty range = 318 x 0.89 = **283 m^3/day**.

Data of days operating is obtained from 3-yr historical data of FFB in the production process multiply with wastewater generation rate during 10-day campaign = 175,200 ton FFB/yr x 0.59 m^3 of wastewater/ton FFB = 102,730 m^3 of wastewater/yr.

Data of COD inlet is obtained from average of 10-day measurement multiply with 0.89 to account for the uncertainty range, see Figure 5).

$BE_{ww, treatment,y} = Q_{ww,y} \times COD_{removed,y} \times MCF_{ww,treatment,BL} \times B_{o,ww} \times UF_{BL} \times GWP_{CH4}$	Eq (6.)

Parameter	Description	Value	Source
$Q_{ww,y}$	Volume of wastewater treated in year y (m^3)	102,730	UPOIC, Krabi
$COD_{removed,y}$	The chemical oxygen demand removed by the anaerobic wastewater treatment system in the baseline situation in tonnes/m^3	Anaerobic pond=0.055 Aerobic poor managed=0.004	UPOIC, Krabi
$MCF_{ww,treatment,BL}$	Methane correction factor for baseline wastewater treatment system	0.8 (anaerobic) 0.3(aerobic, poor managed)	As per AMS III.H. Table III.H.I.
$B_{o,ww}$	Methane producing capacity of the wastewater (kg CH4/kg COD)	0.25	As per AMS III.H.
UF_{BL}	Model correction factor to account for model uncertainties	0.89	As per AMS III.H.
GWP_{CH4}	Global warming potential for methane	21	As per AMS III.H.

(iv) Methane emissions on account of inefficiencies in the baseline wastewater treatment systems and presence of degradable organic carbon in the treated wastewater discharged into river/lake/sea;

$BE_{ww, discharge,y} = Q_{ww,y} \times GWP_{CH4} \times B_{o,ww} \times UF_{BL} \times COD_{ww,discharge,bL,y} \times MCF_{ww,BL,discharge}$ Eq (7.)

Parameter	Description	Value	Source
$Q_{ww,y}$	Volume of wastewater treated in year *y* (m^3)	102,730	UPOIC, Krabi
GWP_{CH4}	Global warming potential for methane	21	As per AMS III.H.
$B_{o,ww}$	See above	0.25	As per AMS III.H.
UF_{BL}	Model correction factor to account for model uncertainties	0.89	As per AMS III.H.
$COD_{ww,discharge,bL,y}$	The chemical oxygen demand of the treated waste water discharged into sea, river or lake in the baseline situation in tonnes/m^3	0.0017	UPOIC, Krabi See figure 5
$MCF_{ww,BL,discharge}$	Methane correction factor based on discharge pathway in the baseline situation	0.1	Value applied for wastewater discharged to sea, river or lake in AMS – III. H. Table III.H.I

Project emissions:

$PE_{y,ex\ ante} = PE_{power,\ y} + PE_{ww,treatement,y} + PE_{s,discharge,y} + PE_{s,\ final,y} + PE_{fugitive,y} + PE_{flaring,y}$

(i) CO_2 emissions on account of power used by the project activity facilities; the electricity that is consumed by biogas system is the electricity generated by the biogas plant itself thus, the emission is considered as zero. In case of generator downwind, electricity will be imported from grid and this amount will be calculated with grid emission factor as project emission during crediting period.

Parameter	Description	Value	Source
$EC_{project,y}$	Approx. amount of electricity consumed by the project activity facilities in year *y* (MWh)	646	Equipment specification
$EF_{y,consumed}$	Grid emission factor for year *y* (tCO2/MWh)	0	Electricity generated in biogas system will be supplied to its own equipment thus, there will be no electricity imported from the grid.

(ii) Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation;

$PE_{ww,\ treatment,y} = Q_{ww,y} \times COD_{removed,PJ,k} \times MCF_{ww,treatment,PJ} \times B_{o,ww} \times UF_{PJ} \times GWP_{CH4}$ Eq (8.)

Parameter	Description	Value	Source
$Q_{ww,y}$	Volume of wastewater treated in year *y* (m^3)	*102,730*	UPOIC, Krabi (design data)
$COD_{removed,PJ,k}$	The chemical oxygen demand removed by the anaerobic wastewater treatment system in the project activities in tonnes/m^3	*Anaerobic pond = 0.00436*	UPOIC, Krabi see Figure 5
		Aerobic poor managed - cooling pond =0.00646 - facultative pond=0.00139	
$MCF_{ww,treatment,PJ}$	Methane correction factor for project wastewater treatment system	*0.8 (anaerobic)*	As per AMS III.H. Table III.H.I.
		0.3(aerobic, poor managed)	
$B_{o,ww}$	Methane producing capacity of the wastewater (kg CH4/kg COD)	*0.25*	As per AMS-III.H.
UF_{PJ}	Model correction factor to account for model uncertainties	*1.12*	As per AMS-III.H.
GWP_{CH4}	Global warming potential for methane	21	As per AMS-III.H.

(iv) Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater;

$PE_{ww,\ discharge,y} = Q_{ww,y} \times GWP_{CH4} \times B_{o,ww} \times UF_{PJ} \times COD_{ww,discharge,PJ,y} \times MCF_{ww,PJ,discharge}$ Eq (9.)

Parameter	Description	Value	Source
$Q_{ww,y}$	See above	See above	See above
GWP_{CH4}	See above	See above	See above
$B_{o,ww}$	See above	See above	See above
UF_{PJ}	See above	See above	See above
$COD_{ww,discharge,PJ,y}$	The chemical oxygen demand of the treated waste water discharged into sea, river or lake in the baseline situation in tonnes/m^3	0.00006	UPOIC, Krabi See Figure 5
$MCF_{ww,PJ,discharge}$	Methane correction factor based on discharge pathway in the baseline situation	0.1	Value for discharge to sea, river or lake in AMS-III.H Table III.H.I

(vi) Methane fugitive emissions on account of inefficiencies in capture systems;

$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y}$ Eq (10.)

$PE_{fugitive,\ ww,\ y} = (1-CEF_{ww}) \times MEP_{ww,\ treatment,y} \times GWP_{CH4}$ Eq (11.)

$MEP_{ww,treatment,y} = Q_{ww,y} \times B_{o,ww} \times UF_{PJ} \times \sum COD_{remove,PJ,k,y} \times MCF_{ww,treatment,PJ,}$ Eq (12.)

Parameter	Description	Value	Source
$PE_{fugitive,\ ww,\ y}$	Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year *y* (tCO_{2e})	-	Calculated as formula (11)
$PE_{fugitive,s,y}$	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year *y* (tCO_{2e})	No sludge treatment system	-
CEF_{ww}	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems	0.9	As per AMS-III.H.
$MEP_{ww,\ treatment,y}$	Methane emission potential of wastewater treatment systems equipped with biogas recovery system in year *y* (tones)	-	Calculated as formula (12)
GWP_{CH4}	See above	See above	See above
$Q_{ww,y}$	See above	See above	See above
$B_{o,ww}$	See above	See above	See above
UF_{PJ}	See above	1.12	As per AMS-III.H.
$COD_{remove,PJ,k,y}$	The chemical oxygen demand removed by the treatment system *k* of the project activity equipped with biogas recovery in the year *y* (tonnes/m^3)	0.052	UPOIC, Krabi See Figure 5
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for the project wastewater treatment system *k* equipped with biogas recovery equipment	0.8	Value for anaerobic reactor without methane recovery AMS – III.H. Table III.H.I

(vii) Methane emissions due to incomplete flaring are determined based on 'Tool to determine project emissions from flaring gases containing methane'. The tool involves the following seven steps:

Step 1: Determination of the mass flow rate of the residual gas that is flare; *As simplified approach, the project proponents only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). Therefore; this step is not applicable.*

Step 2: Determination of the volume fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas;
As simplified approach, the project proponents only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). Therefore; this step is not applicable.

Step 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis;
This step is not applicable since the methane combustion efficiency of the flare is determined from a default value.

Step 4: Determination of the methane mass flow rate of the exhaust gas on a dry basis;
This step is not applicable since the methane combustion efficiency of the flare is determined from a default value.

Step 5: Determination of the methane mass flow rate of the residual gas on a dry basis;
$TM_{RG,h} = FV_{RG,h} \times fv_{ch4,RG,h}, \rho_{CH4,h}$

Step 6: Determination of the hourly flare efficiency;

As per the tool, the case of 'enclosed flares and use of the default value' for the flare efficiency is applied for this $\eta_{flare,h}$) is:

- *0% if the temperature in the exhaust gas of the flare (T_{flare}) is below* 500°C *for more than 20 minutes during the hour h.*
- *50%, if the temperature in the exhaust gas of the flare (T_{flare}) is above* 500°C *for more than 40 minutes during the hour h, but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour h.*
- *90%, if the temperature in the exhaust gas of the flare (T_{flare}) is above* 500°C *for more than 40 minutes during the hour h, and the manufacturer's specifications on proper operation of the flare are met continuously during the hour h.*

According to the manufacturer's specifications, the project shall apply 90% efficiency.

Step 7: calculation of annual project emissions from flaring based on measured hourly values or based on a default flare efficiencies.

$$PE_{flare,y} = \sum TM_{RG} \times (1- \eta_{flare,h}) \times GWP_{CH4} / 1000 \quad \text{Eq (13.)}$$

Parameter	**Description**	**Value**	**Source**
$T_{flare,\ operation}$	Estimated operation time of the flare per year (hours)	0	UPOIC, Krabi

Parameter	Description	Value	Source
TM_{RG}	Mass flow rate of methane in the residual gas in the hour *h* (kg / h). Calculated as flaring tool step 5	177.6	Calculated
$\eta_{flare,h}$	Flare efficiency. As per flaring tool (Step 6), 90% is used for an enclosed flare and use of the default value (if the temperature in the exhaust gas of the flare is above 500°C during the hour *h* and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h).*	90%	As per flaring tool, default value
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h*	364	UPOIC, Krabi
$fv_{CH4,RG,h}$	Volumetric fraction of methane in the residual gas on dry basis in hour *h*	65%	UPOIC, Krabi
$\rho_{CH4,h}$	Density of methane at normal conditions (kg/m^3)	0.716	As per flaring tool
GWP_{CH4}	See above	See above	See above

Note: T_{flare} operation is estimated to be zero for the ex-ante calculation because there are two gensets utilizing the biogas. When one genset is shut down due to its maintenance intervals, another one is still operating therefore; it is assume that no biogas left to be flared. The flare is estimated not being used.

Emission reductions:
Ex ante emission reduction in year y (tCO_{2e}):

Ex ante: $ER_{y,ex\ ante} = BE_{y,ex\ ante} – (PE_{y,\ ex\ ante} + LE_{y,ex\ ante})$

Parameter	Description	Value	Source
$BE_{y,ex\ ante}$	Ex ante baseline emission in year *y* (tCO_{2e})	24,066.76	Calculated as per paragraph 16
$PE_{y,\ ex\ ante}$	Ex ante project reduction in year *y* (tCO_{2e})	6,064.84	Calculated as per paragraph 26
$LE_{y,ex\ ante}$	Ex ante leakage emission in year *y* (tCO_{2e})	0	As per paragraph 28

Emission reduction achieved by the project activity based on monitored values for year y (tCO_{2e}):
Ex post:

$ER_{y,ex\ post} = min((BE_{y,ex\ post} – PE_{y,ex\ post} – LE_{y,ex\ post}),(MD_y - PE_{power,y} – PE_{biomass,y} – LE_{y,ex\ post}))$ Eq (14.)

When
$MD_y = BG_{burnt,y} \times W_{CH4,y} \times D_{CH4} \times FE \times GWP_{CH4}$ Eq (15.)

Parameter	Description	Value	Source
$BE_{y,\ ex\ post}$	Baseline emissions calculated as per paragraph 16 using ex	-	Monitored

Parameter	Description	Value	Source
	post monitored values		
$PE_{y, ex post}$	Project emissions calculated as per paragraph 26 using ex post monitored values	-	Monitored
MD_y	Methane captured and destroyed/gainfully used by the project activity in the year *y* (tCO2e). In case of flaring/fuelling it shall be measured using the conditions of the flaring process.	-	Monitored
$BG_{burnt,y}$	Biogas flared/combusted in year *y* (m^3)	-	Monitored
$W_{CH4,y}$	Methane content in the biogas in year *y* (volume fraction)	-	Monitored
D_{CH4}	Density of methane at the temperature and pressure of the biogas in year *y* (tCO2e/ m^3)	-	Monitored
FE	Flare efficiency in year *y* (fraction)	-	Monitored

B.6.2. Data and parameters fixed ex ante

Data / Parameter	Q_{FFB}
Unit	$t_{FFB/y}$
Description	Quantity of FFB processed per annum
Source of data	Mill owner
Value(s) applied	175,200 tonnes FFB/y
Choice of data or Measurement methods and procedures	Based on average 3-year historical data of the production rate in (2006-2008), the average FFB processed per year was approximately 175,238 tones. The value is rounded down to 175,200 as conservative.
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	Q_{ww}
Unit	$m^{3/}y$
Description	Volume of wastewater from the mill to the lagoons per annum in project baseline
Source of data	Measuring
Value(s) applied	102,730
Choice of data or Measurement methods and procedures	FFB production rate obtained from 3-yr historical data (175,200 multiply with wastewater generation rate obtained from10-day measuring campaign at project site.)
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	$COD_{untreated}$
Unit	tonnes/ m^3
Description	Chemical Oxygen Demand (COD) level of the untreated wastewater entering anaerobic lagoons in project baseline
Source of data	Laboratory (internal and external lab)
Value(s) applied	0.0646
Choice of data or Measurement methods and procedures	Sample analysis was carried out for 10 days by the accredited laboratory following standard and the results are cross-checked for accuracy. The result shall be multiplied with 0.89 to account for the uncertainty range.
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	$MCF_{ww,treatment,BL}$
Unit	Fraction
Description	Methane correction factor for baseline wastewater treatment system
Source of data	AMS-III.H
Value(s) applied	0.8 for anaerobic deep lagoon and 0.3 for aerobic poor managed
Choice of data or Measurement methods and procedures	AMS-III.H Table III.H.I (the existing treatment system consists of series of ponds containing the different conditions, see Figure 5)
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	$COD_{removal,y}$
Unit	tonnes/ m^3
Description	The chemical oxygen demand removed by the anaerobic wastewater treatment system in the project baseline
Source of data	Laboratory (internal and external lab)
Value(s) applied	From anaerobic pond, $COD_{removal,y}$ =0.0622 From aerobic, poor managed pond, $COD_{removal,y}$ =0.00048 (see Figure 5)
Choice of data or Measurement methods and procedures	The wastewater from every open lagoon in the project is sampled and analyzed. The depth of lagoon, the retention time and the temperature at project site are taken into account to specify type of pond according to EB conditions stated in AMS III.H. The result shall be multiplied with 0.89 to account for the uncertainty range.
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	$MCF_{ww,BL,discharge}$ / $MCF_{ww,PJ,discharge}$
Unit	Fraction
Description	Methane correction factor based on discharge pathway in the baseline situation / Methane correction factor based on discharge pathway in the project situation.
Source of data	AMS-III.H
Value(s) applied	0.1

Choice of data or Measurement methods and procedures	Value for discharge to sea, river or lake in AMS III.H Table III.H.I
Purpose of data	Calculation of baseline emission and project emission
Additional comment	-

Data / Parameter	$MCF_{ww,treatment,PJ}$
Unit	Fraction
Description	Methane conversion factor for the wastewater treatment system that will be equipped with methane recovery and combustion
Source of data	AMS-III.H
Value(s) applied	0.8
Choice of data or Measurement methods and procedures	Value for anaerobic reactor without methane recovery in AMS-III.H. para 22, Table III.H.I
Purpose of data	Calculation of project emission
Additional comment	-

Data / Parameter	$EF_{y,\ grid}$ /$EF_{y,\ consumed}$
Unit	tCO_2/MWh
Description	Emission factor for grid electricity
Source of data	EGAT, DEDE, EPPO, IPCC
Value(s) applied	0.52
Choice of data or Measurement methods and procedures	As per AMS-I.D. EFy, consumed is equal to EFy, grid. Details in Annex 3.
Purpose of data	Calculation of project emission
Additional comment	-

As per the guidance on completing SSC PDDs, data that is calculated with equations provided in the approved category and default values specified in the category is not compiled above. Such data are: $B_{o,ww}$, GWP_{CH4}, UF_{BL}, UF_{PJ} and CFE_{ww}.

B.6.3. Ex ante calculation of emission reductions

Baseline Emission

$BE_{y,ex,ante} = BE_{power,y} + BE_{ww,treatment,y} + BE_{ww,discharge,y}$

(i) $BE_{power,y}$ (refer to AMS I.D)

$= EG_{y,exported} \times EF_{y,grid}$
$= 5,123$ MWh/y x 0.52 tCO2/MWh
$= 2,644$ tCO2/y

(ii) $BE_{ww,treatment,y}$ $= Q_{ww,y} \times COD_{removed,y} \times MCF_{ww,treatment,BL} \times B_{o,ww} \times UF_{BL} \times GWP_{CH4}$
$= 102,730\ m^3/y \times 0.05536\ tCOD/m^3 \times 0.8 \times 0.25 \times 0.89 \times 21$
$= 21,258.17\ tCO_2/y$ (anaerobic pond)
$= 102,730\ m^3/y \times 0.00043\ tCOD/m^3 \times 0.3 \times 0.25 \times 0.89 \times 21$
$= 61.52\ tCO_2/y$ (aerobic poor managed pond)
$= 2,258.17 + 61.52 = 21,319.69\ tCO_2/y$

(iii) $BE_{ww,discharge,y}$ $= Q_{ww,y} \times GWP_{CH4} \times B_{oWW} \times UF_{BL} \times COD_{ww,discharge,BL,y} \times MCF_{ww,BL,discharge}$

$= 102{,}730\ m^3/y \times 21 \times 0.25 \times 0.89 \times 0.0017\ tCOD/m^3 \times 0.1$
$= 83.07\ tCO_2/y$

$BE_{y,ex,ante}$ = 24,066.76 tCO2/y

Project emissions

$PE_{y,ex\ ante} = PE_{power,y} + PE_{ww,treatment,y} + PE_{ww,discharege,y} + PE_{fugitive,y} + PE_{flaring,y}$

Project emission according to AMS III.H

(i) $PE_{power,y}$ $= EC_{project,y} \times EF_{grid,y}$
$= 646.32\ MWh/y \times 0\ tCO_2/MWh$
$= 0\ tCO_2/y$

(ii) $PE_{ww,treatment,y}$ $= Q_{ww,y} \times COD_{removed,PJ,k} \times MCF_{ww,treatment,PJ} \times B_{o,ww} \times UF_{PJ} \times GWP_{CH4}$
$= 102{,}730\ m^3/y \times 0.00436\ tCOD/m^3 \times 0.8 \times 0.25 \times 1.12 \times 21$
$= 2{,}107.90\ tCO_2/y$ (anaerobic-anaerobic pond)
$= 102{,}730\ m^3/y \times 0.00646\ tCOD/m^3 \times 0.3 \times 0.25 \times 1.12 \times 21$
$= 1{,}171.20\ tCO_2/y$ (anaerobic poor managed-cooling pond)
$= 102{,}730\ m^3/y \times 0.00139\ tCOD/m^3 \times 0.3 \times 0.25 \times 1.12 \times 21$
$= 252.43\ tCO_2/y$
(aerobic poor managed-facultative, oxidation, polishing pond)
$= 2{,}107.90 + 1{,}171.90 + 252.43 = 3{,}531.53\ tCO_2/y$

(iii) $PE_{ww,discharge,y}$ $= Q_{ww,y} \times GWP_{CH4} \times B_{o,ww} \times UF_{PJ} \times COD_{ww,discharge,PJ,y} \times MCF_{ww,PJ,discharge}$
$= 102{,}730\ m^3/y \times 21 \times 0.25 \times 1.12 \times 0.00006\ tCOD/m^3 \times 0.1$
$= 3.68\ tCO_2/y$

(iv) $PE_{flaring,y}$ $= PE_{fugitive,ww,y} + PE_{fugitive,s,y}$

As there is no sludge treatment system ($PE_{flaring,s,y} = 0$) thus, $PE_{fugitive,y} = PE_{fugitive,y}$

$PE_{fugitive,ww,y}$ $= (1-CEF_{ww}) \times MEP_{ww,treatment,y} \times GWP_{CH4}$
$MEP_{ww,treatment,y}$ $= Q_{ww,y} \times B_{o,ww} \times UF_{PJ} \times \sum COD_{remove,PJ,k,y} \times MCF_{ww,treatment,\ PJ,k}$
$= 102{,}730\ m^3/y \times 0.25 \times 1.12 \times 0.052\ tonnes/m^3 \times 0.8$
$= 1{,}204.58\ tCO_2/y$
$PE_{fugitive,ww,y}$ $= (1 - 0.9) \times 607.19 \times 21$
$= 2{,}529.63\ tCO_2/y$

(v) $P_{Eflare,y}$ $= \sum TMRG \times (1 - \eta_{flare,h}) \times GWP_{CH4}/1000$
$TM_{RG,h}$ $= FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,h}$
$TM_{RG,h}$ $= 364\ m^3/hr \times 0.65 \times 0.716$
$= 170\ tCO_2/y$
$PE_{flare,y}$ $= 170 \times 0 \times (1-0.9) \times 21/1{,}000$
$= 0\ tCO_2/y$

$PE_{y,ex\ ante}$ = 6,064.84 tCO_2/y

Emission Reductions

$ER_{y,ex\ ante}$ $= BE_{y,ex\ ante} - (PE_{y,ex\ ante} + LE_{y,ex\ ante})$
$= 24{,}066.76 - 6{,}064.84 = 18{,}002\ tCO_2/y$

B.6.4. Summary of ex ante estimates of emission reductions

Year	Baseline emissions ($t CO_2e$)	Project emissions ($t CO_2e$)	Leakage ($t CO_2e$)	Emission reductions ($t CO_2e$)
2011 (4 months) start 01/09/2011	2,022	8,022	0	6,001
2012	6,065	24,067	0	18,002
2013	6,065	24,067	0	18,002
2014	6,065	24,067	0	18,002
2015	6,065	24,067	0	18,002
2016	6,065	24,067	0	18,002
2017	6,065	24,067	0	18,002
2018	6,065	24,067	0	18,002
2019	6,065	24,067	0	18,002
2020	6,065	24,067	0	18,002
2021 (9 months) end 31/08/2021	4,043	16,044	0	12,001
Total	60,648	240,665	0	180,017
Total number of crediting years	10			
Annual average over the crediting period	6,064	24,066	0	18,001

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data / Parameter	$Q_{ww,y}$
Unit	m^3/y
Description	Volume of wastewater treated in year *y* entering the cooling pond and entering the digester
Source of data	Measurement (Continuously)
Value(s) applied	102,730 For present estimation purposes, the amount of project wastewater generated is estimated based on the historical data. The actual volume of project wastewater will be based on the measurement at the plant each year.
Measurement methods and procedures	A magnetic inductive flow meter will be installed at the inlet to the cooling pond for measurement of the influent wastewater into the system. Flow rates will be continuously measured with this flow meter. Hourly value will be recorded on the memory card of the recorder and weekly transferred and recorded in computer then, the data will be aggregated monthly and annually for verification report and calculations. Accuracy of meter is based on the specification of the manufacturer or ±0.3% accuracy of reading value. A bypass is provided for maintenance and repair purposes. The volume of wastewater during few days of repair and maintenance will be calculated based on the average daily flow of the previous 3 months record. Thus, level of uncertainty for data is expected to be low. Recording frequency: a confidence/precision level of 90/10 will be attained
Monitoring frequency	Continuous

QA/QC procedures	The flow meter will undergo maintenance / calibration subject to appropriate industry standards and the calibration interval is at least once per year.
Purpose of data	Calculation of baseline emission and project emission
Additional comment	-

Data / Parameter	$COD_{ww,untreated,PJ,k,y}$
Unit	tonnes/m^3
Description	Chemical oxygen demand of wastewater before the treatment system *k*
Source of data	Laboratory tests (internal and external labs)
Value(s) applied	0.06463 for aerobic poor managed condition (cooling pond) 0.05816 for anaerobic digester 0.00582 for anaerobic condition (anaerobic ponds 1-2 of the post treatment system) 0.00145 for aerobic poor managed condition (facultative ponds 1-2, oxidation pond and polishing pond in the post treatment system) (see **Figure 5**) For present estimation purposes, the COD concentration of project wastewater is from the average 10-day campaign.
Measurement methods and procedures	Wastewater influent of the treatment system *k* will be sampled and analyzed for COD at UPOIC laboratory weekly according to specifications of test equipment and national or international standard method i.e. the 'Standard Method of the Examination of Water and Wastewater, American Public Health Association (APHA), American Water Works Association (AWWA) and Water Environment Federation (WEF)'. Furthermore, monthly samples will be collected and analyzed by an accredited laboratory using the similar or equal standards in order to obtain the accuracy of the cross-checked results. Samples and measurements will ensure a 90/10 confidence/precision level
Monitoring frequency	Weekly
QA/QC procedures	The analysis at the plant will follow the standard and the equipment will be calibrated according to the instructions from the supplier. The appointed laboratory must be accredited lab. The uncertainty level of the data will be low. The results from UPOIC Laboratory will be compared to the results from the accredited laboratory and corrective actions undertaken if there are consistence differences.
Purpose of data	Calculation of baseline emission
Additional comment	-

Data / Parameter	$COD_{ww,treated,PJ,k,y}$
Unit	tonnes/m^3
Description	Chemical oxygen demand of the wastewater after the treatment system *k*
Source of data	Laboratory tests (internal and external labs)
Value(s) applied	0.05816 for aerobic poor managed condition (cooling pond) 0.00582 for anaerobic digester 0.00145 for anaerobic condition (anaerobic ponds 1-2 of the post treatment system) 0.00006 for aerobic poor managed condition (facultative ponds 1-2, oxidation pond and polishing pond in the post treatment system) (see **Figure 5**) For present estimation purposes, the COD concentration of the treated wastewater is from the average 10-day campaign.

Measurement methods and procedures	Treated wastewater of the treatment system *k* will be sampled and analyzed for COD at UPOIC laboratory weekly according to specifications of test equipments and national or international standard method i.e. the 'Standard Method of the Examination of Water and Wastewater, APHA, AWWA and WEF'. Furthermore, monthly samples will be collected and analyzed by an accredited laboratory using the similar or equal standards in order to obtain the accuracy of the crosschecked results. Samples and measurements will ensure a 90/10 confidence/precision level
Monitoring frequency	Weekly
QA/QC procedures	See details above. This is the same as parameter $COD_{ww,untreated,PJ,k,y.}$
Purpose of data	Calculation of project emission
Additional comment	-

Data / Parameter	$COD_{ww,discharged,PJ,y}$
Unit	tonnes/m^3
Description	Chemical oxygen demand of the final treated wastewater discharged into the plantation area in the project activity
Source of data	Laboratory tests (internal and external labs)
Value(s) applied	0.00006 The discharged wastewater contains COD as same as the final treated wastewater from the last aerobic pond since the wastewater from this pond will be utilized in the plantation area of the project, please see Figure 6.
Measurement methods and procedures	See details above. This is the same as parameter $COD_{ww,untreated,PJ,k,y.}$
Monitoring frequency	Weekly
QA/QC procedures	See details above. This is the same as parameter $COD_{ww,untreated,PJ,k,y.}$
Purpose of data	Calculation of project emission
Additional comment	-

Data / Parameter	$Q_{ww,discharged,y\ (outlet)}$
Unit	m^3 /y
Description	Volume of wastewater discharged in year *y*
Source of data	Measurement (Continuously)
Value(s) applied	102,730 For present estimation purposes, the volume of wastewater discharged is assumed the same quantity as the influent volume.
Measurement methods and procedures	See details above. This is the same as parameter $Q_{ww,y.}$
Monitoring frequency	Continuous
QA/QC procedures	See details above. This is the same as parameter $Q_{ww,y.}$
Purpose of data	Calculation of project emission
Additional comment	-

Data / Parameter	$S_{final,PJ,y}$
Unit	tonnes/y
Description	End use of treated sludge generated in year *y*
Source of data	Plant operation record
Value(s) applied	The sludge shall be used for soil application.

Measurement methods and procedures	The practice of final disposal of the sludge shall be documented in the plant operation log sheets and documented with additional evidence such as pictures. Data will be archived electronically, for at least 2 years after last issuance of CERs.
Monitoring frequency	The frequency cannot be set ex-ante. The amount of sludge removal out of the system will be measured during the crediting period.
QA/QC procedures	If soil application practice cannot be confirmed or is not documented properly, it shall be assumed that sludge was disposal in a landfill under anaerobic condition without methane recovery, applying the most conservative approach from project emission for final sludge disposal as per AMS III.H, Version 15. In this case, calculation of project emissions from final sludge disposal shall be based on the weight of the untreated sludge and the weight measurement device shall be subject to periodic serving and maintenance according to appropriate industry standard.
Purpose of data	Calculation of project emission
Additional comment	Not applicable as the sludge is expected to be used for soil application in aerobic conditions in the project activity however, according to AMS III.H. Paragraph 39, the end-use of the final sludge will be monitored during the crediting period.

Data / Parameter	$FV_{digester,y}$
Unit	Nm^3/y
Description	Volumetric flow rate of biogas on dry basis leaving the digester in year *y* ($BG_{burnt,y}$)
Source of data	Measurement (continuously)
Value(s) applied	2,622,256 Temperature and pressure of the gas will be measured continuously with the volume to allow for normalization.
Measurement methods and procedures	A flow meter with appropriate range of measurement will be installed at the biogas delivery piping system to measure amount of biogas generated from the digester tanks. Installation and operation will be done on state-of-the-art to avoid air ingress into the piping system. Location of measurement will be the same where methane content will be measured as well. Accuracy of the meter is based on manufacturer standards. Hourly value will be recorded on the memory card of the recorder and weekly transferred and recorded in computer then, the data will be aggregated monthly and annually for verification report and calculations. A confidence/ precision level of 90/10 will be attained A bypass is provided for maintenance and repair purposes. The volume of produced gas during few days of repair and maintenance will be calculated based on the average daily flow of the previous 3 months record. Thus, level of uncertainty for data is expected to be low.
Monitoring frequency	Continuous
QA/QC procedures	Flow meter will undergo maintenance/calibration subject to appropriate industry standards by manufacturer or approved company to ensure accuracy (frequency of calibration as recommended by manufacturer or at least once per year). Therefore, the uncertainty level of the data is expected to be low. Records of calibration will be kept at site.
Purpose of data	Calculation of baseline emission
Additional comment	The amount of the produced gas is applied in order to cross check with the amount of the gas to be utilized ($FV_{electricity}$) and flared (FV_{RG}).

Data / Parameter	$W_{CH4,y}$
Unit	$kgCH_4$ / m^3 biogas
Description	Methane content in the biogas in the year *y* (volume fraction)
Source of data	Measurement (Continuously)

Value(s) applied	N/A – this parameter is not relevant for the purpose of the ex ante estimation
Measurement methods and procedures	CH_4 content will be periodical measured through portable analyzer. Location of measurement will be at the same location where the biogas flow rate will be measured. The measurement will be carried out once a day over the period of one week per year and in a way that does not allow air ingress into the piping system. The results must have 90/10 confidence/precision level. If not, the new measurement must be conducted to obtain the required confidence/precision level of the results.
Monitoring frequency	Continuous
QA/QC procedures	Control measurements for the use of gas analyzer will be prepared and implemented. Accuracy of equipment is based on manufacturer standards or max. ±3.0% with a proper field calibration. Regular calibration is provided by manufacturer or approved company (frequency of calibration as recommended by manufacturer or at least once per year). The error for different levels of measurement frequency will be defined and the level of accuracy will be deducted from average concentration of measurement. The uncertainty level of the data is expected to be low. Records of calibration will be kept at site.
Purpose of data	Calculation of baseline emission and project emission
Additional comment	- As per AMS III.H, paragraph 33, this parameter is not relevant for the purpose of the ex ante estimation but must be monitored in order to achieve the lowest value of emission reduction during crediting period. - ID No.20 is also measuring of WCH4,y but it is not for CDM monitoring purpose. The PP has to install the continuous gas analyzers for controlling of the generator system thus; the values obtained from these sampling points will be not taken into account as methane content in the biogas of the project.

Data / Parameter	T_{biogas} and P_{biogas}
Unit	ºC and bar
Description	Temperature and pressure of produced biogas
Source of data	Measurement (continuously)
Value(s) applied	N/A – this parameter is not relevant for the purpose of the ex ante estimation
Measurement methods and procedures	Temperature and pressure of the produced biogas will be measured continuously with the volume to allow for normalization. The thermometer with measuring ranges of -50 to +600 ºC or according to manufacturing standard and pressure meters with accuracy max. ±0.5% or according to manufacturing standard will be installed at the biogas delivery piping system after the bio-digester, and integrated into the flow meters measuring flow into the flare and into the generator. The installation will be done in a way to avoid air ingress into the system. Rather than storing data electronically, conversion to Nm3 is made directly and the flow rates are stored as Nm3. The temperature and pressure will be measured at the same time the Methane content in biogas is measured.
Monitoring frequency	Continuous
QA/QC procedures	Calibration as per manufacturer's recommendations, or at least once per year. Maintenance will be performed in strict adherence to manufacturer's recommended maintenance schedule. The uncertainty level of the data is expected to be low. Data will be checked on plausibility. Records of calibration will be kept at site.
Purpose of data	To determine the unit of biogas quantity under normal condition.
Additional comment	-

Data / Parameter	$FV_{RG,h}$
Unit	m^3/h
Description	Volumetric flow rate of the biogas to the flare in dry basis at normal conditions in hour h ($BG_{flare,y}$)
Source of data	Measurement (Continuously)

Value(s) applied	364 For present estimation purposes, the volumetric flow rate of the biogas is calculated from the estimated biogas produced per day divided by 24 hours.
Measurement methods and procedures	The flow meter is installed in the individual delivery pipeline to the flaring system after the branch from the main biogas. Accuracy of the meter is based on manufacturer standards or ±1.5% accuracy of measured value. Hourly value will be recorded on the memory card of the recorder and weekly transferred and recorded in computer then, the data will be aggregated monthly and annually for verification report and calculations. The same dry basis is considered for this measurement and the measurement of the volumetric fraction of methane component in the residual gas ($f_{vi,h}$). During calibration of the meter a replacement meter will be installed for continuous measuring. The replacement meter used will have a valid calibration certificate and is the identical type of the meter removed.
Monitoring frequency	Continuous
QA/QC procedures	Flow meter will undergo maintenance/calibration subject to appropriate industry standards by manufacturer or approved company to ensure accuracy (frequency of calibration as recommended by manufacturer or at least once per year). Therefore, the uncertainty level of the data is expected to be low. Records of calibration will be kept at site.
Purpose of data	Calculation of project emission
Additional comment	As per AMS III.H, paragraph 33, this parameter shall be taken into account with T_{flare} operation to obtain ‘$BG_{burnt,y}$ - $Biogas_{flared/combusted}$ in year *y*’ which is not relevant for the purpose of the ex ante estimation but must be monitored in order to achieve the lowest value of emission reduction during crediting period.

Data / Parameter	$fv_{CH4,RG,h}$
Unit	Fraction (volumetric basis)
Description	Volumetric fraction of component *i* in the residual gas in the hour h where *i*=CH4 and N2 of the residual gas in dry basis at normal conditions in the hour *h*
Source of data	Measurement (continuously)
Value(s) applied	65% For present estimation purposes, the volumetric fraction component *i* in the residual gas is based on the technical specification of digester which mention that expected CH4 in biogas is 65%.
Measurement methods and procedures	Values to be averaged hourly or at a shorter time interval by using continuous gas analyzer installed in the individual delivery pipeline to the flaring system. According to the “Tool to determine project emissions from flaring gases containing methane”, *project proponents will only measure the methane content of the residual gas and consider the remaining part as N2*. The same dry basis is considered for this measurement and the measurement of the volumetric flow rate of the residual gas (FVRG,h) as well as same locations of measurement will be used.
Monitoring frequency	Continuous
QA/QC procedures	Analysers will be periodically calibrated according to the manufacturer’s recommendation or at least once per year. A zero check and a typical value check will be performed by comparison with a standard certified gas. The uncertainty level of the data is expected to be low. Records of calibration will be kept at site.
Purpose of data	Calculation of project emission
Additional comment	-

Data / Parameter	T_{flare}
Unit	ºC
Description	Temperature of methane flare used for flame detection

Source of data	Measurement (Continuously)
Value(s) applied	> 500ºC
Measurement methods and procedures	The flare temperature will be measured with a type N thermocouple continuously and data will be logged digitally and stored (1 min aggregated average value) in an easily accessible and transparent format. A temperature above 500ºC indicated that a significant amount of gases are still being burnt and that the flare is operating.
Monitoring frequency	Continuous
QA/QC procedures	The temperature sensor will undergo maintenance / calibration subject to appropriate industry standards, or as per recommendation of supplier, or at least once per year. Data shall be archived for at least 2 years after crediting period ends. Level of uncertainty for data is expected to be low.
Purpose of data	Calculation of project emission
Additional comment	Temperature measurement will be used to confirm that the flare is operating correctly.

Data / Parameter	$T_{flare,operation}$
Unit	hours
Description	Operation time of the flare per year *y*
Source of data	Measurement (continuously)
Value(s) applied	0 For present estimation purposes, it is assumed that the generator works properly that means there is no gas going to be flared. The value of 51 hours per year is estimated from the maintenance time per year of the generator and this time the generator will be shut down and the produced gas will be flared.
Measurement methods and procedures	Continuous measurement with volumetric flow rate meter and the flaring system. The data will be stored electronically.
Monitoring frequency	Continuous
QA/QC procedures	Calibration as per manufacturer's recommendations, or at least once per year. Maintenance will be performed in strict adherence to manufacturer's recommended maintenance schedule.
Purpose of data	Calculation of project emission
Additional comment	-

Data / Parameter	$FV_{electricity,y}$
Unit	Nm^3/y
Description	Volumetric flow rate of biogas on dry basis entering the power generation equipment in year *y* ($BG_{electricity,y}$).
Source of data	Measurement (continuously)
Value(s) applied	N/A – this parameter is not relevant for the purpose of the ex ante estimation
Measurement methods and procedures	The flow meter is installed in the individual delivery pipeline to the genset system after the branch from the main biogas. Accuracy of the meter is based on manufacturer standards. Hourly value will be recorded on the memory card of the recorder and weekly transferred and recorded in computer then, the data will be aggregated monthly and annually for verification report and calculations. During calibration of the meter a replacement meter will be installed for continuous measuring. The replacement meter used will have a valid calibration certificate and is the identical type of the meter removed.
Monitoring frequency	Continuous

QA/QC procedures	Flow meter will undergo maintenance/calibration subject to appropriate industry standards by manufacturer or approved company to ensure accuracy (frequency of calibration as recommended by manufacturer or at least once per year). Therefore, the uncertainty level of the data is expected to be low. Records of calibration will be kept at site.
Purpose of data	Calculation of baseline emission
Additional comment	The amount of the produced gas is applied in order to cross check with the amount of the gas to be utilized (FV_{digest}) and flared (FV_{RG}).

Data / Parameter	Total annual electricity generated from the project in year y
Unit	MWh/y
Description	Total annual electricity generated from the project in year y
Source of data	Measurement (continuously)
Value(s) applied	5,769 For present estimation purposes, the amount of electricity generated in the project is calculated from the amount of produced biogas.
Measurement methods and procedures	The amount of electricity consumed by the project will be monitored continuously by a separate and officially calibrated electric meter. Data will be kept electronically in a systematic and transparent manner.
Monitoring frequency	Continuous
QA/QC procedures	The power meters are accurate based on IEC 62053-21 Class 1 (active energy) and IEC 62053-23 Class 2 (reactive energy) or national/international standard and will be periodically compared by official organization and/or authorized company. No further step is applicable due to external quality control (local utility PEA as electricity buyer). The power production will be cross checked with the amount of gas used by each of the gas engines and with the annual operation hours of the engines.
Purpose of data	To crosscheck amount of monitored power production by considering with the amount of biogas consumed in the generator and the annual operation hours of biogas engine. This parameter is not applied for emission reduction calculation.
Additional comment	-

Data / Parameter	$EG_{y,consumed}$
Unit	MWh/y
Description	Annual electricity to operate the facilities or power auxiliary equipment
Source of data	Measurement (Continuously)
Value(s) applied	646 For present estimation purposes, the amount of electricity consumed in the project is taken from the amount of electricity required for biogas equipment based on their specifications.
Measurement methods and procedures	The amount of electricity consumed by the project will be monitored continuously by a separate and officially calibrated electric meter. Data will be kept electronically in a systematic and transparent manner.
Monitoring frequency	Continuous
QA/QC procedures	The power meters are accurate based on IEC 62053-21 Class 1 (active energy) and IEC 62053-23 Class 2 (reactive energy) or national/international standard and will be periodically compared by official organization and/or authorized company. No further step is applicable due to external quality control (local utility PEA as electricity buyer). The power production will be cross-checked with the amount of gas used by each of the gas engines and with the annual operation hours of the engines.
Purpose of data	Calculation of project emission

Additional comment	Since the electricity for the project will be provided by the electricity generation part of the project, this emission source is not expected, but will be monitored regardless in case of failure or downtime of the biogas generator and resulting use of grid electricity.

Data / Parameter	$EG_{y,exported}$
Unit	MWh/y
Description	Amount of electricity to substitute grid electricity by the Project in year *y*
Source of data	Measurement (Continuously)
Value(s) applied	Electricity produced in the project activities will be substituted electricity used in - Palm oil mill = 433 (based on historical data) - supply to grid = 4,690
Measurement methods and procedures	The power output from the gas engines will be recorded continuously through power meters.
Monitoring frequency	Continuous
QA/QC procedures	The power meters are accurate to 0.1 amp or PEA regulations and will be periodically compared by official organization and/or authorized company. No further step is applicable due to external quality control (local utility PEA as electricity buyer). The power production will be cross checked with the amount of gas used by each of the gas engines and with the annual operation hours of the engines.
Purpose of data	Calculation of baseline emission
Additional comment	Level of accuracy of recorded power production is high. The level of uncertainty is expected to be high, that's why monitoring meters are installed to record amount of biogas generated.

Data / Parameter	D_{CH4}
Unit	Tonnes/m^3
Description	Density of methane at the temperature and pressure of the biogas in the year *y*
Source of data	Calculated
Value(s) applied	It is not relevant for the purpose of the ex ante estimation but must be monitored in order to achieve the lowest value of emission reduction during crediting period. The density shall be calculated from ID14 $fv_{CH4,RG,h}$ and ID19 $W_{CH4,y}$ which is obtained by the continuous monitoring then, multiply with density of methane 0.716 kg/m^3 as per tool to determine project emission from flaring gases containing methane.
Measurement methods and procedures	See details in parameter W_{CH4} and $fv_{CH4,RG,h}$
Monitoring frequency	Not applicable
QA/QC procedures	See details in parameter W_{CH4} and $fv_{CH4,RG,h}$
Purpose of data	Calculation of baseline emission and project emission
Additional comment	-

Data / Parameter	FE
Unit	Fraction
Description	Flare efficiency in year y
Source of data	Use default value 90% from “Tool to determine project emissions from flaring gases containing methane”
Value(s) applied	90%

Measurement methods and procedures	0% if the temperature in the exhaust gas of the flare (Tflare) is below 500 °C for more than 20 minutes during the hour h . 50%, if the temperature in the exhaust gas of the flare (Tflare) is above 500 °C for more than 40 minutes during the hour h, but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour h. 90%, if the temperature in the exhaust gas of the flare (Tflare) is above 500 °C for more than 40 minutes during the hour h and the manufacturer's specifications on proper operation of the flare are met continuously during the hour h.
Monitoring frequency	Not applicable
QA/QC procedures	-
Purpose of data	Calculation of project emission
Additional comment	-

B.7.2. Sampling plan

This is not applicable.

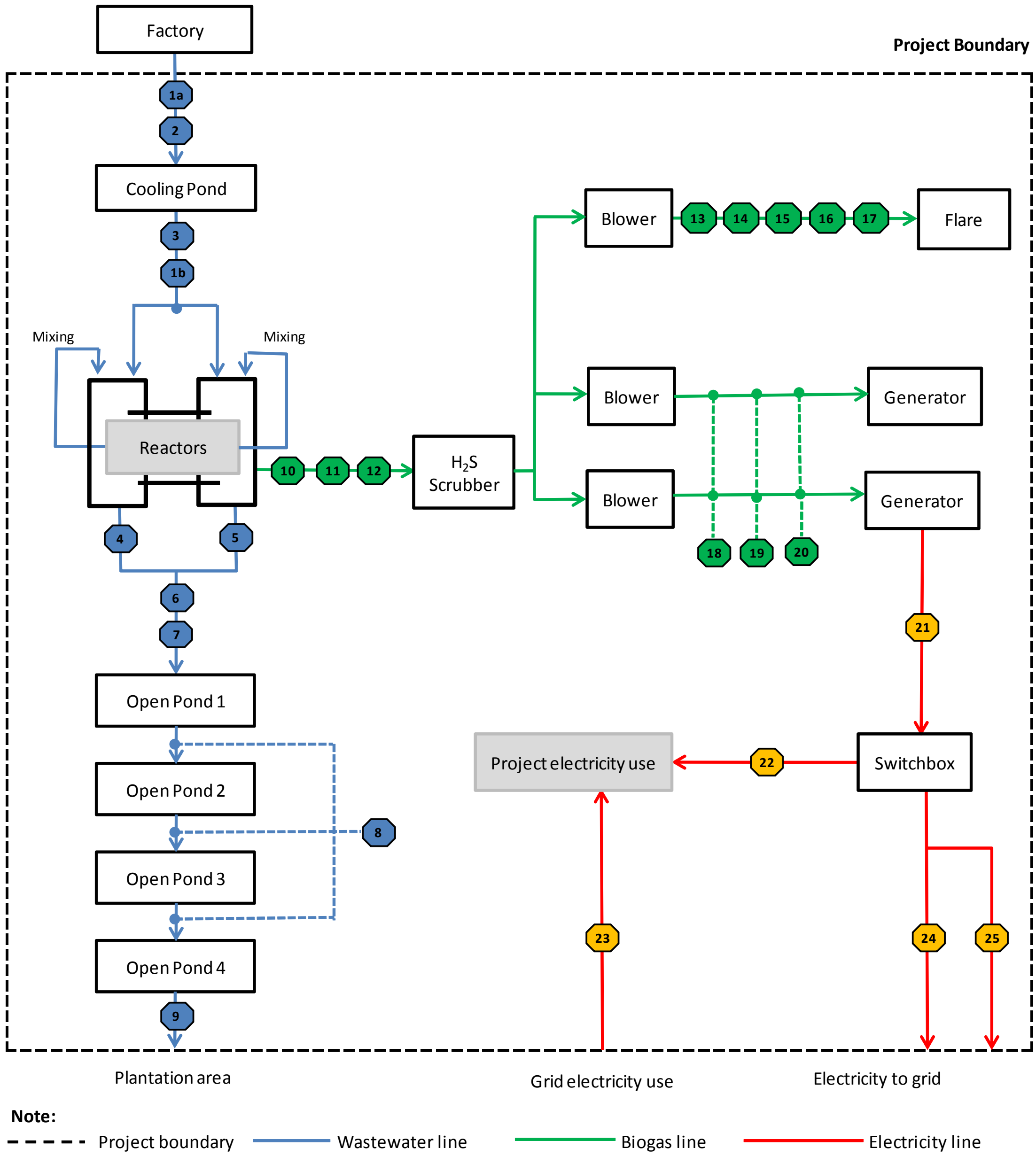
B.7.3. Other elements of monitoring plan

The purpose of the Monitoring Implementation Plan is to provide a documented procedure by which monitoring and verification activity can be conducted on the project activity. The plan will be adhered for the duration of the project activity. The monitoring implementation plan ensures that accurate and valid monitoring data are obtained for determination of project's Certified Emission Reductions (CERs), which will be used for periodic verification purpose.

UPOIC PCL will fulfill the required operational and data collection obligations so that CERs are calculated in a transparent manner. All data required for baseline and emission reduction determination shall be monitored as directed in this PDD. All monitoring equipment will be installed by a qualified contractor and regularly calibrated for quality control according to the appropriate industry standards. Monitoring and recording of the required parameters will be undertaken by trained personnel under the management of a CDM Manager. Execution of the monitoring plan will be carried out by UPOIC staff, which will keep monitor, record and store relevant data. Such data will be made available to the DOE for verification in a transparent manner. The monitoring instruments are summarized in Figure 6:

Organizational and management structures

All monitored data will be safely kept in an electronic data base and submitted to the DOE for verification purposes. The key manager of the waste water plant will be the responsible person for monitoring all of the above mentioned parameters and for recording all data appropriately. UPOIC QA/QC staff will be in charge and responsible for the accuracy of the data collection and processing. Data will be recorded as part of the daily responsibilities of QA/QC staff and based on requirements of the ISO 9001:2000 scheme. The ISO 9001:2000 a scheme defines organizational and management structures in detail, as well as responsibilities of staff and procedures in cases of technical irregularities in details. The scheme will be updated to incorporate the new biogas system before operation of the plant. The management structure as well as implementation and operation management of the efficient monitoring system will be as shown in Figure 7.



Parameter monitored			
(1a,1b)	Qww,y (Influent)	(14)	FVRG,h
(2,3)	CODww, untreated,PJ,k,y	(15)	fvCH4,RG,h
(4,5, 6, 8)	CODww, treated,PJ,k,y	(16)	Tflare
(7)	Qww,y (Effluent)	(17)	Tflare operation
(9)	CODww, discharged, PJ,k,y	(19)	FV electricity,y
(10)	FV digester,y	(21)	Total electricity generated
(11,20)	WCH4,y	(22,23)	Ecpj,y
(12,13,18)	Temp. & pressure sensor	(24,25)	Egpj,y

Figure 7: Monitoring diagram of project activity

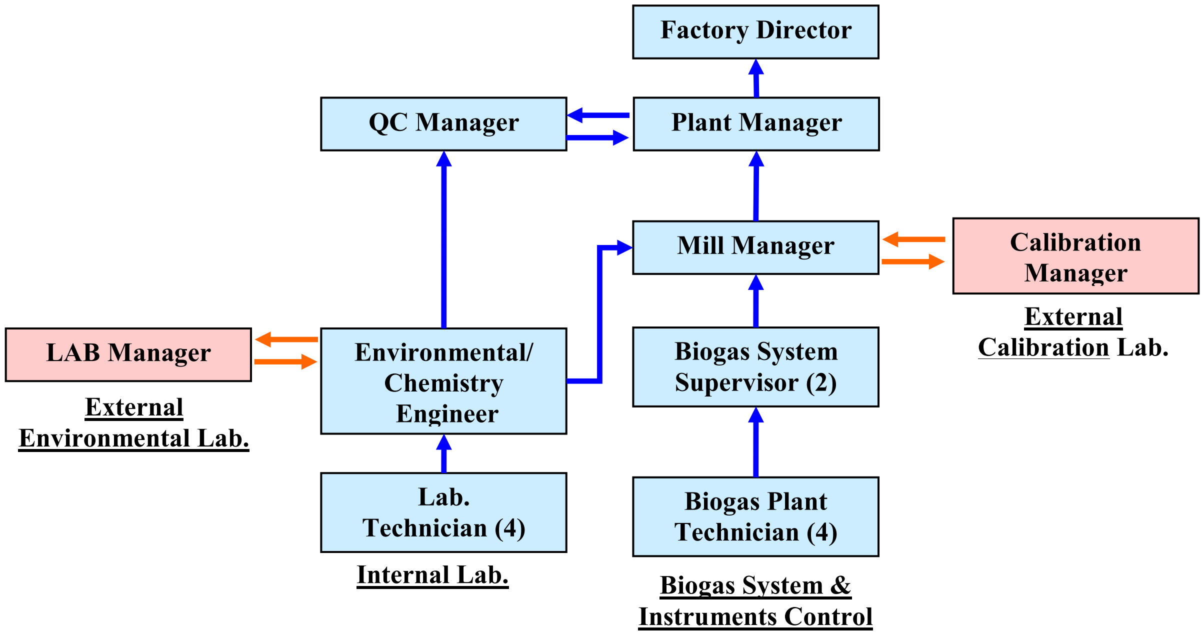


Figure 7: Management structure of monitoring system

Key persons responsibilities:
The lab technician: is responsible for maintaining all daily laboratories testing to international standards, including COD and oxidation substances. The parameters required by the CDM projects are done by an internal laboratory and periodically cross-checked with the external certified laboratory. Laboratory results will be daily recorded in electronic file and reported to Environmental/Chemistry engineer.

The Environmental/Chemistry engineer: is responsible to supervise Lab Technician to assure quality of waste water sampling and analysis as well as preparing laboratory report and arrange quality control check with QC manager and checking daily on the quality control data collection and filing procedure.

The QC manager: is responsible to inspect the overall laboratory data and managing all monitoring data reporting on any significant fluctuations and variations identified in the POME to Plant Manager as well as co-coordinating with engineering manager for biogas system management.

The biogas plant technician: is responsible to maintain daily operational and maintenance for smooth operational of the biogas system, electricity generation system, flaring system and monitoring system. Detail information on site concerning the operation of the plant will be recorded and reported to the biogas system supervisor.

The biogas system supervisor: is responsible to control the entire operation, guiding decision making on process management and changes, and resolving equipment, operational and monitoring issues; include managing all monitoring data from data of Biogas Plant to prepare monthly Operational, Maintenance and Monitoring Report of Biogas Project and submitting to Engineer Manager. And corporate with the Provincial Electricity Authority (PEA)

The mill manager: is responsible to 1. Support and guide the biogas system supervisor to ensure the effective operation of biogas system management and report to the plant manager. 2. Cooperate between factory and biogas operation and staff. 3. Managing quality control check with the QC manager. 4. Coordinate and review annual calibration checks of equipment with equipment suppliers and the external certified agencies for equipment calibration, and recording any biogas losses throughout the project system.

Plant Manager: is responsible to supervision overall biogas and electricity generation system by interacts with QC manager, Engineering manager, Laboratory manager, and staffs in the factory. The plant manager is a coordinating point of the factory with external stakeholder i.e. local people, NGO, PEA, DOE, etc. for smooth biogas and electricity system operation, sustainability management, and CDM process.

Factory Director: is responsible to set and revise the monitoring policy and communicate with the UNFCCC regarding the CDM project.

Monitoring implementation and operation management and procedure
In order to implement, operate, maintain and control the monitoring system appropriately, the following operation procedure will be implemented as shown in Figure 8: (details in Annex 4)

Training
To assure the correct handling of the equipment, correct monitoring, the training of the local stuff will be organized. Minimum two persons will be trained on the field of:

- General knowledge about the applied equipment at the digesters and biogas utilization units;
- Reading, recording and processing data and elaboration of monitoring reports;
- Inspection and maintenance of equipment;
- Calibration methodology;
- Emergency situation (complete exchange of equipment).

Chosen trainees must have a good understanding of the processes and technology of the digester and the biogas utilizing units. Accompanying and observing starts parallel with preparation work for the installation. The main course of the training will be carried out by staff of the monitoring equipment supplier. UPOIC staff will attend the installation of the equipment, calibration and start up operation

Guidebooks for the monitoring system and a handbook of the digester operation are provided in local or English language by the suppliers. The operator and the monitoring management team can find information about:

- Operation and maintenance of the monitoring instruments;
- Operation manual of the digester;
- Design parameters of the biogas composition, temperature, pressure, flow rate, etc.;
- Drawings;
- Inspection, maintenance and simple emergency repair instructions;
- Description of parts of the equipment;

The training will be in accordance with the already implemented ISO 9001:2000 procedures at UPOIC and will consider the above presented Monitoring Management Organization and staff assigned to the positions within this organization structure.

Reconstruction/calculation of data in case of instrument failure
Missing monitoring data derived from instrument failure and during replacement of broken instruments will be reconstructed from former and subsequent series of measurement. Within the first month of monitoring, missing data will not be reconstructed and losses accepted accordingly.
After one month of monitoring and one month data record respectively, missing data will be reconstructed from the average of the lowest measured values of the previous and the following month, if the monitoring interruption is longer than one week (5 working days).

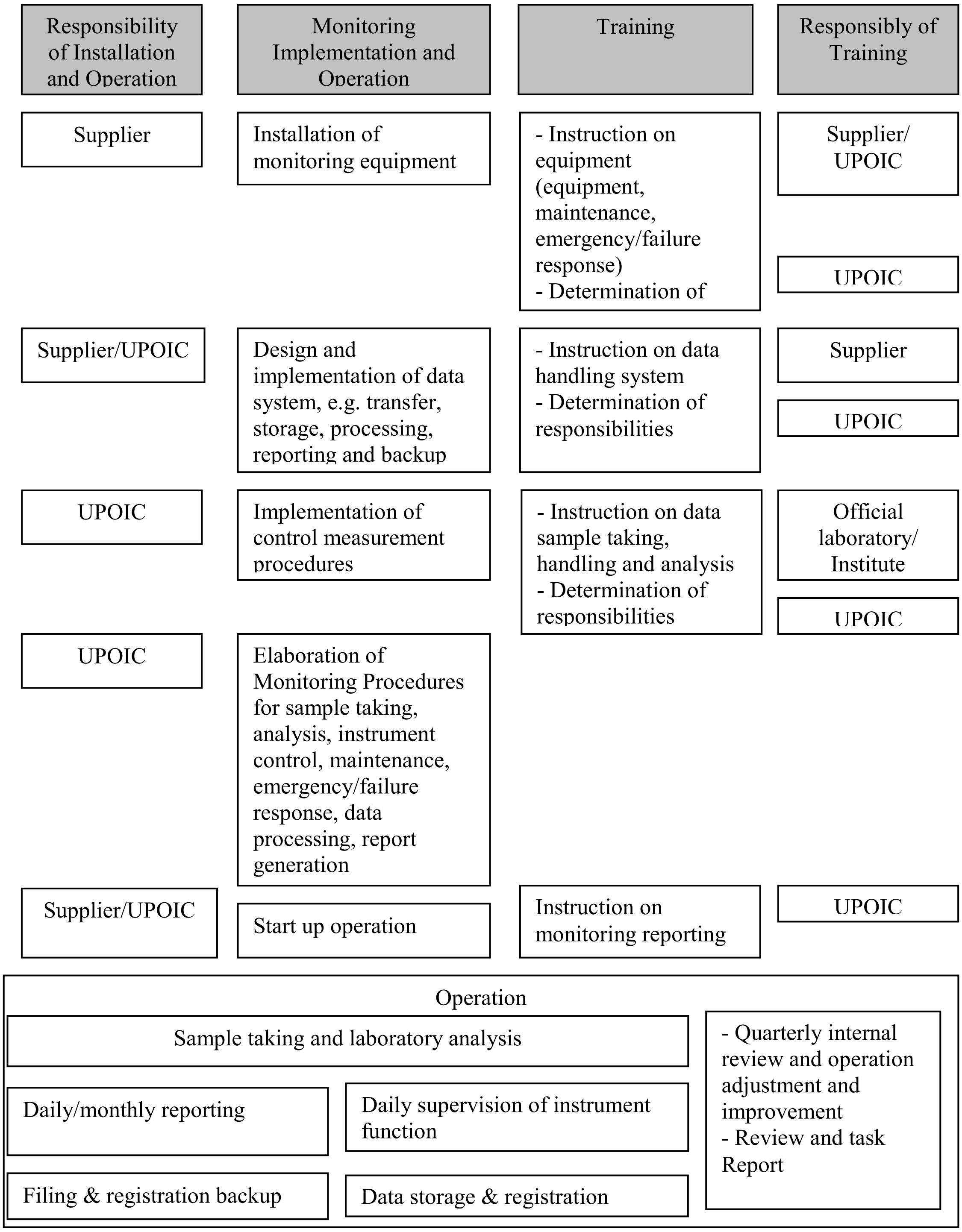


Figure 8: Monitoring operation procedure

This method is appropriate and conservative, since the flow rates of wastewater and biogas as well as the COD content in the waste water and CH4 content in the biogas is not subject to huge variations in such production processes. To avoid suspicion referring bridging of complete production interruptions, corresponding data from parallel instruments and proved production data from the same period of the instrument failure will be recorded and documented in order to prove the continuity of the production process. Reconstructed values will be marked in the record and monitoring reports accordingly.

Data Storage

The gathered monitoring data will be digitally stored in a recorder. At regular intervals, data will be printed out and archived. All data will be kept for at least two years following the end of the crediting period or the last issuance of CERs (whatever is the later). For all monitoring supervision, maintenance, data storage, data handling and plausibility check measures will be elaborated by United Palm Oil Industry PCL for their monitoring and management staff. For all the internal Audit reports and project performance review reports would be archived and shall be subjected to verification during issuance.

B.8. Date of completion of application of methodology and standardized baseline and contact information of responsible persons/ entities

Date of completion: 08/07/2015
Mr. Renat Heuberger
Managing Partner, Swiss Carbon Asset Limited.

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity

10/03/2008
(The date that the project started construction is chosen as per EB 41, paragraph 67 which states that “the start date shall be considered to be the date on which the project participant has committed to expenditures related to the implementation or related to the construction of the project activity.)

C.1.2. Expected operational lifetime of project activity

20 Years

C.2. Crediting period of project activity

C.2.1. Type of crediting period

Fixed crediting period.

C.2.2. Start date of crediting period

01/09/2011 or the date of registration.

C.2.3. Length of crediting period

10 years 0 months.

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

According to the regulations of the Kingdom of Thailand, a comprehensive environmental impact assessment (EIA) is not required for the underlying project activity[7].

Figure 9 summarizes the results from the Gold Standard EIA pre-screen, elaborated on the basis of local conditions, secondary data and information and in collaboration with stakeholders.

1. Will there be a large change in environmental conditions?	No
2. Will new features be out-of-scale with the existing environment?	No
3. Will the effect be unusual in the area or particularly complex?	No
4. Will the effect extend over a large area?	No
5. Will there be any potential for transfrontier impact?	No
6. Will many people be affected?	No
7. Will many receptors of other types (fauna and flora, businesses, facilities) be affected?	No
8. Will valuable or scarce features or resources be affected?	No
9. Is there a risk that environmental standards will be breached?	No
10. Is there a risk that protected sites, areas, features will be affected?	No
11. Is there a high probability of the effect occurring?	No
12.Will the effect continue for a long time?	No
13.Will the effect be permanent rather than temporary?	No
14.Will the impact be continuous rather than intermittent?	No
15. If it is intermittent will it be frequent rather than rare?	No
16.Will the impact be irreversible?	No
17.Will it be difficult to avoid, or reduce or repair or compensate for the effect?	No

(Adapted from: CEC, 1993, Environmental Manual, Annex 1)

However the result of the EIA screen is, the Thai DNA requires generally an Initial Environmental Evaluation (IEE) for potential CDM project activities as minimum requirement. Since the Thai DNA has adopted the standards and requirements on sustainable development and environmental impact screening from the Gold Standard Scheme, the IEE has been conducted closely following the Gold Standard procedures. Potential environmental impacts of the project activity have been assessed by means of stakeholder consultations, the EIA-activities as described in section A2, and by applying the Gold Standard pre-screen checklists for Sustainable Development and EIA Pre-Screen.

Despite this summary of the results of the EIA pre-screen (EIA is not required for this project, comprehensive table please see D.2.1), an IEE according to Thai DNA requirements has been carried out by the environmental specialist of ENVIMA (Thailand) Co., Ltd. in cooperation with local stakeholders. The results are summarized in the following paragraphs, and – in a more detailed form – in D.2.2. No significant environmental and social impacts through the project activities have been identified.

Major findings are:

- The project plays an important role with regard to the establishment of efficient and environmentally friendly self-supply of electric power supply under the Very Small Power

[7] Legal requirements for conducting EIAs are defined under the "Enhancement and Conservation of the Natural Environmental Quality Act of 1992", Part 4, Section 46-51. This Act lists project types that require an EIA. The adoption of a different technology for an existing wastewater treatment plant is not subject of this law.

Producer Scheme in the agro-industry in Thailand. It fully complies with the goals of Thailand on increasing the proportion of renewable energy in energy generation.

- The project activity helps to decrease the level of air-borne particles deriving from the utilization of fossil fuels in common coal and oil fired power plants in Thailand.
- The new wastewater treatment system is more efficient in terms of COD-reduction and thus improves the quality of discharged water.
- The project activity will take place on the existing site of the facility. Hence, no additional land use occurs, which potentially would impact surrounding ecosystems.
- Regarding the utilization of methane gas instead of fossil fuel or bad filtered biomass burners, less harmful pollutants or smoke/soot will be emitted. Also, fugitive methane emissions and odour from the existing open-pond system will be eliminated.
- The project activity will not significantly produce noise. At a distance of 20 m or more, no noise or vibration will be noticeable.

Summary of the initial environmental evaluation (IEE)

This report presents the initial environmental evaluation of "UPOIC Wastewater Treatment for Energy Generation, Krabi" for United Palm Oil Industry Public Company Limited, which is mainly focussed on the impacts on the location of the plant and the surrounding areas. The objective of the project is to replace the existing wastewater treatment system (a traditional, open, anaerobic pond with uncontrolled release of methane into the atmosphere) with a closed system (digester tank with biogas capture and utilization). Primary data was collected through the stakeholder consultation meetings and opinion survey of people living in the nearby area. Maps and other basic information of the study area were also collected as secondary data. The plant's location and surrounding area are comprised of agricultural area; Para- rubber and oil palm plantations, and municipal areas with existing wastewater treatment, the Klong Paksai River, and schools within 2 kilometres. There is a small amount of people (approximately 20 houses) living in the area. To make an initial environmental evaluation, the stakeholder consultation meeting and opinion survey had been organized in order to inform stakeholders and receive comments and concerns from the surrounding people's opinion. Governmental officers from the ministry of industrial works, ministry of Natural Resources and Environment, a representative from the local medical centre, a schools' representative, farmers and people who live nearby the factory area were invited. All information obtained is considered in the study.

The evaluation study found that the applied biogas technology is expected to cause negative impacts during the construction period, for example dust and noise problems, but no negative impacts will be caused during the operation period. Moreover, it was found that the biogas technology would render a positive impact, as the methane emissions will be reduced by the biogas system and thus the prevalence of bad odours caused by the existing wastewater treatment system will be decreased. The wastewater will not release effluent to receiving water; the better treated wastewater and sludge will be used as fertilizer for agricultural purpose in the palm area without harming the groundwater. Furthermore, air pollution will be reducing through the substitution of fossil fuels by biogas in the combustion process. All these effects will improve water and air quality as well as quality of life of humans in the surrounding area.

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

Scope of the local stakeholder consultations

The initial stakeholder consultations, the publications of a non-technical PDD and Initial Environmental Evaluation (IEE), and a final stakeholder meeting have been carried out as stakeholder and public consultations process for CDM. Although there is formally no regulation for public participation under Thai law, it is common practice of the governmental agencies responsible for licensing factories or large projects to call for such. With the initial stakeholder consultations, these requirements are met. The additional steps of local stakeholder consultation have been conducted to meet the requirements of the Gold Standard. UPOIC invited all relevant local NGOs to participate in the meeting via letter, telephone call, and personal contacts. The Sustainable Energy Group of Krabi province (a local NGO) and the representative from Renewable Energy Institute of Thailand Foundation (REITF) were attended and played an important role to motivate stakeholders to express their valuable opinion, requests, and comments to the project developer which lead to a successful understanding between UPOIC and the stakeholders.

A more detailed description of the individual steps is provided below.

Step 1: Initial stakeholder consultations

- The initial local stakeholder consultations were conducted on 26/05/2008 at Nuaklongprachabumroon school's meeting room, Nuaklong district, Krabi province.
- The invitation to the local stakeholder has been distributed by letter, telephone, fax for approximately one month before meeting started.
- Information of the project activities has been provided to all stakeholders through hard copies of non-technical project descriptions written in local language, presentations and explanations by experts of the project proponent. It has been considered all information about technology that will be employed, environmental issues and CDM, and consultation with people living within 2 kilometers from the project site and representatives of governmental authorities and the private sector in Nuaklong area.
- Involved stakeholders include different groups of people. A total of 19 people - governmental officers, school teachers, monks, officers of the Tambon Authority Office (TAO), community leaders, health center officer, factory workers, and villagers – have shown their interest and indicated to further spread the information and gather further comments to the project until second stakeholder consultation.
- Stakeholders have been briefed on the project purpose and interviewed concerning their perception of the impacts of the wastewater treatment plant of the palm oil factory on the environment, social systems and general economics. Their opinions on future impacts through the planned project activity and operation of the plant have been gathered through discussion and questionnaires and evaluated. The results have been summarized in E.2.
- The summary report has been made available on 04/06/2008 (Thai version).
- The summarized initial stakeholder consultation meeting: During the consultation meeting, participants rose up many questions and gave comments about the project activity. The participants gave some opinions that the project owner should distribute more information to the local stakeholders thus they can receive more knowledge about the biogas system. In addition, the documents should be prepared with easy explanation and easy to understand. They wish the project owner will invite people within the community to participate the next stakeholder consultation meeting again.

Step 2: **Publication of a non-technical PDD and IEE in the office and factories of UPOIC PCL. and ENVIMA (Thailand) Co., Ltd. Office**

- Public access to all documents at UPOIC Local Authority, UPOIC Factory in Krabi, UPOIC Office in Bangkok, ENVIMA Office in Bangkok.
- Announcement of the project and access to all documents through press publications "Matichon"- a Thai newspaper and "Daily Express"- a local English newspaper on 30/05/2008, including invitations for comments to the project.
- There was no comment raised.

Step 3: **Final Stakeholder Meeting**

- The second Stakeholder Meeting conducted on 09/07/2008 - 4 weeks after the first publication of the project documents at Nuaklong district, Krabi province.
- The consultations covered the same topic as the first meeting; information of project activities, technology will be employed, environmental issue and CDM. In this time more people living within 2 kilometers from the production site and representative of governmental authorities and private sections in Nuaklong area.
- Involved stakeholders include different groups of people. A total of 22 people - governmental officers, school teachers, monks, officers of the Tambon Authority Office

(TAO), community's leaders, health center officer, factory's workers, general villagers attended.

- The first stakeholder meeting, questions and discussion were briefed for stakeholders before the beginning of the meeting. The results have been summarized in E.2

Step 4: The third Stakeholder Meeting
The third stakeholder meeting was conducted on 22/04/2009 during project validation in order to give a picture of the previous stakeholder consultation and give an opportunity for validators to interview involved stakeholders

E.2. Summary of comments received

Most concerns have been expressed referring the long term operation of wastewater treatment system. They expect that the factory plans a good monitoring system, involved stakeholder in the monitoring plan, and implement accordingly to make sure there will be no environmental effect in the future.

The participants also appreciated this stakeholder meeting to be informed about the factory's activities involving local people in the project and the further development of the company giving opportunities for jobs and business relations.

E.3. Report on consideration of comments received

As pointed out above, no concerns of severe environmental impacts through the project have been expressed. There was a broad understanding of the applied technology and its improvements compared to the environmental impacts to be expected if the existing open pond would be continued.

SECTION F. Approval and authorization

The letter of approval from following parties to be involved in the project activity is available at the time of submitting the PDD to the validating DOE

Date of approval	Party to be involve in the project activity
18/06/2009	Thailand (horst country)
23/07/2014	Switzerland

Appendix 1. Contact information of project participants and responsible persons/ entities

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	United Palm Oil Industry Public Company Limted
Street/P.O. Box	236 Moo4, Bangpoo Industrial Estate, Sukumvit Rd., Praeksa Sub-district
Building	-
City	Muang, Samut Prakarn
State/Region	-
Postcode	10280
Country	Thailand
Telephone	+66 2 709 3610-24
Fax	+66 2 324 0638
E-mail	sawang@lamsoon.co.th
Website	-
Contact person	
Title	Plant manager
Salutation	Mr.
Last name	Lertthirasuntorn
Middle name	-
First name	Sawang
Department	-
Mobile	-
Direct fax	-
Direct tel.	-
Personal e-mail	sawang@lamsoon.co.th

Project participant and/or responsible person/ entity	☒ Project participant ☒ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Swiss Carbon Assets Ltd.
Street/P.O. Box	-
Building	Technoparkstrasse 1
City	Zurich
State/Region	-
Postcode	8005
Country	Switzerland
Telephone	+41 43 501 3550
Fax	+41 43 501 3599
E-mail	registration@southpolecarbon.com
Website	www.thesouthpolecarbongroup.com
Contact person	
Title	Managing Partner

Salutation	Mr.
Last name	Heuberger
Middle name	-
First name	Renat
Department	-
Mobile	-
Direct fax	-
Direct tel.	-
Personal e-mail	registration@southpolecarbon.com

Appendix 2. Affirmation regarding public funding

No official development assistance (ODA) is used in the project activity. No loans from international financial institutions (IFIs) are included. The project financing will be realized by UPOIC its own capital, the Energy Conservation Promotion fund from Energy Policy and Planning Office (EPPO), and the sale of generated CERs to private investors. The ODA declaration letter from UPOIC and EPPO can be found below;

Notification of the Energy Policy and Planning Office

Affirmation of the Financial Assistance Provided under

the Project on Biogas Technology Promotion for Industrial Facilities

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The Energy Policy and Planning Office (EPPO), in the capacity as Secretariat to the Energy Conservation Promotion Fund (the Fund), has formulated a **Biogas Technology Promotion Plan 2008-2011**. To implement the plan, a **Project on Biogas Technology Promotion for Industrial Facilities** has been initiated with a view to inviting potential industrial operators, wishing to invest in the construction of a biogas system for on-site wastewater or solid waste management, to submit proposals for funding from the Fund. The **objective** of the Biogas Technology Promotion Plan/Project is to provide financial assistance to various types of industrial facilities in order to boost wider application of biogas technology, on a voluntary basis, in Thailand. This will be a means to encourage clean energy development, which will bring about reduction of greenhouse gas emissions and also solution to environmental problems in a sustainable manner.

EPPO wishes to hereby affirm that the financial assistance provided under the **Project on Biogas Technology Promotion for Industrial Facilities** is allocated from the Fund, of which the revenue is currently from contributions pursuant to Section 24(2) of the Energy Conservation Promotion Act, B.E. 2535 (1992), as amended up to No. 2, B.E. 2550 (2007), delivered by producers of petroleum at refineries and petroleum importers for distribution within Thailand. The Fund does not receive any money or asset from the private sector, both local and overseas, or from any foreign governments or international organizations, to be used for the implementation of programs/projects under the Fund.

Announced on January 2009

V - Jirapraditkul

(Viraphol Jirapraditkul)

Director-General Energy Policy and Planning Office

Appendix 3. Applicability of methodology and standardized baseline

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Appendix 4. Further background information on ex ante calculation of emission reductions

Baseline information

Table A 3.1: 3 –year historical production rate of UPOIC Palm Oil Mill, during 2006-2008

United Palm Oil Industry Public Company Limited

Month	Year 2006		Year 2007		Year 2008	
	Production rate (tonnes)	Operation day (days)	Production rate (tonnes)	Operation day (days)	Production rate (tonnes)	Operation day (days)
1	5,010	12	13,418	25	19,530	29
2	13,016	21	15,118	24	22,644	28
3	22,706	26	17,915	27	27,034	29
4	31,359	27	16,450	23	22,343	26
5	26,816	30	14,953	23	27,520	31
6	25,793	29	7,124	15	19,974	25
7	17,978	27	4,304	10	22,095	26
8	11,067	23	5,426	14	10,143	18
9	9,970	24	4,710	16	12,489	20
10	10,514	23	9,014	19	11,214	21
11	9,558	24	7,504	18	7,803	16
12	8,700	19	7,797	16	6,705	13
Total	**192,487**	**285**	**123,733**	**230**	**209,494**	**282**
3-year data average of production rate					**175,238**	**tonnes/y**

Table A 3.2: COD inlet and COD final data of the existing system for the project baseline measured for 10-days campaign during June 2009.

Item	Samplig date	Analyser	Sampling ponds									Wastewater Flowrate (M^3)	T-FFB Production	M^3/T-FFB
			Inlet pond 1	Inlet pond 2	Inlet pond 3	Inlet pond 4	Inlet pond 5	Inlet pond 6	Inlet pond 7	Inlet pond 8	Outlet pond 8			
1	6/27/2009	Trang sure	60,670.14	57,463.47	19,624.80	12,762.54	4,396.34	3,751.80	2,712.84	2,177.33	1,738.02	629	1012.50	0.62
2	6/29/2009	Trang sure	59,855.84	67,519.84	18,965.40	9,618.32	4,088.75	3,835.83	3,391.32	2,245.55	1,944.74	281	460.00	0.61
3	6/30/2009	Trang sure	57,283.52	66,652.32	21,414.40	16,730.00	8,508.40	4,187.28	3,279.06	2,405.30	2,223.60	261	442.17	0.59
4	7/2/2009	Trang sure	70,600.00	79,000.00	20,260.00	12,400.00	4,092.70	3,819.42	3,400.39	2,762.08	2,453.67	238	385.28	0.62
5	7/4/2009	Trang sure	60,256.40	59,092.40	20,079.00	13,463.00	4,242.14	3,165.36	2,964.67	2,465.18	2,323.20	302	508.45	0.59
6	7/8/2009	Trang sure	70,470.40	39,494.40	17,391.74	4,394.72	2,174.78	2,023.12	1,920.51	1,916.74	1,877.92	334	608.40	0.55
7	7/9/2009	Trang sure	62,914.80	55,539.47	18,528.12	11,313.12	2,166.43	1,924.00	1,734.94	1,980.30	1,903.02	308	542.80	0.57
8	7/10/2009	Trang sure	77,602.00	56,929.60	16,576.56	12,615.96	3,258.64	1,648.00	1,792.90	1,995.76	1,729.14	217	354.20	0.61
9	7/11/2009	Trang sure	50,244.00	64,744.80	18,412.20	13,769.40	2,144.70	1,669.50	1,583.64	1,713.39	1,770.63	309	551.25	0.56
10	7/13/2009	Trang sure	76,360.00	67,462.40	14,501.76	12,549.60	4,812.67	1,519.90	1,464.12	1,390.42	1,480.05	303	561.20	0.54
Min		Trang sure	50,244.00	39,494.40	14,501.76	4,394.72	2,144.70	1,519.90	1,464.12	1,390.42	1,480.05	217.00	354.20	0.54
Max		Trang sure	77,602.00	79,000.00	21,414.40	16,730.00	8,508.40	4,187.28	3,400.39	2,762.08	2,453.67	629.00	1,012.50	0.62
Avg		Trang sure	64,625.71	61,389.87	18,575.40	11,961.67	3,988.56	2,754.42	2,424.44	2,105.21	1,944.40	318.20	542.63	0.59

Remark : **Analysis Method**
Trang Sure **In- house method : Closed Reflux , Titrimetric Method Based on Standard method for the Examination of Water and Waste water 2005**

Table A 3.3: Historical data of electricity consumed from grid for the palm oil factory during no operation process

Electricity Imported: Year 2006			Electricity Imported: Year 2007		Electricity Imported: Year 2008	
Months	No.of day imported electricity	Amount of Electricity (KWh)	No.of day imported electricity	Amount of Electricity (KWh)	No.of day imported electricity	Amount of Electricity (KWh)
Jan	5	28,596	6	25,671	2	59,803
Feb	6	29,208	4	20,764	0	55,768
Mar	5	30,847	4	13,209	2	54,274
Apr	3	26,290	7	17,371	4	49,702
May	1	27,639	8	27,797	0	39,089
Jun	1	24,003	15	33,971	3	35,894
Jul	3	19,097	21	36,827	5	58,124
Aug	6	25,222	17	46,645	10	53,074
Sep	6	27,792	10	41,861	10	48,124
Oct	7	25,964	11	44,324	10	49,089
Nov	6	29,269	12	47,269	13	50,015
Dec	13	25,454	14	34,020	17	36,499
Total	**62**	**319,381**	**129**	**389,729**	**76**	**589,455**
AVG		**5,151**		**3,021**		**7,756**

Note: During no process operation means the palm oil plant cannot generate electricity while some parts of the factory still need electricity i.e.; office buildings, wastewater pumps, thus, electricity must be imported from the grid.

Thus, the number of days the electricity imported from the grid when the biomass plant is not operated and the total amount of electricity consumed per year are calculated as follows:

3-yr data average		
No.of day imported electricity	89	days/yr
Amount of electricity used a day	5,309	kW/day
Amount of electricity used a year	432,855	kW/y

Table A 3.4: Electricity consumption for operate existing project wastewater treatment plant and the biogas system during crediting period.

Electricity consumption for operate POME project at UPOIC, Krabi		
Existing Plant		
Item	**Electricity Consumption (kw/day)**	**Remark**
1. Feed in pump 11 kw@1 unit opearte at 16 hrs/day	176	Mill Plant operate 16 hr
2. Feed out pump 55 kw@1 unit operate at 16 hrs/day	880	Mill Plant operate 16 hr
Total Electricity consumption that would be affacted by project activity	**1,056**	
During non-operating, electricity will be imported from grid and 3-yr historical data present the day elec imported from grid is 89 days/yr thus, elec consumed per year for WWTP is	***93,984***	***kW/yr***
Project Activity		
Item	**Electricity Consumption (kw/day)**	**Remark**
1. Feed in pump 11 kw@1 unit opearte at 16 hrs/day	176	will be used as the same w/ baseline
2. Suction pump 1 st 11 kw@1 unit operate at 10 hrs/day	110	From waste water pond to biogas pond
3. Suction pump 2 nd 3.7 kw@1 unit operate at 17.5 hrs/day	64.75	From mixing pond 2 to sump 3
4. Mixing pump 3.7 kw@12units operate 5 mins of each hour	88.8	System of Biogas digester
5. Suction pump 3 rd 7.5 kw@1 unit operate at 10 hrs/day	75	From sump 3 to waste water pond (existing)
4. Blower gas for electrical engine unit 11 kw@3units operate at 9 hrs/day	297	Estimate time that can sell electrical to grid
5. Electric fan 1.10 kw@8 units operate at 9 hrs/day	79.2	Estimate time that can sell electrical to grid
6. Feed out pump 55 kw@1 unit operate at 16 hrs/day	880	will be used as the same w/ baseline
Total Electricity consumption	**1,770.75**	
It is assumed that the system run 365 days per year	***646,324***	***kW/yr***

Thai Grid Emission Factor Calculation

The "Tool to calculate the emission factor for an electricity system" (version 02, EB50) is used. As per the tool, the grid emission factor is developed by following six steps.

STEP 1: Identify the relevant electricity system
The project electricity system is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity and that can be dispatched without significant transmission constraints.

As no DNA guidance on delineation of the project electricity system is available in Thailand and there is no layer dispatch system, the grid boundary of the project electricity system is defined at the national level.

STEP 2: Choose whether to include off-grid power in the project electricity system (optional)
Project participants may choose between the following two options to calculate the operating margin and build margin emission factor:
Option I: Only grid power plants are included in the calculation.
Option II: Both grid power plants and off-grid power plants are included in the calculation.
Option I is applied to the project due to there is no reliable of off-grid data.

STEP 3: Select a method to determine the operating margin (OM)
The simple OM (a) is chosen, as the low-cost/must-run (LCMR) resources constitute less than 50% of total grid generation in the average of the five most recent years (see Table A 3.5).
The ex-ante option is chosen as data vintage, so a generation-weighted average OM over the 3 most recent years will be calculated.

Table A 3.5: Grid generation and low-cost/must-run (LCMR) resources from 2003 to 2007, Source: EPPO Energy statistics[8], Table 5.2-2Y and Table 5.2-4Y

Yearly generation [GWh]					
Fuel type	**2003**	**2004**	**2005**	**2006**	**2007**
Natural Gas	85688	90289	94468	94398	98148
Fuel Oil	2434	5468	7640	7808	2967
Diesel Oil	75	233	177	77	28
Lignite	16856	17994	18335	18028	18498
Imported Coal	2445	2411	2280	6441	12383
Power Imports	2473	3378	4372	5152	4488
Hydro	7208	5896	5671	7950	7961
Renewables	1231	1842	1856	2065	2553
LCMR	**8439**	**7738**	**7527**	**10015**	**10514**
Total	**118410**	**127511**	**134799**	**141919**	**147026**
LCMR/Total	**7.13%**	**6.07%**	**5.58%**	**7.06%**	**7.15%**

STEP 4: Calculate the operating margin emission factor according to the selected method
The simple OM emission factor is calculated as the generation-weighted average CO2 emissions per unit net electricity generation (tCO_2/MWh) of all generating sources serving the system, not including low- operating cost and must-run power plants / units.

[8] http://www.eppo.go.th/info/stat/T05_02_02-2.xls and http://www.eppo.go.th/info

It is calculated based on data on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system (Option B). Option B is applicable because no data on fuel consumption or efficiency of individual power plants is available, and only renewable power generation is considered as low-cost/must-run power sources while the quantity of electricity supplied to the grid by these sources is known. Option B can only be used in case Option I has been chosen in step 2.

The simple OM emission factor is calculated as follows:
Option B-Calculation based on total fuel consumption and electricity generation of the system

$$EF_{grid,OMsimple,y} = \frac{\sum_i (FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y})}{EG_y}$$ **(Emission factor: 7)**

Where:

$EF_{grid,OM,simple,y}$	Simple operating margin CO2 emission factor in year *y* (tCO2/MWh)
$FC_{i,y}$	Amount of fossil fuel type *i* consumed in the project electricity system in year *y* (mass or volume unit)
$NCV_{i,y}$	Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ / mass or volume unit)
$EF_{CO2,I,y}$	CO2 emission factor of fossil fuel type *i* in year *y* (tCO2/GJ)
EG_y	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost / must-run power plants / units, in year y (MWh)
i	All fossil fuel types combusted in power sources in the project electricity system in year y
y	Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option), following the guidance on data vintage in step 3.

This calculation is conducted for three years to produce a generation-weighted average OM emission factor. Data for the fuel consumption is sourced from EPPO[9], data for NCV is based on data from a “Study on Electricity Sector Baseline in Thailand”[10] and data for the fuel emission factors comes from IPCC[11].

[9] EPPO Energy Statistics, TABLE 5.4-1Y, http://www.eppo.go.th/info/stat/T05_04_01-2.xls
[10] Study on Electricity Sector Baseline in Thailand, December 2005
[11] IPCC 2006 Vol 2 Table 1.4 (IPCC default values at the lower limit of the uncertainty at a 95% confidence interval)

Table A 3.6: Calculation of simple OM emission factors for 2005 to 2007

2005	Thailand Grid Operating Margin						
Fuel type	**Generation** [GWh]	**Fuel consumpt.**	**Unit**	**NCV** [GJ/Unit]	**EF_CO2,i,y** [tCO2/GJ]	**Emissions** [tCO2]	**EF_simple,y** [tCO2/MWh]
Natural Gas	94,468	1,740	MMSCFD	372,300	0.0543	35,175,649	0.372355174
Fuel Oil	7,640	1,851	million liters	39,770	0.0755	5,557,877	0.727470862
Diesel Oil	177	49	million liters	3,6420	0.0726	129,561	0.731980271
Lignite	18,335	16.57	million tons	10,470,000	0.0909	15,770,050	0.86010636
Imported Coal	2,280	2.073	million tons	26,370,000	0.0895	4,892,518	2.145841401
Power Imports	4,372						
Hydro	5,671						
Renewables	1,856						
Non-LCMR & Imports	12,7272					**Total EF =**	**0.500615582**
LCMR	7,527						
TOTAL	134,799						

2006	Thailand Grid Operating Margin						
Fuel type	**Generation** [GWh]	**Fuel consumpt.**	**Unit**	**NCV** GJ/Unit	**EF_CO2,i,y** [tCO2/GJ]	**Emissions** [tCO2]	**EF_simple,y** [tCO2/MWh]
Natural Gas	94,398	1,766	MMSCFD	372,300	0.0543	35,701,262	0.378199345
Fuel Oil	7,808	1,895	million liters	39,770	0.0755	5,689,993	0.728738899
Diesel Oil	77	21	million liters	36,420	0.0726	55,526	0.721116
Lignite	18,028	15.82	million tons	10,470,000	0.0909	15,056,258	0.835159633
Imported Coal	6,441	3.462	million tons	26,370,000	0.0895	8,170,718	1.268548072
Power Imports	5,152						
Hydro	7,950						
Renewables	2,065						
Non-LCMR & Imports	131,904					**Total EF =**	**0.510238552**
LCMR	10,015						
TOTAL	141,919						

2007	Thailand Grid Operating Margin						
Fuel type	**Generation** [GWh]	**Fuel consumpt.**	**Unit**	**NCV** [GJ/Unit]	**EF_CO2,i,y** [tCO2/GJ]	**Emissions** [tCO2]	**EF_simple,y** [tCO2/MWh]
Natural Gas	98,148	1,715	MMSCFD	372,300	0.0543	34,670,251	0.353244604
Fuel Oil	2,967	780	million liters	39,770	0.0755	2,342,055	0.78936815
Diesel Oil	28	8	million liters	36,420	0.0726	21,153	0.755454857
Lignite	18,498	15.81	million tons	10,470,000	0.0909	15,046,741	0.813425269
Imported Coal	12,383	5.434	million tons	26,370,000	0.0895	12,824,865	1.035683187
Power Imports	4,488						
Hydro	7,961						
Renewables	2,553						
Non-LCMR & Imports	136,512					**Total EF =**	**0.491615653**
LCMR	10,514						
TOTAL	147,026						

Table A3.7: Calculation of average simple OM emission factor

Average Simple OM Emission Factor (tCO2/MWh)			
2005	2006	2007	Average
0.501	0.510	0.492	0.501

The average simple OM emission factor is calculated as 0.501 tCO2/MJ.

STEP 5: Calculate the build margin (BM) emission factor
For the vintage of data, Option 1 is chosen, calculation of the build margin emission factor *ex ante* based on the most recent information available on units already built for sample group *m* at the time of CDM- PDD submission to the DOE for validation. As the crediting period of this project is 10 years fixed, the recalculation of the build margin in the 2^{nd} and 3^{rd} crediting period is not relevant.

Sub-steps to identify the sample group of power units m used to calculate the build margin are: (a)The set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5\text{-units}}$) and determine their annual electricity generation ($AEG_{SET\text{-}\%\text{-units}}$, in MWh).

Table A3.8: Generation of the five power units most recently built

Company	Date of Commission	Fuel Type	Generation 2007 (MWh)
Gulf Power Generation Co.,Ltd.	May-07	Natural Gas	3,590,000
BLCP Power Limited-Unit1/2	Oct.-06	Coal	10,218,000
Bang Pakong	Jan.-05	Natural Gas	1,056,517
Krabi Thermal	Aug.-03	Fuel Oil	1,015,000
Eastern Power - Electric	Mrz.-03	Natural Gas	2,649,000
AEG SET-5units			**18,528,517**

Electrical Power in Thailand 2007, DEDE, Introduction, Table 8, Page 10

The electricity generation for the set of 5 most recently built power unit (SET $_{5\text{-units}}$) the annual electricity generation ($AEG_{set\text{-}\%\text{-}units}$) is 18,528,517 MWh.

(b) the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and comprise 20% of AEG total:

Table A 3.9: Set of power units recently built and comprising >20% of total electricity generation

Company	Date of Commission	Fuel Type	Generation 2007 (MWh)
Gulf Power Generation Co.,Ltd.	May-07	Natural Gas	3,590,000
BLCP Power Limited-Unit1/2	Oct.-06	Coal	10,218,000
Bang Pakong	Jan.-05	Natural Gas	1,056,517
Krabi Thermal	Aug.-03	Fuel Oil	1,015,000
Eastern Power - Electric	Mrz.-03	Natural Gas	2,649,000
Glow IPP Co.	Jan.-03	Natural Gas	5,271,000
Ratchaburi CC Steam	Apr.-02	Natural Gas	13,818,000
AEG SET>20%			**37,617,517**
Total Generation in 2007 (AEG_{total})			**147,025,890**
Total grid % grid contribution of AEG SET>20%			**29,405,178**

Electrical Power in Thailand 2007, DEDE, Introduction, Table 8, Page 10

(c) The set of power units comprising the larger annual electricity is AEG $_{SET>20\%}$, therefore the power units in sub-step (b) are set as sample (SET_{sample}). None of the power units in SET_{sample} started to supply electricity more than 10 years ago. Sub-steps (d), (e) and (f) are ignored.

The build margin emissions factor is calculated as the generation-weighted average emission factor (tCO_2/MWh) of all power units *m* during the most recent year *y* for which power generation data is available, calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$ **(Emission factor: 13)**

Where:

$EF_{grid,BM,y}$	Build margin CO2 emission factor in year *y* (tCO2/MWh)
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y*
$EF_{EL,m,y}$	CO2 emission factor of power unit *m* in year *y* (tCO2/MWh)
m	Power units included in the build margin
y	Most recent historical year for which power generation data is available

The CO2 emission factor of each power plant unit ($EF_{EL,m,y}$) should be determined as per the simple OM. Option A2 is used to calculate the emission factor, based on fuel types and efficiency of the power units.

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} \times 3.6}{\eta_{m,y}}$$

The efficiency published in 'Electrical Power in Thailand 2007, Table 18 ' in Btu is converted to MWh (1Btu = 2.93 x 10^{-7})

Table A3.10: Calculation of $EF_{EL,m,y}$ using Option A2.

Company	Date of Com.	Fuel Type	Generation 2007 (MWh)	Efficiency Btu/MWh	$\eta_{m,y}$ %	EF $_{CO2,m,i}$ tCO2/GJ	EF $_{EL,m,y}$ tCO2/MWh
Gulf Power Generation	May-07	Natural Gas	3,590,000	6,992,000	0.4881	0.0543	0.4005
BLCP Power Limited	Oct.-06	Coal	10,218,000	9,089,000	0.3755	0.0909	0.8715
Bang Pakong	Jan.-05	Natural Gas	1,056,517	8,377,000	0.4074	0.0543	0.4798
Krabi Thermal	Aug.-03	Fuel Oil	1,015,000	8,895,000	0.3837	0.0755	0.7084
Eastern Power-Electric	Mrz.-03	Natural Gas	2,649,000	6,831,000	0.4996	0.0543	0.3912
Glow IPP Co.	Jan.-03	Natural Gas	5,271,000	6,909,000	0.4940	0.0543	0.3957
Ratchaburi CC Steam	Apr.-02	Natural Gas	13,818,000	7,050,000	0.4841	0.0543	0.4038

Electrical Power in Thailand 2007, DEDE, Table 18, Page 22 Efficiency, 2006 IPCC Guidelines for default values for Co2 emission factor

Table A3.111: Calculation of the Build Margin Emission Factor

Company	EG m,y MWh	EF $_{EL,m,y}$ tCO2/MWh	EG m,y * EF $_{EL,m,y}$ tCO2
Gulf Power Generation Co.,Ltd.	3,590,000	0.4005	1,437,692
BLCP Power Limited-Unit1/2	10,218,000	0.8715	8,904,633
Bang Pakong	1,056,517	0.4798	506,915
Krabi Thermal	1,015,000	0.7084	719,000
Eastern Power - Electric	2,649,000	0.3912	1,036,421
Glow IPP Co.	5,271,000	0.3957	2,085,826
Ratchaburi CC Steam	13,818,000	0.4038	5,579,615
∑ EG m,y=	**37,617,517**	**∑ EG m,y * EF EL,m,y=**	**20,270,102**

Build Margin (BM) = 0.539 tCO_2/Mwh

STEP6: Calculate the combined margin emissions factor

The combined margin emission factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$ **(Emission factor: 14)**

w_{OM} and w_{BM} are both 0.5, the default values as per the tool.

Operating Margin	
Margin	Weight
0.501	0.5

Build Margin	
Margin	Weight
0.539	0.5
Combined Margin	
0.520	

Therefore, $EF_{grid,CM,y}$ is 0.520 tCO_2/MWh.

Demonstration, how the period for the 10-day measurement campaign is considered representative for the typical operation conditions and the ambient conditions of the site.

The measurement was conducted in June 2009. The number taken into account from the 10-days measurement are the average values below:

Table A.5.1: Results 10 days Measurement Campaign

10 days Measurement Campaign		
Average m3/t FFB	Wastewater flow rate (m3/day)	FFB Production in tonnes
0.68	318.20	542.63

Table A5.2: UPOIC Production Rate 2006 – 2008

UPOIC Production Rate 2006 to 2008			
Month	Average Year 2006 to 2008		
	Production rate (tonnes)	Wastewater (m^3)	Operation day (days)
1	12,653	7,465	22
2	16,926	9,986	24
3	22,552	13,305	27
4	23,384	13,797	25
5	23,096	13,627	28
6	17,630	10,402	23
7	14,792	8,727	21
8	8,879	5,238	18
9	9,056	5,343	20
10	10,247	6,046	21
11	8,288	4,890	19
12	7,734	4,563	16
Total	175,238	103,390	266
Average per month	14,603	**8,616**	22
Average per day	487	**287**	

As shown in Table 2, June and July are the months of the year, where the season comes to its end. The average monthly wastewater flow rate in June/July varies from 8,727 to 10,402m3. When compared to the average monthly wastewater flow rate per year (8,616m3) it is apparent that both months June and July can be considered as representative for the whole year. The measured average flow rate of 318,20m3/d (10 days campaign) is slightly, but not significant above the average day flow rate (287m^3/d).

Table A5.3: Average Temperature - Trang

30 year Average (1961-1990) - TRANG		
Month	Minimum Temperature (°C)	Maximum Temperature (°C)
January	21.2	31.9
February	21.2	34
March	22	35.2
April	23.1	35.2
May	23.5	33
June	23.3	32.1
July	23	31.6
August	23.1	31.5
September	23	31.2
October	22.9	31.4
November	22.7	30.8
December	22.3	30.7
Average	**22.6**	**32.4**

Monthly Average Trang 2008	
Month	Temperature (°C)
Jan	27.6
Feb	27.6
Mar	28.5
Apr	28.7
May	28.1
Jun	27.9
Jul	27.7
Aug	28.1
Sep	27.6
Oct	27.7
Nov	26.4
Dec	26.5
Average	**27.7**

Thai Meteorological Department http://www.tmd.go.th/en/province_stat.php?StationNumber=48567

Comparing the average monthly temperatures over the whole year it appears that the temperature difference is only marginal. The month June can be considered as representative for the conditions of the site.

Appendix 5. Further background information on monitoring plan

Monitoring Information

The monitoring and operational procedures for the Monitoring Implementation Plan to ensure credibility and verifiability of the CERs achieved are described in the following sections.

- Procedures for handling of emergency situations

The biogas plant has been designed to run continuously for biogas capture and utilization with minimum chance of emergency situations. However, if emergency situations do occur which can result in biogas supply interruptions, the following procedures will be observed:

- Identify the problem
- Mobilize the emergency team to tackle the situation on an urgent basis
- Evaluate all practical alternative solutions
- Implement the action plan that will alleviate the emergency situation
- Review of effectiveness of plan
- Review effects on CERs.
- Implement preventive actions that will prevent similar emergency situations in future

- Procedures for monitoring, measurement and reporting

The Engineering Manager shall ensure that monitoring, measurement and reporting are carried out as required in this PDD. The requirements for data recording, reporting and achieving are identified. The procedures below will be observed:

- All parameters as listed in section B.7 of this PDD will be monitored.
- The monitoring implementation plan will address the following aspects:
  - Monitoring schedule
  - Assignment of responsibilities
  - Sampling methodology
  - Laboratory analysis methodology
  - QA/QC schedule
- Plant operators are responsible for carrying out day-to-day monitoring and recording of instrument readings as required in this PDD. Specific forms have been designed for this recording.
- Plant operators shall carry out sampling of effluents and laboratory staff shall carry out analysis of parameters required in this PDD. Specific forms have been designed for sampling and analysis records.
- Laboratory personnel shall carry out biogas composition analysis as required. Specific form has been designed for this recording.
- Measures to be implemented for ensuring data quality of all parameters to be monitored is:
  - Use of standard methods of analysis;
  - Frequent calibration of monitoring and analytical equipment;
  - Incorporation of QA/QC protocols in routine analysis;
  - Regular crosscheck of internally monitored parameters with external MS ISO/IEC accredited laboratories; and
  - Regular maintenance of monitoring equipment.

- Procedures for maintenance of biogas plant

The Engineering Manager shall ensure that the biogas plant will be maintained in tip-top conditions for continuous operations. Reference shall be made to Biogas Plant Operations Manual and equipment manuals. Specifically, the following procedures will be observed:

- Regular checking and maintenance of all equipment and treatment units, specific forms for recording of plant status have been incorporated.
- Provide standby equipment wherever appropriate for reducing downtime.
- Close monitoring of required parameters to ensure optimum treatment efficiency is achieved.

- Specific forms for sampling and monitoring records have been incorporated.

- Procedures for handling of day-to-day records

- The specific procedures for handling day-to-day records are:
- The plant operators shall submit day-to-day records for biogas monitoring to Engineering Manager for review so that any unusual conditions can be identified and remedied promptly.
- The monitoring records will be kept secure at the Biogas plant site.
- The Engineering Manager shall input monitoring records as electronic achieve on monthly basis while keeping raw data for verification in accordance with CDM requirement.

- Procedures for handling of monitoring data adjustments and data uncertainties

The specific procedures for handling of monitoring data adjustments and data uncertainties are:

- The monitoring plan shall incorporate QA/QC protocols so as to enhance the confidence of results generated and to reduce the data uncertainties.
- When uncertainties emerge (such as unusual data), the monitoring data shall be subject to immediate checks such as repeat testing or verification with external parties.
- Any departure of monitoring data from those normally observed or previously estimated should be verified. Once verified, the data should be reflected in the reported CERs.
- The Engineering Manager will immediately report any CERs data adjustment to the Plant Manager will in turn report to the Executive Director.
- The monitoring data shall be subject to internal and third party verification.

- Procedures for review of reported results

- The specific procedures for review of reported results are:
- The Engineering Manager shall submit the monitoring records to the Plant Manager for review weekly.
- Based on the monitoring records, the Plant Manager shall provide the direction for plant operation and monitoring in keeping up with obligations under the project activity.
- The top management shall review and approve reported results on a quarterly basis.

- Procedures for internal audit of GHG project based on operational requirements

United Palm Oil Industry PCL shall, in accordance with a predetermined schedule and procedure, conduct yearly internal audits of the project activities to verify that its operations continue to fulfill the requirements of the PDD. The procedures below are observed:

- The internal audit programme shall address all monitoring and operational requirements.
- The Plant Manager shall plan and organize audits as required by the schedule and requested by management from time to time.
- Audits shall be carried out by trained and qualified personnel who are independent of the operations and monitoring.
- Audits shall be guided by an audit checklist.
- The internal auditor will report the audit findings to the Plant Manager.

- Procedures for project performance review

In accordance with a predetermined schedule and procedure, the top management of United Palm Oil Industry PCL shall conduct a yearly performance review of the biogas plant operations and monitoring to ensure their continuing suitability and effectiveness, and to introduce necessary changes and improvements in meeting with the obligations under the PDD. The review shall take account of, among others:

- Recent monitoring data
- Validation and verification reports from DOE
- Suitability of monitoring procedures and schedule
- Reports from managerial and operation staff
- Outcome from recent internal audits
- Recommendation for improvement in monitoring and operations

- Procedures for corrective actions in order to provide more accurate future monitoring and reporting

United Palm Oil Industry PCL has established a procedure and designate personnel for implementing corrective actions to provide more accurate future monitoring and reporting. The procedures below are observed.

- Identification of doubtful monitoring data
- Investigation to determine the root cause(s) of the problem (cause analysis)
- Identification of potential correction actions
- Selection and implementation of actions that most likely to eliminate the problem and to prevent recurrence
- Monitor the results to ensure that corrective actions taken have been effective

The calibration interval of the monitoring equipment

ID. No.	Equipment	Calibration Interval
1a, 1b, 7	Magnetic inductive flow meter	As per manufacturer's recommendations, or at least once per year.
2,3,4,5,6,8,9	Laboratory Equipment	As per "Guideline for the determination of calibration intervals of measuring instruments" of the "Intentional Laboratory Accreditation Cooperation" (ILAC) and the "Organization International de Methologies Legale" (OLML)
10,14,19	Gas flow meter	As per manufacturer's recommendations, or at least once per year.
11	CH_4 portable analyzer	As per manufacturer's recommendations, or at least once per year.
12,13,18	Temperature and pressure sensor	As per manufacturer's recommendations, or at least once per year.
15,20	Continuous gas analyzer	As per manufacturer's recommendations, or at least once per year.
16	Type N thermocouple	As per manufacturer's recommendations, or at least once per year.
17	Gnerator	As per manufacturer's recommendations, or at least once per year.
21,22,23,24,25	Power meter	Periodically compared by official organization and/or authorized company.

Appendix 6. Summary of post registration changes
