CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD)
Version 03 - in effect as of: 22 December 2006

CONTENTS

Annexes

Revision history of this document

Version Number	Date	Description and reason of revision
01	21 January 2003	Initial adoption
02	8 July 2005	• The Board agreed to revise the CDM SSC PDD to reflect guidance and clarifications provided by the Board since version 01 of this document. • As a consequence, the guidelines for completing CDM SSC PDD have been revised accordingly to version 2. The latest version can be found at <http://cdm.unfccc.int/Reference/Documents>.
03	22 December 2006	• The Board agreed to revise the CDM project design document for small-scale activities (CDM-SSC-PDD), taking into account CDM-PDD and CDM-NM.

SECTION A. General description of small-scale project activity

A.1 Title of the small-scale project activity:

Metro Group Energy WWT Project
Version: 1.0
Date: 07/10/2010

A.2. Description of the small-scale project activity:

"Metro Group Energy WWT Project", hereafter referred to as 'the Project' is being implemented by Metro Group Energy Co., Ltd (MGE) at Chaophyapeuchrai 2999 (Kamphaengphet) Co., Ltd., a tapioca starch processing plant in the north of Thailand. The starch plant has a design starch production capacity of 250 tonne per day.

Prior to the project implementation, the wastewater from the starch plant has been treated through open anaerobic lagoons. The open anaerobic lagoons are sufficient to treat the waste water and comply with the environmental regulation of Thailand.

The purpose of project activity is to treat the waste water from the starch factory to generate biogas. The project activity entails the installation of an anaerobic wastewater treatment facility, based on an "Up flow Anaerobic Sludge Blanket" (UASB) system, to complement the existing open lagoon based system. The implementation of the project activity will enable the generation and capture of biogas which will be used for electricity and thermal energy generation. A part of the biogas will be fed to the gas engine having a capacity of 985kW_{el}. The remaining biogas will be sent to the thermal oil boiler of capacity 4,060kW_{th} to generate heat energy which will be utilised in the starch drying process.

The project will contribute significantly in the reduction of GHG emissions by combusting biogas which is rich in methane (a greenhouse gas). In the absence of the project activity, methane would have been emitted to the atmosphere. Furthermore, the electricity generated by the gas engine will be exported to the national grid which will displace electricity generated from fossil fuels in the grid. The biogas utilised in the thermal oil boiler will replace the usage of bunker oil thereby contributing further in the reduction of GHG emissions. In the case of an emergency, excess biogas may be flared in an enclosed flare system.

Sustainable Development Benefits of the Project
According to the definition of sustainable development criteria for CDM projects by the Thai DNA[1], the project will directly contribute to sustainable development in Thailand in several ways as shown below:

Natural Resources and Environment benefits

- Reduction of greenhouse gas emissions through the avoided electricity generation by other grid connected power plants,
- Reduction of offensive odors,
- Reduction in usage of non-renewable energy, i.e. fossil fuel for grid electricity generation.

[1] http://www.tgo.or.th/english/index.php?option=com_content&task=view&id=15&Itemid=1

Social benefits

- Involvement of local communities through a public participation meeting, in which people have a opportunity to learn about and project and present their own perspective and doubts during the meeting,
- Increased employment by employing full time staff to operate the system.

Technology transfer benefits

- Promoting technological excellence in Thailand, which could be replicated across Thailand and the region,
- Necessary training on the management of the biogas plant will be provided to staff.

Economic benefits

- Reduction in dependency on fossil fuel for electricity generation while at the same time enhancing energy security by increasing diversity of supply,
- Generating incomes to the local community through additional local employment,

A.3. Project participants:

Name of Party involved (*) ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Thailand (host)	Metro Group Energy Co., Ltd. (private entity)	No
Switzerland	South Pole Carbon Asset Management Ltd. (private entity)	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

A.4. Technical description of the small-scale project activity:

A.4.1. Location of the small-scale project activity:

A.4.1.1. Host Party(ies):

Thailand

A.4.1.2. Region/State/Province etc.:

Kamphaengphet province

A.4.1.3. City/Town/Community etc:

Prankatai sub-district, Prankatai district.

A.4.1.4. Details of physical location, including information allowing the unique identification of this small-scale project activity :

Physical address of site:
Metro Group Energy Company Limited
111 Moo 7, Prankatai sub-district,
Prankatai district, Kamphaengphet Province,
62110, Thailand

The exact coordinates of the project are:
- Latitude: 16°36'53.94"N
- Longitude: 99°31'8.13"E

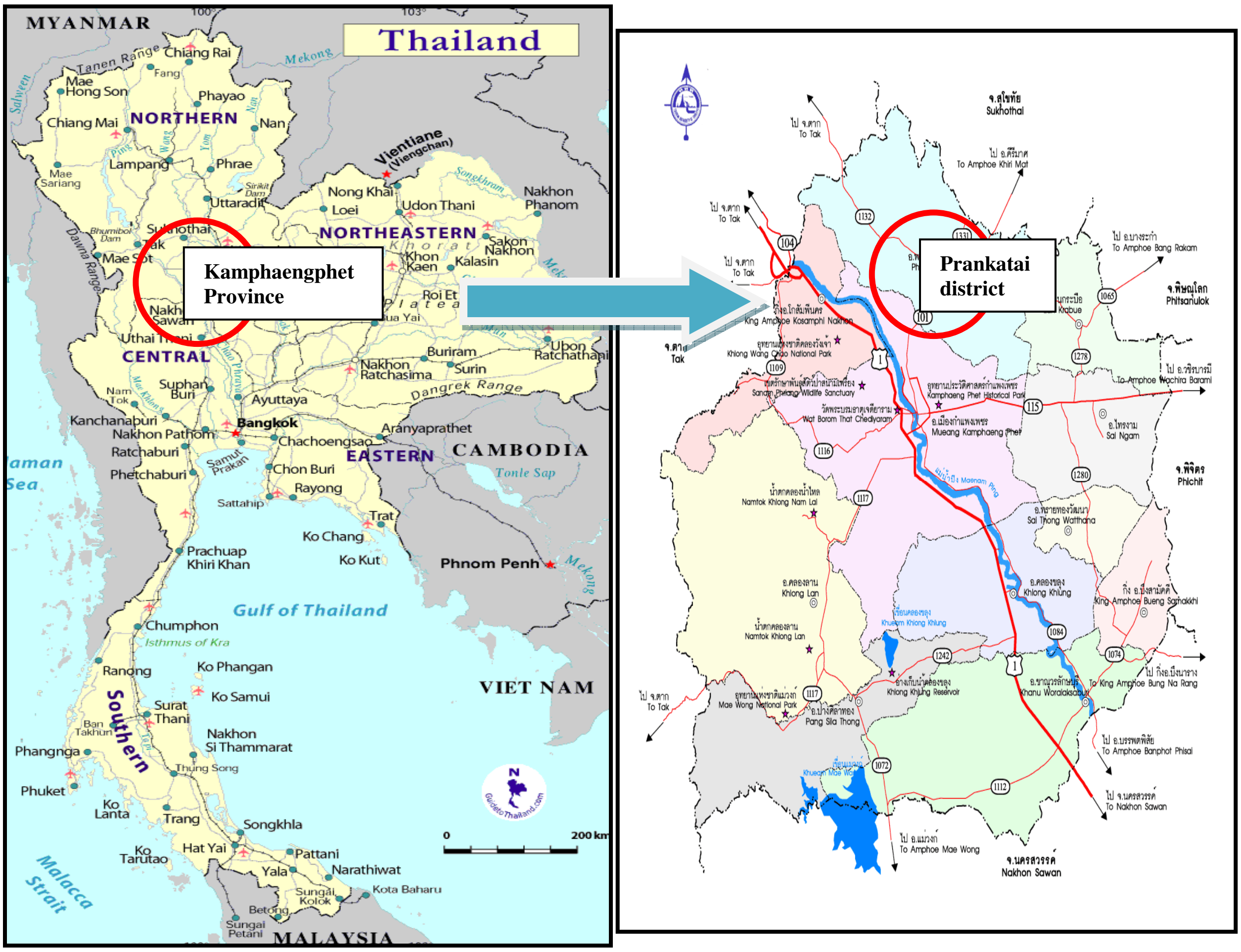

Figure 1: Maps showing the location of the Project activity

A.4.2. Type and category(ies) and technology/measure of the small-scale project activity:

Categories of project activity:

According to Appendix B to the *Simplified Modalities and Procedures for Small-Scale CDM Project Activities*, the project type and category are as follows:

Methane avoidance component:

Type III:	Other project activities
Category M:	Methane Recovery
Sectoral Scope 13:	Waste handling and disposal

Heat generation component:

Type I:	Renewable energy projects
Category C:	Thermal energy for the user
Sectoral Scope 1:	Energy industries (renewable /non-renewable sources)

Electricity generation component:

Type I:	Renewable energy projects
Category D:	Electricity generation for a system
Sectoral Scope 1:	Energy industries (renewable /non-renewable sources)

Technology to be employed by the project activity:

The starch factory has a maximum production capacity of 250 ton starch/day. The production of starch generates wastewater which should be treated. The starch factory and the biogas plant (the project) are located adjacent to each other. The exact location is provided in section A.4.1.4.

Under the Project activity, the effluent from the starch plant will be fed to the anaerobic digester with biogas recovery. This entails the installation of an anaerobic wastewater treatment facility, based on an "Up flow Anaerobic Sludge Blanket" (UASB) system that is described in more detail below:

Pre-treatment

There are two sources of wastewater- one from the separator and the other from cassava washing process of the starch factory. The wastewater effluent first passes through a screen extractor, in order to remove coarse particles (roots, pulp, and peels). After the screening, the wastewater flows into an acid pond for removal of settle-able solids. Through the use of Acedogenic bacteria under the acidification process, wastewater is converted into Volatile Fatty Acids (VFA). This also results in the pH of the wastewater dropping significantly. The wastewater from the acidic pond flows into an adjacent pump pit, equipped with submerged pumps, pumping the wastewater continuously to the next stage. The acidic wastewater has to be neutralized under the pH adjustment process with hydrated lime. Lime powder is directly added in a lime mixing basin, which receives the wastewater from the acidification process. The wastewater from the cassava washing will be sent to the sedimentation pond in order to screen and prevent some slits.

In the next adjacent basin, grit (including impurities present in the lime) is trapped and removed periodically. From the grit trap, the wastewater pre-treated is then pumped into the biogas digester

through an influent distribution system at the bottom of the reactor. The methane reactor is of the UASB type, with a special "3 phase separator" device at the top of the reactor.

Anaerobic treatment

In the UASB, the wastewater rises through an expanded bed of anaerobic active methanogenic sludge (the so called "sludge blanket") undergoing an anaerobic biological process, where organic matter is converted into biogas and sludge. An internal device at the top of the reactor separates the mixed liquor into clarified wastewater, biogas and sludge. With an average inlet[2] COD of 15,053 mg/l and a COD removal efficiency of around 95%, the production of biogas is expected at 32,000 m^3 per day (with the methane percentage being at around 65%). This represents the expected level of activity.

Biogas handling

The project activity plans to utilise the biogas for thermal and power generation purposes. Part of the biogas captured will be combusted for the starch drying process in an existing thermal oil boiler that is equipped with a dual fuel firing burner. The thermal oil boiler is designed with a rated capacity of 4,060 kW_{th}. In order to utilise the biogas for electricity generation, it will be treated to reduce the sulphur content by the hydrogen sulphide scrubber. The biogas will then be used as fuel in a power generator (gas engine) that consists of a biogas fired engine and an alternator, with an installed capacity of 985 kW_{el}. The electricity generated will be exported to the grid. In addition, there is a gas storage system at the site to ensure a supply of biogas in the event of an emergency. The excess biogas will be flared by enclosed flaring system.

Post-treatment system

Effluent from the UASB system is collected in a sedimentation pond prior to discharge to the aerobic ponds. The post treatment system will receive the wastewater of COD lower than 1,000 mg/l. The treated wastewater from the last open pond will be used either for washing of raw tapioca or for irrigation purpose within the plant's boundary.

Technology transfer and training:

The UASB system is developed by Papop Co,Ltd., local technology provider. The biogas gas engine will be provided by a Spanish manufacturer (Gauascor) and the flaring equipments (Automatic Enclosed Flare 1,000 Nm^3/hr) are designed and manufactured by the technology provider of the host country (Gas Step Co., Ltd.). Papop will provide one year follow-up and training as per the contract in order to support the project activity.

Environmentally safe and sound technology:

The technology is expected to be environmentally safe. The project construction is conducted according to the national safety standard. The project complies with environmental regulation of the country as well. The critical parameters for smooth operation of the system will be monitored as per the recommendations of the technology provider, these are for example, pH, volatile fatty acids and alkalinity. The biogas will be collected in safety closed concrete reactors with adequate coating, multiple controls of gas pressure, gas flow, CH_4 content and extended safety devices such as automatic blowout,

[2] Data from COD campaign

flame arrestor, pressure control and switches. The project activity will use enclosed flare which is foreseen for safety and start-up reasons.

The process diagram is presented as Figure 2.

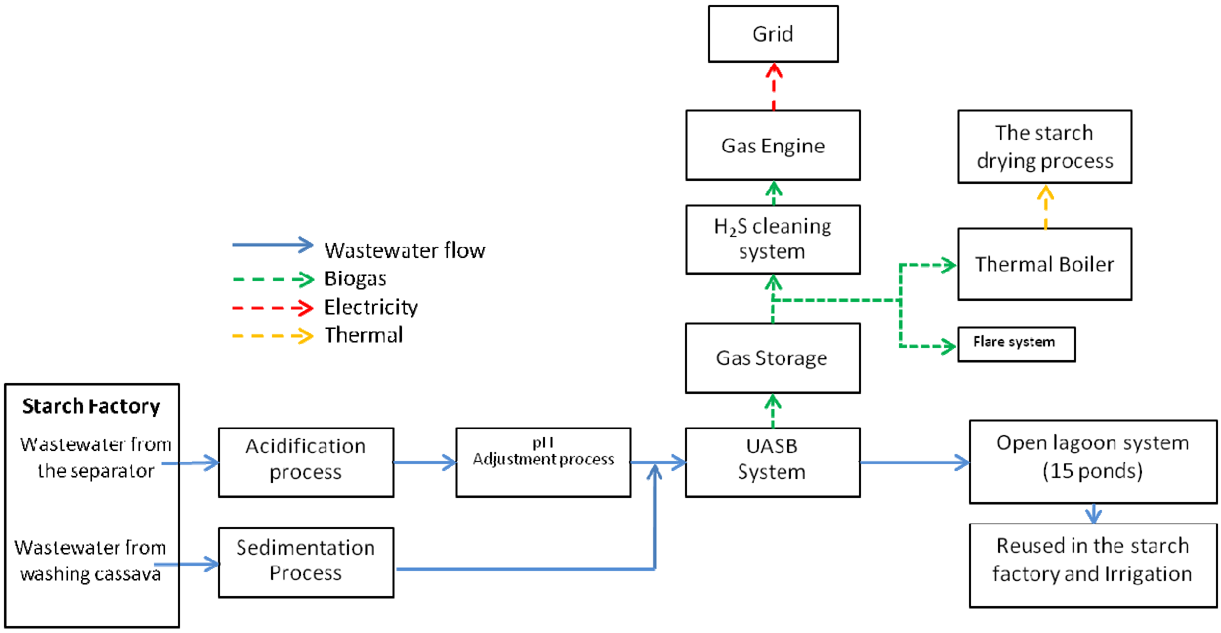

Figure 2: Process Flow Diagram

A.4.3 Estimated amount of emission reductions over the chosen crediting period:

A seven year renewable crediting period has been selected for the project activity.

Years	Annual estimation of emission reductions in tonnes of CO_2e
2011	35,819
2012	41,789
2013	47,758
2014	47,758
2015	47,758
2016	47,758
2017	47,758
Total emission reductions (tonnes of CO_2e)	**316,398**
Total number of crediting years	**7**

Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	**45,199**

A.4.4. Public funding of the small-scale project activity:

The Project receives no public funding from Annex I Parties.

A.4.5. Confirmation that the small-scale project activity is not a debundled component of a large scale project activity:

In reference to the "Guidelines on assessment of debundling for SSC project activities", version 03, EB54 (Annex 13)"

"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 an application to register another small-scale CDM project activity:

(a) With the same project participants;

(b) In the same project category and technology/measure; and

(c) Registered within the previous 2 years; and

(d) Whose project boundary is within 1 km of the project boundary of the proposed small- scale activity at the closest point. "

The project participants confirm that there is no registered small-scale CDM project activity or an application to register another small-scale CDM project activity with the same project participants and whose project boundary is within 1 km of the Project boundary of the proposed small-scale activity, at the closest point. Therefore the project activity is not a de-bundled component of a large-scale project activity.

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the small-scale project activity:

The following methodologies are applicable to the project activity:

Methane avoidance component:

AMS III.H: "Methane Recovery in Wastewater Treatment" (Version 15)

Thermal displacement component:

AMS I.C: "Thermal energy production with or without electricity" (Version 18)

Electricity generation component:

AMS I.D: "Grid connected renewable electricity generation" (Version 16)

For more information on these methodologies, please refer to the link:
http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html

The latest version of the following tools will also be used in this Project activity:

- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", version 01;
- "Tool to determine project emissions from flaring gases containing methane", version 01;
- "Tool to calculate the emission factor for an electricity system", version 02.

B.2 Justification of the choice of the project category:

In the following section, it is demonstrated that the approved methodology AMS III.H. (Version 15), AMS.I.C (Version 18), and AMS I.D. (Version 16) are applicable following to applicability conditions described in table 1, 2 and 3, respectively.

Table 1: Applicability of AMS III.H.

Applicability Criteria		Project eligibility
1	*This project activity comprises measures that recover biogas from biogenic organic matter in wastewaters by means of one, or a combination, of the following options:* ***(a)*** *Substitution of aerobic wastewater or sludge treatment systems with anaerobic systems with biogas recovery and combustion;* ***(b)*** *Introduction of anaerobic sludge treatment system with biogas recovery and combustion to wastewater treatment plant without sludge treatment;* ***(c)*** *Introduction of biogas recovery and combustion to sludge treatment system;* ***(d)*** *Introduction of biogas recovery and combustion to an existing anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an on site industrial plant;* ***(e)*** *Introduction of anaerobic wastewater treatment with biogas recovery and combustion, with or without anaerobic sludge treatment, to an untreated wastewater stream;* ***(f) Introduction of a sequential stage of***	In the absence of the Project activity the wastewater would have been treated in existing open lagoons (all with depth greater than 2 meters) under anaerobic condition without biogas recovery. The Project activity involves the installation of a UASB (Up flow Anaerobic Sludge Blanket) system to treat high COD concentration of wastewater generated and to capture biogas. **Therefore, the Project activity satisfies the applicability criterion (f).**

Applicability Criteria		Project eligibility
	wastewater treatment with biogas recovery and combustion, with or without sludge treatment, to an anaerobic 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 methane recovery).	
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;* (b) *Ambient temperature above 15°C, at least during part of the year, on a monthly average basis;* (c) *The minimum interval between two consecutive sludge removal events shall be 30 days.*	In the baseline scenario, the wastewater was treated in existing open anaerobic lagoons. - The depth of the lagoons is greater than two meters and do not have any aeration. - On monthly average basis the ambient temperature[3] in Kamphaengphet is above 15°C. - No sludge has been removed from the anaerobic lagoons. As mentioned above, the project activity satisfies the conditions for the anaerobic lagoons for the baseline system.
3	*The recovered biogas from the above measures may also be utilised for the following applications instead of combustion/flaring:* (a) ***Thermal or electrical energy generation directly; or*** (b) *Thermal or electrical energy generation after bottling of upgraded biogas; or* (c) *Thermal or electrical energy generation after upgrading and distribution:* (i) *Upgrading and injection of biogas into a natural gas distribution grid with no significant transmission constraints; or* (ii) *Upgrading and transportation of biogas via a dedicated piped network to a group of end users; or* (d) *Hydrogen production.*	The project activity will capture the biogas and further utilise it for heat and power generation in thermal oil boiler and gas engine.
4	*If the recovered biogas is used for project activities*	The recovered biogas will be used for

[3] The average ambient temperature of Province by the Energy Policy and Planning Office, Ministry of Energy. Available from: http://www.ereport.energy.go.th/weather.html.

Applicability Criteria		Project eligibility
	*covered under paragraph **2 (a), that component of the project activity can use a corresponding category under type I**.*	heat and power generation as mentioned above. The heat generation component will utilise the methodology AMS IC and the electricity generation component will utilise the methodology AMS I.D**.**
5	*New facilities (Greenfield projects) and project activities involving a change of equipment resulting in a capacity addition of the wastewater or sludge treatment system compared to the design 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 methodologies concerning these topics.*	This is not a Greenfield project and it does not involve capacity expansion of the plant.
6	*The location of the wastewater treatment plant shall be uniquely defined as well as the source of generating the wastewater and described in the PDD.*	The location of the project activity and the source of waste water are clearly identified in section A.4.1.4and section A.4.2.
7	*Measures are limited to those that result in aggregate emission reductions of **less than or equal to 60 kt CO_2** equivalent annually from all type III components of the project activity.*	The annual emission reductions from all *type III* component of the project activity is calculated at 48,708 tCO_2e which is below the limit of 60kt CO_2.

Table 2: Applicability of AMS I.C.

Applicability Criteria		Project eligibility
1	***This category comprises renewable energy technologies that** supply users[4] with thermal energy that displaces fossil fuel use. **These units include** technologies such as solar thermal water heaters and dryers, solar cookers, energy derived from renewable biomass and other **technologies that provide thermal energy that displaces fossil fuel.***	The project activity will capture biogas (a renewable fuel) from the project's wastewater treatment system and utilise a part of it for thermal energy generation to substitute fossil fuel in the drying process of the starch factory. Therefore, the project activity meets this applicability criterion.
2	*The total installed/rated thermal energy generation capacity of the project equipment is equal to or **less than 45 MW thermal[5] .***	The thermal generation capacity of the thermal oil boiler is 4,060 kW_{th} which is less than 45 MW thermal as per the applicability criteria.
3	*For co-fired[6] systems, the total installed thermal energy generation capacity of the project*	Thermal oil boiler is a duel fuel boiler. The total installed thermal energy generation

[4] E.g., residential, industrial or commercial facilities.

[5] Thermal energy generation capacity shall be manufacturer's rated thermal energy output, or if that rating is not available the capacity shall be determined by taking the difference between enthalpy of total output (for example steam or hot air in kcal/kg or kcal/m^3) leaving the project equipment and the total enthalpy of input (for example feed water or air in kcal/kg or kcal/m^3) entering the project equipment. For boilers, condensate return (if any) must be incorporated into enthalpy of the feed.

Applicability Criteria		Project eligibility
	equipment, when using both fossil and renewable fuel ***shall not exceed 45 MW thermal.***	capacity is 4,060 kW which is less than 45MW thermal.
4	*In case electricity and/or steam/heat produced by the project activity is delivered to another facility or facilities within the project boundary, a contract between the supplier and consumer(s) of the energy will have to be entered into specifying that only the facility generating the energy can claim emission reductions from the energy displaced.*	The project activity does not deliver directly the heat to the starch factory. However, a part of biogas which is generated from the methane avoidance component of the project is delivered which is combusted in the boiler in the starch factory. The contract for biogas supply is available.
5	*Project activities that seek to retrofit or modify an existing facility for renewable energy generation are included in this category.*	The project activity does not involve any retrofit or modification of an existing facility.
6	*In the case of project activities that involve the addition of renewable energy units at an existing renewable energy facility, the total capacity of the units added by the project should comply with capacity limits in paragraphs 4 to 6 (of the methodology) and should be physically distinct*[7] *from the existing units.*	The Project activity does not involve an addition of renewable energy units at an existing renewable energy facility; thus this criterion is not relevant.

Table 3: Applicability of AMS I.D.

Applicability Criteria		Project eligibility
1	*This category comprises* ***renewable energy generation units****, such as photovoltaic, hydro, tidal/wave, wind, geothermal and renewable biomass* ***that supply electricity to a national or a regional grid.*** *Project activities that displace electricity from an electricity distribution system that is or would have been supplied by at least one fossil fuel fired generating unit shall apply AMS-I.F.*	The project activity will use a part of biogas (a renewable fuel) which is captured from the methane avoidance component of the project activity to generate electricity in the gas engine. The electricity generated will be exported to the national grid. Therefore, the project activity satisfies this applicability condition.
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);*** *(b) involve a capacity addition ; (c) involve a retrofit of (an) existing plant(s); or (d) involve a replacement of*	The project activity will install a power plant at a site where there was no renewable energy power plant operating prior to the implementation of the project.

[6] Co-fired system uses both fossil and renewable fuels.

[7] Physically distinct units are those that are capable of producing thermal/electrical energy without the operation of existing units, and that do not directly affect the mechanical, thermal, or electrical characteristics of the existing facility. For example, the addition of a steam turbine to an existing combustion turbine to create a combined cycle unit would not be considered “physically distinct”.

	(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 new unit co-fires fossil fuel, the capacity of the entire unit shall not exceed the limit of 15 MW.*	The project activity entails in the installation of a gas engine which operates only on biogas. Therefore, the project has only the renewable component and has a total generation capacity of 985 kW_e which is less than 15MW.
3	*Combined heat and power (co-generation) systems are not eligible under this category.*	The project activity involves only electricity generation.
4	*In the case of project activities that involve the addition of renewable energy generation units at an existing renewable power generation facility, the added capacity of the units added by the project should be lower than 15 MW and should be physically distinct from the existing units.*	The project activity does not involve addition of renewable energy generation at an existing renewable power generation facility. The project activity implements a new gas engine at a location where there was no power generation.
5	*In the case of retrofit or replacement, to qualify as a small-scale project, the total output of the retrofitted or replacement unit shall not exceed the limit of 15 MW.*	The project activity does not involve any retrofitting or replacement.

Therefore, from the above description, the different components of the project activity meet all the relevant applicability conditions of the respective methodologies.

B.3. Description of the project boundary:

As per the AMS III.H, AMS I.C and AMS I.D., the Project boundary shall respectively include the following:

Project boundary for AMS III.H is given as per the paragraph 14 of the methodology:

> *"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."*
>
> As per paragraph 15 of the methodology, implementation of the project activity at a wastewater and/or sludge treatment system will affect certain sections of the treatment systems while others may remain unaffected. The waste water treatment system which is affected due to the implementation of the project is the open anaerobic lagoon system. The waste water from the starch factory will no longer be fed directly in the open anaerobic lagoons. The waste water will be first treated in the biogas reactor before being fed to the open lagoons. The COD levels entering the open lagoons in the project activity will be much lower than those in the baseline scenario. The resulting methane emissions will be considered under the project emissions. Furthermore, the electricity consumption in the baseline and project wastewater treatment system will also be affected. These emission sources are also dealt separately in the baseline and project emission calculations. In the project activity, the pre-treatment process unit, the biogas system and the subsequence open lagoon system (post treatment) including the utilisation of effluent are

covered within the boundary. The exclusion of sections or the components of the treatment system affected by project activity are taken into account for ex ante GHG calculation and further justified in the section B 6.3.

Project boundary for AMS I. C as per paragraph 12 of the methodology is given as:

"The physical, geographical site of the project equipment producing the renewable energy delineates the project boundary. The boundary also extends to the industrial, commercial or residential facility, or facilities, consuming energy generated by the system and the processes or equipment that is affected by the project activity."

Project boundary for AMS I.D as per paragraph 9 in the methodology is given as:

"The physical, geographical site of the renewable generation source delineates the project boundary."

The GHG gases considered in the analysis are given in the following table:

	Source	Gas		Justification / Explanation
Baseline	Wastewater treatment processes	CH_4	Included	The major source of emissions in the baseline from open lagoons (decay of organic matter in anaerobic conditions).
		N_2O	Excluded	Excluded for simplification. This is conservative.
		CO_2	Excluded	CO2 emissions from the decomposition of organic waste are not accounted for
	Electricity consumption/generation	CO_2	Included	Electricity is consumed for the operation of the wastewater treatment in the baseline scenario. The electricity generated with biogas under the project activity will displace grid electricity.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	Thermal energy generation	CO_2	Included	The thermal energy will be generated by biogas under the project activity displacing fossil fuels in the baseline
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
Project activity	Wastewater treatment processes	CH_4	Included	The treatment of wastewater under the project activity may cause different emissions: (i) Methane emissions from lagoons (ii) Physical leakage of methane from the digester system (iii) Methane emissions from flaring
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted for
		N_2O	Excluded	No land application of sludge
	On-site electricity use	CO_2	Included	If the biogas reactor uses electricity generated from the biogas fired gas engine, this will be excluded. However, if the electricity is sourced from the grid, this will be included.
		CH_4	Excluded	Excluded for simplification.

		N_2O	Excluded	Excluded for simplification
	On-site fossil fuel consumption	CO_2	Excluded	No on-site fossil fuel consumption in the project activity
		CH4	Excluded	No on-site fossil fuel consumption in the project activity
		N20	Excluded	No on-site fossil fuel consumption in the project activity

In addition, the exclusion of sections or components of the system affected by project activity including physically delineating unit or process based on the description provided in section A4.2 are also presented in the figure 3 of project boundary.

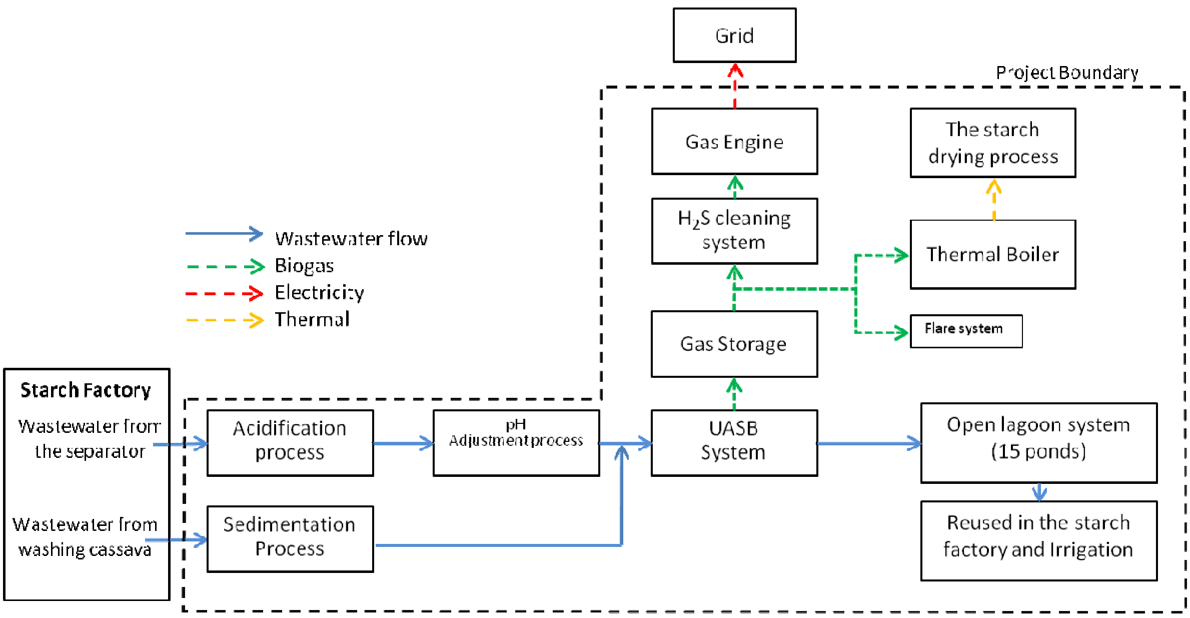

Figure 3: Project boundary

B.4. Description of baseline and its development:

Methane avoidance component:

The baseline scenario comprises of 15 open anaerobic lagoons, which were used to treat wastewater from the starch production process without methane recovery prior to the implementation of the project activity. The open lagoons of existing wastewater treatment system had anaerobic condition according to the applicability criteria given in paragraph 2 of methodology applied as described in Table 1 in section B.2. The descriptions of the open lagoons will be provided to the DOE.

Table 4: Characteristics of the baseline open lagoons at the starch facility

No.	Depth (m)

No.	Depth (m)
1. Open Anaerobic Lagoon 1.1	5.00
2. Open Anaerobic Lagoon 1.2	5.00
3. Open Anaerobic Lagoon 2.1	5.10
4. Open Anaerobic Lagoon 2.2	5.10
5. Open Anaerobic Lagoon 3.1	5.20
6. Open Anaerobic Lagoon 3.2	5.20
7. Open Anaerobic Lagoon 4.1	5.30
8. Open Anaerobic Lagoon 4.2	5.30
9. Open Anaerobic Lagoon 5.1	3.40
10.Open Anaerobic Lagoon 5.2	3.40
11.Open Anaerobic Lagoon 6.1	2.50
12.Open Anaerobic Lagoon 6.2	2.50
13.Open Anaerobic Lagoon 7.1	2.10
14.Open Anaerobic Lagoon 7.2	2.10
15.Open Anaerobic Lagoon (Collecting Pond)	3.90

Source: Chaophyapeuchrai 2999 (Kamphaengphet) Co., Ltd.,

Therefore, baseline emissions for the methane avoidance component will be the emissions from the open anaerobic lagoons which would have continued to operate to treat the waste water. As per the guidance given in the paragraph 18 of the methodology, baseline emissions shall be determined using historical records of at least one year prior to the project implementation. However, due to non-availability of one year historical data and following the guidance given in paragraph 19 of the methodology, the parameters necessary for the estimation of baseline emissions are based on a 10 day measurement campaign. Average values from the measurement campaign are used and the result is multiplied by 0.89 to account for uncertainty.

Thermal displacement component:
The project activity generates biogas as a part of waste water treatment system equipped with biogas recovery. A part of this biogas will be sent to the thermal oil boiler to generate heat for the starch drying process. In the absence of project activity, the starch drying process would have obtained heat from the existing boiler using bunker oil. Therefore, in the baseline scenario, consumption of bunker oil in the boiler would have lead to GHG emissions.. According to paragraph 13 of AMS I.C (Version 18), the baseline for the proposed project activity is the fuel consumption of the technology that would have been used in the absence of the project activity times an emission coefficient for the fossil fuel displaced.

Electricity generation component:
In accordance to Paragraph 10 of the methodology AMS I.D. (Version 16):

> *"If the project activity is the installation of a new grid-connected renewable power plant/unit, the baseline scenario is the electricity delivered to the grid by the project activity that otherwise would have been generated by the operation of grid-connected power plants and by the addition of new generation sources."*

The project activity involves the installation of a new grid-connected renewable power plant and therefore, the baseline scenario is the electricity delivered to the grid by the project activity. In the

absence of the project activity, the electricity would have been generated by the operation of grid-connected power plants and by the addition of new generation sources.
Furthermore, the baseline emissions shall be calculated using Paragraph 11 in the methodology:

> *"The baseline emissions are the product of electrical energy baseline $EG_{BL,y}$ expressed in MWh of electricity produced by the renewable generating unit multiplied by the grid emission factor."*

$$BE_y = EG_{BL,y} * EF_{CO2,grid,y}$$

Where:

BE_y	Baseline Emissions in year *y* (t CO_2)
$EG_{BL,y}$	Quantity of net electricity supplied to the grid as a result of the implementation of the CDM project activity in year *y* (MWh)
$EF_{CO2,grid,y}$	emission factor of the grid in year y (t CO_2/MWh)

The emission factor has been calculated following the approach given in paragraph 12 (a) of the methodology.

> "11 *(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"*

A detailed analysis on combined margin (CM) can be found in Annex 3.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered small-scale CDM project activity:

As per attachment A of Appendix B of the *Simplified Modalities and Procedures for Small-Scale CDM Project Activities*, additionality of the project shall be demonstrated by providing an explanation to show that the project activity would not have occurred anyway due to at least one of the following barriers: (a) investment barrier, (b) technological barrier, (c) barrier due to prevailing practice, and (d) other barriers.

Furthermore, in reference to the "**Non-binding best practice examples to demonstrate additionality for SSC project activities**", Annex 34, EB35[8], project participants shall provide an explanation to show that the project activity would not have occurred due to at least one of the following barriers:

(a)- **Investment barrier:** a financially more viable alternative to the project activity would have led to higher emissions
(b)- **Access to finance barrier:** the project activity could not access appropriate capital without consideration of the CDM revenues
(c)- **Technology barrier:** a less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity and so would have led to higher emissions

[8] http://cdm.unfccc.int/Reference/Guidclarif/ssc/methSSC_guid15_v01.pdf

(d)- **Barrier due to prevailing practices:** prevailing practice or existing regulatory or policy requirements would have led to implementation of a technology with higher emissions;
(e)-**Other barriers** such as institutional barriers or limited information, managerial resources, organizational capacity, or capacity to absorb new technologies.

In line with the above guidance, the additionality is demonstrated using option (b) Access to finance barrier.

Access to Finance barrier

The tapioca processing industry is considered to be one of the largest food processing industrial sector in Thailand. However, the growth of the tapioca starch industry has resulted in heavy water pollution as it generates large amount of solid waste and wastewater with high organic content.

Government of Thailand is promoting renewable energy based on the investment subsidy mechanism in various sectors. Following the initial biogas promotion in the livestock sector, the Ministry of Energy expanded its biogas campaign into the agro-industrial sector, and focused on the tapioca starch sub-sector. During 2003–2005, pilot demonstrations of biogas system in the starch industry were carried out by receiving financial support from the Energy Conservation Promotion Fund (ENCON). As per the report there has been insufficient knowledge / confidence in the available technology. Besides, wastewater treatment technology comes together with high investment cost and high operating cost. As a result, most of manufacturers choose to retain wastewater in open ponds within their factory. The treatment of wastewater in the open lagoons is the least cost option with minimum operating costs. The project proponent was also treating the wastewater in the open lagoons prior to the implementation of the project activity.

Therefore penetration of advanced wastewater treatment technologies (for e.g. UASB) is difficult in Thailand and biogas projects are considered high risk propositions by financiers.
It is important to note that private investment in the renewable/clean technology sector in Thailand faces some key challenges. The following is the outcome of the Investment plan[9] for The Clean Technology Fund (CTF)[10].

The key challenge in stimulating private investment in cleaner technology is overcoming institutional, technical, market, and financial barriers considered as high by investors. Although there is ample liquidity in the domestic financial market, lending to renewable energy projects remain limited. ***Access to affordable financing is a key barrier to investors***, suggesting there are structural rigidities in the renewable power generation development market. Key factors include: (i) lack of knowledge (e.g., limited familiarity and experiences of such projects among lenders and borrowers); and (ii) lack of demonstrated successes (e.g., project designs, deal flows, and business models for such investment projects have not yet been widely demonstrated). As a result financial institutions perceive lending to these projects as risky, resulting in higher costs of project development and debt financing.

[9] Paragraph 36, 71, 88, 94: Clean Technology fund investment plant for Thailand, http://www.nesdb.go.th/Portals/0/home/interest/09/Final_Draft_CTF_InvestmentPlan_Oct09.pdf
[10] The Clean Technology Fund (CTF) invests in projects and programs that contribute to the demonstration, deployment and transfer of low carbon technologies with a significant potential for long-term greenhouse gas emissions savings. The CTF Trust Fund Committee oversees the operations of the Fund. The World Bank (IBRD) is the Trustee of the Fund.

Furthermore, the following instances reflect the views of two banks:

TMB Bank Public Co. Ltd (a major Thai bank) states "Access to financial resources and Low priority projects" as the major barriers faced by projects in the wastewater treatment sector[11].

Furthermore, the same view has been highlighted explicitly for the biogas projects by PROPARCO[12] (private sector financing arm of French Development Agency – AFD) as follows:

- High transaction cost – size rather small to attract commercial lenders
- New technologies, less experienced developers
- Capital intensive: projects extremely sensitive to the structure & conditions of capital cost financing
- High level of uncertainty – related to the level of activities of the host companies creates a difficult risk profile, including difficulty in guaranteeing cash flows

The issues highlighted above lead to a complicated and time-consuming process from lender's point of view.

It is therefore, clear that biogas project face sever access to finance barrier both from the point of view of a local commercial bank and development agencies and additional benefits from CDM play a crucial role in successful implementation of such projects.

In reference to the Guidelines for objective demonstration and assessment of barrier, Annex 13, EB50, it is important to enhance the objectivity of the demonstration of additionality by providing quantitative approach to demonstration of barrier. Point 4, Guideline 1 states that:

"While demonstrating barriers related to the lack of access to capital, information should include nature of company, organization and its ownership and, financial information".
The project proponent – "Metro Group Energy Company Limited" is a private limited company incorporated on 5th August 2008 with a registered capital of 10mTHB. The main business of the company is to implement biogas plant and generate power[13]. The ownership detail of the company will be provided to the DOE.

As can be seen from above from the information about the company, it is classified under the SME category. The Thai government classifies SME[14] as a company having capitol not more than 200 million THB.

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[11] Slide no - 6 and 7
http://www.google.co.th/url?sa=t&source=web&cd=9&ved=0CDwQFjAI&url=http%3A%2F%2Fwww.cd4cdm.org%2FAsia%2FFifth%2520Regional%2520Workshop%2FID%26developCDM-Thailand_Prapasawad.ppt&rct=j&q=financial%20barrier%20%2B%20clean%20technology%20%2B%20thailand&ei=cX6ETLmoNInksQOvvez2Bw&usg=AFQjCNG4YY-blMPmMvEg1Ud-sp9miPCNnQ&cad=rja

[12] Slide no – 9 and 10
http://www.setatwork.eu/events/thailand/25%20Paper/Working%20session%203.5_Proparco.pdf

[13] Company affidavit

[14] http://www.sme.go.th/cms/c/portal/layout?p_l_id=47.43

In English - http://www.smebank.co.th/whoissme_en.php

The project proponent applied for loan to various banks many of which showed interest initially. However, either the banks had very stringent conditions (high securities and interest rates) or simply refused to lend without giving a written refusal letter. The banks normally do not wish to provide written rejection letter. This issue can be verified after interaction with the project proponent. Nevertheless, the problem in securing loan faced by the project proponent is a problem faced by SMEs in Thailand. This can be verified by a detailed analysis provided by the Bank of Thailand's discussion paper on "*A Cross-Country Survey on SME Financial Access and implications for Thailand*"[15]. The paper clearly outlines barriers from SME's point of view and financial institution's perspective.

SME perspective: "*it has been reported that lack of information and advice from financial institutions, complexity and inconvenience related to loan application process, inadequate qualification of SMEs, expenses/fees and interest rates charged, and lack of collateral are the main obstacle to access to finance."*

Financial institution perspective: *" the main obstacles for lending to SMEs include the following factors: inadequate collateral; lack of business experience; inadequate management; unreliable accounting system; lack of business planning, firm's NPL history; high transaction and operational costs per SME loan application; strict government rules and regulations regarding loan lost provision and credit history in credit bureau."*

Referring back to the "Guidelines for objective demonstration and assessment of barrier" it is mentioned in Guideline 1:

"A company that is a subsidiary of a multinational group may have different access to capital, technologies or skilled labour than a local SME company."

The project proponent is not a subsidiary of a multinational group and clearly has a different access to capital due to its size and local financial environment.

The above discussion demonstrates the existence of **access to finance** barrier faced by the project proponent in an objective manner.

In the light of above, the project activity needs additional revenues from CDM to overcome access to finance barrier. The project proponent got into Emission reduction purchase agreement (ERPA) during early stages of the project activity to commercialize the carbon credits generated from the project activity. Therefore, additional revenues from CDM have played an important role in alleviating the access to finance barrier faced by the project activity.

Table 5: Schedules and main events of the Project

Date	CDM Timeline	Date	Project Timeline
05/08/2008	Company registration –	20/06/2008	Proposal from technology

[15] Page 2, 3 – section 2.2 Challenges in SME financing

http://www.bot.or.th/Thai/EconomicConditions/Publication/Documents/dp032010_SME.pdf

Date	CDM Timeline	Date	Project Timeline
	mentioning that the company will manage biogas plant and generate carbon credits *Source: Company affidavit, Minute of meeting*		supplier *Source: Proposal from Papop*
29/10/2008	Early consideration - Letter of Intention (LoI) to TGO *Source: Copy of letter*	28/05/2009	Contracted with technology provider *Source: Contract between Metro Group Energy Co., Ltd., and Papop Co., Ltd.*
07/05/2009	Early consideration – Letter to UNFCCC *Source: Letter of Intent to UNFCCC*	02/06/2009	First payment to technology supplier *Source: First payment receipt to Papop Co., Ltd.*
12/05/2009	Emission reduction purchase agreement signed *Source: ERPA*	23/09/2009	Operation permit for biogas plant *Source:MGE Factory License*
01/07/2009	Confirmation that LoI has been received by the UNFCCC *Source: Email communication with UNFCCC*	16/11/2009	Subsidy from EPPO *Source: ENCON Fund contract*
22/09/2009	Local Stakeholder Consultation meeting Source: LSC documents	Nov-Dec2010	Expected commissioning of the project activity
21/05/2010	Application for Host country Approval to TGO Source: Covering letter	-	-

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

The emission reductions from the methane avoidance component of the project activity are calculated as per the guidance given in the methodology (version 15 of AMS-III.H). The emission reductions from thermal and electrical components are calculated as per the guidance given in the methodologies (version 18 of AMS-I.C) and (version 16 of AMS-I.D) respectively. The following sections outline in detail the methodological choices made for each component.

Baseline emissions (BE_y)

1: Baseline emissions for methane avoidance component (AMS III.H):
Baseline emissions for the systems affected by the project activity may consist of:

(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 ($BE_{s,final,y}$).

$$BE_{CH4,y} = \{BE_{power,y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{s,final,y}\} \quad \textbf{Eq-1}$$

Where:

Parameter	Details
$BE_{CH4,y}$	Baseline emissions from methane avoidance component in year y (tCO_2e)
$BE_{power,y}$	Baseline emissions from electricity or fuel consumption in year y (tCO_2e)
$BE_{ww,treatment,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year y (tCO_2e)
$BE_{s,treatment,y}$	Baseline emissions of the sludge treatment systems affected by the project activity in year y (tCO_2e)
$BE_{ww,discharge,y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year y (tCO_2e).
$BE_{s,final,y}$	Baseline methane emissions from anaerobic decay of the final sludge produced in year y (tCO_2e).

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

The baseline emissions from electricity consumption are not considered as the electricity consumption of the open anaerobic lagoons in the baseline scenario is very low. Furthermore, it is conservative to neglect this emission source. The baseline emissions from fuel consumption are zero as no fossil fuels have been consumed in the operation of the open anaerobic lagoons in the baseline scenario. Therefore, $BE_{power,y}$ is assumed zero and removed from removed from further consideration.

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

Methane emissions from the baseline wastewater treatment systems affected by the project ($BE_{ww,treatment,y}$) are determined using the methane generation potential of the wastewater treatment systems as per the paragraph 21 of AMS III.H., version 15. The following equation is used.

$$BE_{ww,treatment,y} = \sum_i (Q_{ww,i,y} * COD_{removed,i,y} * MCF_{ww,treatment,BL,i}) * B_{o,ww} * UF_{BL} * GWP_{CH4} \quad \textbf{Eq-2}$$

Where:

Parameter	Details
$Q_{ww,i,y}$	Volume of wastewater treated in baseline wastewater treatment system i in year y (m^3)
$COD_{removed,i,y}$	Chemical oxygen demand removed by baseline treatment system i in year y (tonnes/m^3) measured as the difference between inflow COD and the outflow COD in system *i*
$MCF_{ww,treatment,BL,i}$	Methane correction factor for the baseline anaerobic wastewater treatment i (MCF values as per table III.H.1)
i	Index for baseline wastewater treatment system

$B_{o, ww}$	Methane producing capacity of the wastewater (IPCC value of 0.25 kg CH_4/kg COD)
$UF_{,BL}$	Model correction factor to account for model uncertainties (0.89)[16]
GWP_{CH4}	Global warming potential (value of 21)

As the baseline treatment system is different from the treatment system in the project scenario, the monitored values of COD inflow during the crediting period will be used to calculate the baseline emissions ex-post. The outflow COD of the baseline system will be estimated using the removal efficiency of the baseline treatment system. The COD removal efficiency of the baseline system has been measured ex-ante through measurement campaign.

1(c): $BE_{s, treatment, y}$ - Baseline emissions of the sludge treatment systems affected by the project activity

There is no baseline sludge treatment system. Therefore, this baseline emission source is excluded from further consideration.

1(d): $BE_{s, final, y}$ – Baseline methane emissions from anaerobic decay of the final sludge produced

The baseline treatment system did not generate any sludge. Therefore, this baseline emission source is excluded from further consideration.

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

In the baseline treatment system the wastewater is not discharged into a sea/lake/river, therefore this baseline emission source is excluded from further consideration.

Therefore, the baseline emissions from methane avoidance component applicable to the project activity are given as:

$$BE_{CH4,y} = BE_{ww,treatment,y}$$ **Eq-3**

2: $BE_{thermal,CO2,y}$ - Baseline emission for Thermal displacement component: (AMS I.C)

As per AMS IC, paragraph 18, for heat[17] produced using fossil fuels the baseline emissions are calculated as follows:

$$BE_{thermal,CO_2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{FF,CO_2}$$ **Eq-4**

Where:

Parameter	Details
$BE_{thermal,CO_2,y}$	The baseline emissions from steam/heat displaced by the project activity during the year y (tCO_2)
$EG_{thermal,y}$	The net quantity of heat supplied by the project activity during the year y (TJ)

[16] Reference: FCCC/SBSTA/2003/10/Add.2, page 25.

[17] The biogas will be utilised partly in the thermal boiler to generate heat.

EF_{FF,CO_2}	The CO_2 emission factor of the fossil fuel that would have been used in the baseline plant; tCO_2 / TJ, obtained from reliable local or national data if available, otherwise, IPCC default emission factors are used.
$\eta_{BL,thermal}$	The efficiency of the plant using fossil fuel that would have been used in the absence of the project activity

3: $BE_{elec,y}$ - Baseline emission for Electricity generation component: (AMS I.D)
As per AMS I. D., paragraph 11, the baseline is the MWh produced by the renewable generating unit multiplied by an emission coefficient as follows:

$$BE_{elec,y} = EG_{BL,y} * EF_{CO2,grid,y} \quad \textbf{Eq-5}$$

Where:

Parameter	Details
$BE_{elec,y}$	Baseline Emissions from electricity generation during the year y (tCO_2)
$EG_{BL,y}$	The quantity of net electricity supplied by the project activity during the year *y* (MWh)
$EF_{CO2,grid,y}$	Thailand National Grid emission factor (tCO_{2e}/MWh)

Detailed calculation of grid emission factor is given in Annex 3.

Project emissions (PE_y)

4: Project activity emission for methane avoidance component (AMS III.H):
Project activity emissions from the systems affected by the project activity are:

(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 ($PE_{biomass,y}$).[18]

[18] For instance in the baseline situation Palm Kernel Shells (PKS) are used as fuel in a boiler. In the project situation PKS is replaced by biogas captured at a wastewater treatment system. The PKS will no longer be used as fuel in the boiler, but sold on the market. Before it is sold it is likely it will be stored for a period of time (few months or longer) on site which might lead to methane emissions from anaerobic decay.

$$PE_{CH4,y} = \begin{Bmatrix} PE_{power,y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + \\ PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y} \end{Bmatrix} \quad \textbf{Eq-6}$$

Where:

Parameter	Details
$PE_{CH4,y}$	Project activity emissions from methane avoidance component in the year *y* (tCO_2e)
$PE_{power,y}$	Emissions from electricity or fuel consumption in the year *y* (tCO_2e). These emissions shall be calculated as per paragraph 20, for the situation of the project scenario, using energy consumption data of all equipment/devices used in the project activity wastewater and sludge treatment systems and systems for biogas recovery and flaring/gainful use
$PE_{ww,treatment,y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year *y* (tCO_2e).
$PE_{s,treatment,y}$	Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year *y* (tCO_2e).
$PE_{y,ww,discharge}$	Methane emissions from degradable organic carbon in treated wastewater in year *y* (tCO_2e).
$PE_{s,final,y}$	Methane emissions from anaerobic decay of the final sludge produced in year *y* (tCO_2e).
$PE_{fugitive,y}$	Methane emissions from biogas release in capture systems in year *y*, calculated as per paragraph 28 (tCO_2e)
$PE_{flaring,y}$	Methane emissions due to incomplete flaring in year *y* as per the “Tool to determine project emissions from flaring gases containing methane”(tCO_2e)
$PE_{biomass,y}$	Methane emissions from biomass stored under anaerobic conditions.

4(a): $PE_{power,y}$ - Emissions from electricity consumption

Emissions from electricity consumption by the project activity facilities will be calculated according to the paragraph 20 of AMS III.H, for the situation of the project scenario, using energy consumption data of all equipment/devices used in the project activity wastewater and sludge treatment systems and systems for biogas recovery and flaring/gainful use. The “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” shall be applied for $PE_{power,y}$. However as per paragraph 35, table III.H.2, **ex-ante** estimate of the emissions from electricity consumption is done assuming all relevant electrical equipment operate at full rated capacity, plus 10% to account for distribution losses, for 8760 hours per annum using the following equation:

$$PE_{power,exante} = \frac{\sum P_{el} * 110\% * 8,760 * EF_{CO2.grid,y}}{1000} \quad \textbf{Eq-7}$$

Where:

Parameter	Details
$PE_{power,exante}$	Emissions from electricity consumption in the project activity, (tCO2)
P_{el}	Total installed electrical capacity of the equipments installed in the project activity (kW)
$EF_{CO2,grid,y}$	Thailand National Grid emission factor (tCO_{2e}/MWh)

The **ex-post** emissions from the electricity consumption in the project activity will be calculated

following the guidance given in the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". The project activity will consume electricity imported from the grid. Therefore, scenario **A: Electricity consumption from the grid** is applicable to the project activity. The generic approach is used to calculate the project emissions as follows:

$$PE_{EC,y} = \sum EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y}) \quad \textbf{Eq-8}$$

Where:

Parameter	Details
$PE_{EC,y}$	Project emissions from electricity consumption in year y (tCO_2)
$EC_{PJ,j,y}$	Quantity of electricity consumed by the project electricity consumption source j in year y (MWh)
$EF_{EL,j,y}$	Emission factor for electricity generation source j in year y (tCO_2/MWh)
$TDL_{j,y}$	Average technical transmission and distribution losses for providing electricity to source j in year y.
j	Source of electricity consumption in the project

Determination of emission factor for the electricity generation ($EF_{EL,j,y}$)
Option A1 has been used to determine emission factor. This option proposes to calculate the combined margin emission factor of the applicable electricity system, using the procedures in the latest approved version of the. Tool to calculate the emission factor for an electricity system. ($EF_{EL,j,y} = EF_{CO2,grid,y}$).
The grid emission factor details are further explained in Annex 3.

4(b): $PE_{ww,treatment,\ y}$ - Emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation.
Methane emissions from wastewater treatment systems affected by the project activity are calculated as per the equation 2 given in paragraph 21 of AMS III.H:

$$PE_{ww,treatment,y} = \sum (Q_{ww,k,y} * COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k}) * B_{o,ww} * UF_{PJ} * GWP_{CH4} \quad \textbf{Eq-9}$$

Where:

Parameter	Details
$Q_{,ww,k,y}$	Volume of wastewater treated in system affected by the project activity in year y (m^3)
$COD_{removed,PJ,k,y}$	Chemical oxygen demand removed by project wastewater treatment system *k* in year *y* (t/m^3), measured as the difference between inflow COD and the outflow COD in system *k*
$B_{o,ww}$	Methane producing capacity of the wastewater (IPCC default value of 0.25 kg CH_4/kg COD)
$MCF_{,ww,treatment,PJ,k}$	Methane correction factor for project wastewater treatment system *k* (MCF values as per Table III.H.1)
UF_{PJ}	Model correction factor to account for model uncertainties (0.89)[19]
GWP_{CH4}	Global Warming Potential for methane (value of 21)

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

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

There is no sludge treatment system prior to the implementation of the project activity. Therefore, this parameter is not applicable in the calculations and has been excluded from further consideration.

4(d): $PE_{ww,discharge,y}$ - Methane emissions from degradable organic carbon in treated wastewater.

In the project activity, the treated wastewater will not be discharged into to a river, sea or lake. Therefore, project emissions from this component have not been included in the assessment.

4(e): $PE_{s,final,y}$ - Emissions from anaerobic decay of the final sludge produced

It is not expected that the project activity will generate significant amount of sludge. However, the sludge treatment and/or use and/or final disposal shall be monitored during the crediting period. For ex-ante estimation, the emissions from this source have been assumed to be zero.

4(f): $PE_{, fugitive\ y}$ - Emissions on account of inefficiencies in capture systems

Project activity emissions from methane release in capture systems are determined as per paragraph 28 of AMS III.H as follows:

$$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y} \quad \textbf{Eq-10}$$

Where:

Parameter	Details
$PE_{fugitive\ ww,\ y}$	Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment in the year y (tCO_{2e})
$PE_{fugitive,s,\ y}$	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year y (tCO2e)

$PE_{fugitive,ww,\ y}$

These emissions are calculated as follows:

$$PE_{fugitive,ww,y} = (1 - CFE_{ww}) * MEP_{ww,treatment,y} * GWP_{CH4} \quad \textbf{Eq-11}$$

Where:

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

Further,

$$MEP_{ww,treatment,y} = Q_{ww,y} * B_{o,ww} * UF_{PJ} * \sum_k COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k} \quad \textbf{Eq-12}$$

Where:

Parameter	Details

$COD_{removed, PJ,k,y}$	The chemical oxygen demand removed[20] by the treatment system *k* of the project activity equipped with biogas recovery in the year *y* (t/m^3)
$MCF_{ww,treatment,PJ,k}$	Methane correction factor for the project wastewater treatment system *k* equipped with biogas recovery equipment (MCF values as per Table III.H.1)
UF_{PJ}	Model correction factor to account for model uncertainties (1.12)

$PE_{fugitive,s,y}$

There is no anaerobic sludge treatment in the project activity. Therefore, this source of emissions is excluded from further consideration.

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

$$PE_{fugitive,y} = PE_{fugitive,ww,y}$$ **Eq-13**

4(g): $PE_{flaring\ y}$ - Methane emissions due to incomplete flaring

Methane emissions due to incomplete flaring in year y are calculated as per the "Tool to determine project emissions from flaring gases containing methane" (hereafter the flaring tool). The project activity will implement an enclosed flare system. For the determination of the flare efficiency, the default value of 90% (for enclosed flare) will be used for the calculation of project emissions from flaring gases. Steps 1 to 7 of the flaring tool are used to determine the project emissions from flaring of the residual gas stream.

Step1 - Determination of the mass flow rate of the residual gas that is flared

$$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h}$$ **Eq-14**

Where:

Parameter	Details
$FM_{RG,h}$	Mass flow rate of the residual gas in hour h (kg/h)
$\rho_{RG,n,h}$	Density of the residual gas at normal conditions in hour h (kg/m^3)
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h (m^3/h)

Where:

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} \times T_n}$$ **Eq-15**

Where:

Parameter	Details
$\rho_{RG,n,h}$	Density of residual gas at normal conditions in hour h (kg/m^3)
P_n	Atmospheric pressure at normal conditions (pa)

[20] Difference between the inflow COD and the outflow COD.

R_u	Universal ideal gas constant (Pa.m³/kmol.k)
$MM_{RG,h}$	Molecular mass of the residual gas in hour h (kg/kmol)
T_n	Temperature at normal conditions (K)

As per the Step 5 of the flaring tool, methane mass flow rate in the residual gas on a dry basis is calculated as per the following equation:

$$TM_{RG,h} = FV_{RG,h} * fv_{CH4,RG,h} * \rho_{CH4,n}$$ **Eq-16**

Where:

Parameter	Details
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour h (kg/h)
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (m3/h)
$fv_{CH4, RG,h}$	Volumetric fraction of methane in the residual gas on dry basis in hour h
$\rho_{CH4,n}$	Density of methane at normal condition (0.716 kg/m3)

As per Step 6 of the flaring tool for determination of the hourly flare efficiency, a default value of 90% is used, provided the flare is operational. 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 specification on proper operation of the flare are met continuously during the hour (h).

According to step 7 annual project emissions from flaring are calculated as the sum of emissions from each hour h, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour h ($\eta_{flare, h}$), as follows:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} * (1 - \eta_{flare-h}) * GWP_{CH4} / 1000$$ **Eq-17**

Where:

Parameter	Details
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour h (kg/h)
$\eta_{flare-h}$	Flare efficiency in hour h
GWP_{CH4}	Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)

4(h): PE $_{biomass, y}$ - Methane emissions from biomass stored under anaerobic conditions

There is no biomass storage in the project activity. Therefore, this source of emissions has been excluded from further consideration.

5: Project emission for Thermal displacement component: (AMS I.C)

As per AMS I. C., paragraph 35, CO_2 emissions from on-site consumption of fossil fuels due to the project activity shall be calculated using the latest version of "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". Since the project activity does not consume any fossil fuel, the emissions from this source are considered zero.

6: Project emission for Electricity generation component: (AMS I.D)

As per AMS I. D., paragraph 19, for the most renewable energy project activity, $PE_y = 0$. The project emission under AMS I.D are considered zero.

Leakage (LE_y)

Leakage is assumed to be zero as no equipment is transferred from another activity.

Emission Reduction (ER_y)

Emission reductions from the methane avoidance component of the project activity $ER_{CH4,y}$

As per the guidance given in the paragraph 31 of the methodology AMSIIIH, *ex post* emission reductions shall be based on the lowest value of the following:

(i) The amount of biogas recovered and fuelled or flared (*MDy*) during the crediting period, that is monitored *ex post*;

(ii) *Ex post* calculated baseline, project and leakage emissions based on actual monitored data for the project activity.

Therefore, as per paragraph 32,

$$ER_{CH4,y} = \min\begin{pmatrix} \left(BE_{CH4,y} - PE_{EC,y} - PE_{ww,treatment,y} - PE_{fugitive,y} - PE_{flare,y}\right), \\ \left(MD_y - PE_{EC,y}\right) \end{pmatrix} \qquad \textbf{Eq-18}$$

As per paragraph 33 in AMS III.H., *In the case of flaring/combustion MD_y will be measured using the conditions of the flaring and combustion process:*

$$MD_y = W_{CH4} * D_{CH4} * GWP_{CH4} * [(BG_{flare,y} * FE) + (BG_{combusted,y} * DE)] \qquad \textbf{Eq-19}$$

Where:

Parameter	Details
$w_{CH4,y}$	Methane content of the biogas in the year *y* (volume fraction)
D_{CH4}	Density of methane at the temperature and pressure of the biogas in the year *y* (tonnes/m^3)
GWP_{CH4}	Global warming potential of methane, 21
$BG_{flare,y}$	Amount of biogas flared during the year y, Nm^3/year
$BG_{combusted,y}$	Biogas combusted for gainful use in year *y* (Nm^3/year)
FE	Flare efficiency (fraction)
DE	Destruction efficiency of biogas combusted for a gainful use (100%)

Emission Reduction from the methane avoidance, thermal and electrical component (ER_y)

From equations 4,5 and 18, the total emission reductions from the project activity are given as:

$$ER_y = ER_{CH4,y} + BE_{thermal,CO2,y} + BE_{elec,y} \qquad \textbf{Eq-20}$$

B.6.2. Data and parameters that are available at validation:

Data / Parameter:	GWP_{CH4}
Data unit:	-
Description:	Global warning potential of methane gas
Source of data used:	Default value from AMS III.H.
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied :	Intergovernmental Panel on Climate Change, Climate Change 1995: The Science of Climate Change (Cambridge, UK: Cambridge University Press, 1996)
Any comment:	-

Data / Parameter:	$B_{o, ww}$
Data unit:	kg CH_4/kg COD
Description:	Methane producing capacity of the COD in wastewater
Source of data used:	IPCC default value, as per methodology AMS III.H
Value applied:	0.25 kg CH_4/kg COD
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Data / Parameter:	UF_{BL}
Data unit:	Factor
Description:	Model correction factor to account for model uncertainties
Source of data used:	AMS III.H., Version 15
Value applied:	0.89
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Data / Parameter:	UF_{PJ}
Data unit:	Factor
Description:	Model correction factor to account for model uncertainties
Source of data used:	AMS III.H., Version 15

Value applied:	1.12
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Data / Parameter:	$MCF_{ww, treatment,BL,i}$
Data unit:	-
Description:	Methane correction factor for the baseline anaerobic wastewater treatment systems
Source of data used:	Table III.H.1. of AMS III.H., Version 15
Value applied:	0.8
Justification of the choice of data or description of measurement methods and procedures actually applied :	The baseline wastewater treatment system consists of a succession of anaerobic deep lagoons (depth more than 2 metres) therefore the MCF value is chosen as 0.8
Any comment:	IPCC Default values from chapter 6 of volume 5 page no 6.21. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Data / Parameter:	$MCF_{ww, treatment, PJ,k}$
Data unit:	-
Description:	Methane correction factor for project wastewater treatment system k
Source of data used:	Table III.H.1. of AMS III.H., Version 15
Value applied:	0.8
Justification of the choice of data or description of measurement methods and procedures actually applied :	In the project scenario the post treatment of wastewater treatment system without biogas recovery consists of a succession of lagoons, with depth greater than 2 metres, thus the value of 0.8 has been chosen.
Any comment:	IPCC Default values from chapter 6 of volume 5 page no 6.21. Waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Data / Parameter:	$COD_{removed\_BL}$
Data unit:	%
Description:	COD removal efficiency of the baseline treatment
Source of data used:	Measurement campaign in the baseline wastewater system for 10 days
Value of data applied for the purpose of calculating expected emission reductions:	88.17% - Used for ex-ante estimation of baseline emissions.
Justification of the	The COD removed value is based on COD campaign data and multiplied by a

choice of data or description of measurement methods and procedures actually applied :	factor of 0.89 to account of uncertainty due to data from the campaign measurement. This is in line with the guidance given in paragraph 19(a) which requires a measurement campaign of the baseline waste water treatment system for at least 10 days. The campaign was conducted by an external laboratory and further details are provided in Annex 3.
Any comment:	-

Data / Parameter:	**CFE_{ww}**
Data unit:	Fraction
Description:	Capture efficiency of the biogas recovery equipment in the wastewater treatment systems.
Source of data used:	AMSIIIH version 15
Value applied:	0.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value as per AMS III.H.
Any comment:	-

Data / Parameter:	**$EF_{CO2,grid,y}$**
Data unit:	tCO_2/MWh
Description:	CO_2 emission factor for grid power
Source of data used:	TGO - Thailand greenhouse gas management organisation (Thai DNA)
Value applied:	0.581 – fixed ex-ante
Justification of the choice of data or description of measurement methods and procedures actually applied :	The emission factor is calculated according to the “Tool to calculate the emission factor for an electricity system” (version 02).
Any comment:	The emission factor was published by TGO on 3rd Sept 2010 – http://www.tgo.or.th/index.php?option=com_content&task=view&id=359&Itemid=1

Data / Parameter:	EF_{FF,CO_2}
Data unit:	tCO_2/TJ
Description:	CO_2 emission factor of the fossil fuel for the thermal component of the project activity
Source of data used:	2006 IPCC
Value applied:	77.40 – for fuel oil

Justification of the choice of data or description of measurement methods and procedures actually applied :	The IPCC default value of the CO_2 emission factor of fuel oil is applied as per Table 1.4, default CO2 emission factor for combustion.
Any comment:	-

Data / Parameter:	NCV_{biogas}
Data unit:	MJ/Nm^3
Description:	NCV of biogas
Source of data used:	See footnote.
Value applied:	23.27
Justification of the choice of data or description of measurement methods and procedures actually applied :	Based on a NCV of methane[21] = 35.8 MJ/m3 and a methane percentage of 65%
Any comment:	-

Data / Parameter:	ρ_{CH4}
Data unit:	$tonnes/m^3$
Description:	Density of methane at normal temperature and pressure
Source of data used:	Tool to determine project emissions from flaring gases containing methane.
Value applied:	0.716
Justification of the choice of data or description of measurement methods and procedures actually applied :	CDM EB as per EB28 Meeting report (Annex 13).
Any comment:	-

Data / Parameter:	DE
Data unit:	%
Description:	Destruction efficiency of the electricity generator
Source of data used:	Default value, paragraph 33 AMSIIIH
Value applied:	100%
Justification of the choice of data or	Default value based on guidance given in paragraph 33 of AMSIIIH.

[21] www.agroparistech.fr/IMG/pdf/syn08-eng-Bonnier.pdf

description of measurement methods and procedures actually applied :	
Any comment:	-

B.6.3 Ex-ante calculation of emission reductions:

Baseline emissions (BE_y)

The ex-ante estimation of the baseline emissions can be given as per the equations 3, 4 and 5 in section B.6.1.

$$BE_y = BE_{CH4,y} + BE_{thermal,CO2,y} + BE_{elec,y} \quad \textbf{Eq-21}$$

Where:

$$BE_{CH4,y} = BE_{ww,treatment,y}$$

$$BE_{thermal,CO_2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{FF,CO_2}$$

$$BE_{elec,y} = EG_{BL,y} * EF_{CO2,grid,y}$$

The following section gives details of ex–ante estimation of baseline emissions:

Methodology: AMS III. H. (Methane avoidance component)		
Formula: $BE_{ww,treatment,y} = \sum_i Q_{ww,i,y} * COD_{removed,i,y} * MCF_{ww,treatment,BL,i} * B_{o,ww} * UF_{BL} * GWP_{CH4}$		
$Q_{ww,i\ y}$	1,296,648 m^3	Based on: wastewater generation of 21.61 m^3/t and a starch production capacity of 250 ton/day, 80% of starch plant load factor and operation of 240 days.
$COD_{removed,i,y}$	0.01327 ton/m^3	Based on measurement campaign in the baseline wastewater system for 10 days, the value is multiplied by 0.89 of a conservative factor (as per AMS III.H).
$COD_{in,}$	15,053.14 mg/l	Sample test reports
$B_{o,ww}$	0.25kg CH_4/kg COD	Default value - IPCC
$MCF_{ww,treatment,BL,i}$	0.8	Default value for anaerobic deep lagoons (as per Table III.H.1)
UF_{BL}	0.89	Model correction factor from AMS III. H.
GWP_{CH4}	21	Default value
Calculation: $BE_{CH4,y} = BE_{ww,treatment,y}$ = 1,296,648 X 0.01327 X 0.8 X 0.25 X 0.89 X 21 = **64,331 tCO_2e**		
Methodology: AMS I. C. (Thermal displacement component)		
Formula: $BE_{thermal,CO_2,y} = (EG_{thermal,y} / \eta_{BL,thermal}) * EF_{FF,CO_2}$		

$EG_{thermal,y}$	94.90 TJ	Based on the initial assumptions that 57.5% of biogas will be sent to the boiler. Detailed calculations are provided in the calculation spreadsheet[22].
EF_{FF,CO_2}	77.40 tCO2/TJ	For fuel oil – 2006 IPCC.
$\eta_{BL,thermal}$	100%	The efficiency of the boiler using the biogas.
Calculation: $BE_{thermal,CO_2,y}$ = 94.90 X 77.40 X 1 = **7,345 tCO_2e**		
Methodology: AMS I. D (Electricity generation component)		
Formula: $BE_{elec,y} = EG_{BL,y} * EF_{CO2,grid,y}$		
$EG_{BL,y}$	5,417 MWh	Based on the initial assumption that 32.5% of biogas generated will be sent to the gas engine. Detailed analysis is provided in the calculation sheet.
$EF_{CO2,grid,y}$ =	0.5812 tCO2/MWh	Latest data available from Thai DNA[23]
Calculation: $BE_{elec,y}$ = 5,417 X 0.5812 = **3,148 tCO_2e**		

Project emission (PE_y)

The ex-ante estimation of the project emissions can be given as per the equations 7,8,9,13 and 17 given in section B.6.1.

$$PE_y = PE_{power,exante} + PE_{ww,treatment,y} + PE_{fugitive,y} + PE_{flare,y} \quad \textbf{Eq-22}$$

As already mentioned in section B.6.1, there are no project emissions from the thermal and electrical component of the project activity. Therefore, the project emissions are only from the methane avoidance component of the project activity as given in the equation above.

The following section gives details of ex – ante estimation of project emissions:

Methodology: AMS III H (Methane avoidance component)		
Emissions from electricity consumption		
Formula: $PE_{power,exante} = \frac{\sum P_{el} * 110\% * 8{,}760 * EF_{CO2.grid,y}}{1000}$		
P_{el} =	200kW	Power rating based on the list given by technology provider.

[22] During actual project operation, the parameter will be calculated based on the temperature (in and out) from the heater and the amount of thermic fluid circulated. These are included in the monitoring section.

[23] http://www.tgo.or.th/index.php?option=com_content&task=view&id=359&Itemid=1

$EF_{CO2,grid,y} =$	0.5812 tCO2/MWh	Latest data available from Thai DNA[24]
Calculation: $PE_{power,y}$ = 1,120 tCO2e (detailed calculation given the calculation sheet)		
Emissions in wastewater treatment system without biogas recovery		
Formula: $PE_{ww,treatment,y} = \sum (Q_{ww,k,y} * COD_{removed,PJ,k,y} * MCF_{ww,treatment,PJ,k}) * B_{o,ww} * UF_{PJ} * GWP_{CH4}$		
$Q_{ww,k,y}$ =	1,296,648 m^3	Based on: wastewater generation of 21.61 m^3/t and a starch production capacity of 250 ton/day, 80% of starch plant load factor and operation of 240 days.
$COD_{removed,PJ,k,y}$ =	0.000752 ton/m^3	Based on COD out by project's biogas (this is conservative)
$MCF_{ww,treatment,PJ,k}$ =	0.8	Default value as per Table III.H.1 of AMS III.H.
$B_{o,ww}$ =	0.25 kg CH_4/kg COD	Default value as per AMS III.H
UF_{PJ}	1.12	Default value as per AMS III.H
GWP_{CH4} =	21	Default value as per AMS III.H
Calculation: $PE_{ww,treatment,y}$ = 1,296,648 X 0.000752 X 0.8 X 0.25 X 1.12 X 21 = 4,591 tCO2		
Fugitive emissions in wastewater treatment system with biogas recovery		
Formula: $PE_{fugitive,ww,y} = (1 - CFE_{ww}) * MEP_{ww,treatment,y} * GWP_{CH4}$		
CFE_{ww} =	0.9	Default value as per AMS III.H.
$MEP_{ww,treatment,y}$ =	4,153.56 tonnes	Detailed calculations are available in the calculation sheet.
GWP_{CH4} =	21	Default value
Calculation: $PE_{fugitive,ww,y}$ = 4,153.56 X (1-0.9) X 21= 8,721 tCO2e		
Methane emissions due to incomplete flaring		
Formula: $PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} * (1 - \eta_{flare-h}) * GWP_{CH4} / 1000$		
$T_{flare,operation}$	5760	Based on 240 days of operation.
$\eta_{flare,h}$	0.9	Efficiency of the enclosed flare as per flaring tool.
$TM_{RG,h}$	57.31 kg/h	The calculation of mass flow rate of methane in the residual gas in the hour (h) as per flaring tool step 5.
GWP_{CH_4}	21	Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4) as per

[24] http://www.tgo.or.th/index.php?option=com_content&task=view&id=359&Itemid=1

		IPCC guidance.
Calculation: $PE_{flare,y}$ = 5760 X 57.31 X (1-0.9) X 21/1000 = **693 tCO_2e**		

Emission Reduction Summary:

To summarise ex-ante baseline and project emissions are given as follows:

As per equation 21, total baseline emissions are given as:

BE_y = 64,331 + 7,345 + 3,148 = 74,825 tCO2/year

As per equation 22, the total project emissions are given as:

PE_y = 1,120 + 4,591 + 8723 + 693 = 15,127 tCO2/year

Therefore, the ex-ante estimates on emissions reductions are given as:

ER_y = 74,825 - 15,127 = 59,698 tCO2/year

The above estimate assumed that the starch plant will operate at full capacity. The operation of the starch will depend on season length and availability of raw material to manufacture starch and this will have a direct impact on the availability of wastewater for the project activity. Therefore, for being realistic and conservative, it is assumed that the starch plant will have load factor of 60% in 2010 and 2011, 70% in 2012 and 80% thereafter. Therefore, ex-ante estimation on vintages is as follows:

Year	2011	2012	2013	2014	2015	2016	2017
Load of starch plant	60%	70%	80%	80%	80%	80%	80%
Baseline Emissions	44,895	52,377	59,860	59,860	59,860	59,860	59,860
Project Emissions	9,076	10,589	12,101	12,101	12,101	12,101	12,101
Leakage	0	0	0	0	0	0	0
Emission Reductions	35,819	41,789	47,758	47,758	47,758	47,758	47,758

B.6.4 Summary of the ex-ante estimation of emission reductions:

Year	Emission of project activity emissions (tCO2e)	Estimation of baseline emissions (tCO2e)	Estimation of leakage (tCO2e)	Estimation of overall emission reductions (tCO2e)
2011	9,076	44,895	0	35,819

2012	10,589	52,377	0	41,789
2013	12,101	59,860	0	47,758
2014	12,101	59,860	0	47,758
2015	12,101	59,860	0	47,758
2016	12,101	59,860	0	47,758
2017	12,101	59,860	0	47,758
Total (tonnes CO_2e)	**80,171**	**396,570**	**0**	**316,398**

B.7 Application of a monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

The following data and parameters will be monitored after the implementation of the Project. The values provided in this section are the ones for the ex-ante estimation of the emission reductions provided in this PDD.

Data / Parameter:	$Q_{ww,i,y}$, $Q_{ww,k,y}$
Data unit:	m^3
Description:	Volume of wastewater treated in the baseline and project treatment system during the year *y*
Source of data to be used:	Plant records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1,296,648 m^3 per annum
Description of measurement methods and procedures to be applied:	The data is measured continuously using Volumetric flow meters. The flow meter will be integrated with SCADA (Supervisory Control And Data Acquisition system) to have real time data monitoring and control. The monthly data will be used in the calculation of emission reductions.
QA/QC procedures to be applied (if any):	The meters will be calibrated periodically based on manufacturer's specification from a certified testing agency but at least once every three years.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$COD_{ww,untreated, y}$
Data unit:	tCOD/m3
Description:	COD of the wastewater before the treatment system affected by the project activity.
Source of data to be used:	Plant records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.015 tCOD/m3
Description of measurement	The COD content will be analyzed using a colorimetric method in the on-

methods and procedures to be applied:	site laboratory. The results will be logged in the plant operation report on a daily basis. However, the measurement shall ensure a 90/10 confidence level.
QA/QC procedures to be applied (if any):	The colorimetric measurement will be done based on national standard. The colorimeter will be calibrated based on standard samples as well by an external agency.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$COD_{ww,treated,y}$
Data unit:	$tCOD/m^3$
Description:	COD of wastewater after the treatment system *k* of the project activity equipped with biogas recovery in the year *y*
Source of data to be used:	Plant records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.0075
Description of measurement methods and procedures to be applied:	The COD content will be analyzed using a colorimetric method in the on-site laboratory. The results will be logged in the plant operation report on a daily basis. However, the measurement shall ensure a 90/10 confidence level.
QA/QC procedures to be applied:	The colorimetric measurement will be done based on national standard. The colorimeter will be calibrated based on standard samples as well by an external agency.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$S_{final,PJ,y}$
Data unit:	t (tonnes)
Description:	Amount of dry matter in final sludge generated by the project wastewater treatment in the year y
Source of data to be used:	Plant records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	The MGE does not envisage the generation of any sludge during the crediting period; however records will be kept in case of any generation of sludge and its final treatment. 100% of the sludge amount will be monitored (on wet basis) through continuous or batch measurements. Moisture content will be monitored through representative sampling to ensure 90/10 precision level.
QA/QC procedures to be applied:	The measurement equipment shall be calibrated on a regular basis but at least once every three years.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$Q_{biogas,gas\ engine,y}$

Data unit:	Nm^3 in year *y*
Description:	Quantity of biogas combusted in gas engine
Source of data to be used:	Plant records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	2,305,089.03
Description of measurement methods and procedures to be applied:	The biogas shall be monitored using continuous flow meter. The measurement will be taken on an hourly basis. The flow meter will be integrated with SCADA (Supervisory Control And Data Acquisition system) to have real time data monitoring and control. The biogas flow meter displays output as normalised flow of biogas.
QA/QC procedures to be applied:	The gas flow meter will calibrated at regular intervals based on manufacturer specification from a certified testing agency or institution. However, it will be made sure that calibration is done at least once a year.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$Q_{biogas,boiler,y}$
Data unit:	Nm^3 in year *y*
Description:	Quantity of biogas combusted in thermal boiler
Source of data to be used:	Plant records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	4,078,234.43
Description of measurement methods and procedures to be applied:	The biogas shall be monitored using continuous flow meter. The measurement will be taken on an hourly basis. The flow meter will be integrated with SCADA (Supervisory Control And Data Acquisition system) to have real time data monitoring and control. The biogas flow meter displays output as normalised flow of biogas.
QA/QC procedures to be applied:	The gas flow meter will calibrated at regular intervals based on manufacturer specification from a certified testing agency or institution. However, it will be made sure that calibration is done at least once a year.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$Q_{biogas, flared, y}$
Data unit:	Nm^3 in year *y*
Description:	Total quantity of biogas flared
Source of data to be used:	Plant records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	709,258.16
Description of measurement methods and procedures to be	The biogas shall be monitored using continuous flow meter. The measurement will be taken on an hourly basis. The flow meter will be

applied:	integrated with SCADA (Supervisory Control And Data Acquisition system) to have real time data monitoring and control. The biogas flow meter displays output as normalised flow of biogas.
QA/QC procedures to be applied:	The gas flow meter will calibrated at regular intervals based on manufacturer specification from a certified testing agency or institution. However, it will be made sure that calibration is done at least once a year.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	EG_y
Data unit:	MWh
Description:	The quantity of electricity supplied by the project activity during the year *y*
Source of data to be used:	Plant records
Value of data applied for the purpose of calculating expected emission reductions in section B.5	5,417 MWh– for ex-ante estimation of emission reductions.
Description of measurement methods and procedures to be applied:	The electricity exported will be continuously measured using the energy meters. The readings will be based on monthly invoices to PEA.
QA/QC procedures to be applied:	The calibration of the export meters is under the control of the PEA.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	T_{out}
Data unit:	Deg C
Description:	Temperature of thermic fluid leaving the boiler for starch drying.
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods and procedures to be applied:	Temperature gauge shall be used to monitor the temperature of the thermic fluid.
QA/QC procedures to be applied:	The temperature gauge shall be calibrated as per manufacturer's specification or once every three years.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	T_{in}
Data unit:	Deg C
Description:	Temperature of thermic fluid entering the boiler for starch drying.
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions	-

in section B.5	
Description of measurement methods and procedures to be applied:	Temperature gauge shall be used to monitor the temperature of fluid going back into boiler.
QA/QC procedures to be applied:	The temperature gauge shall be calibrated as per manufacturer's specification or once every three years.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$Q_{oil, y}$
Data unit:	m^3
Description:	Quantity of the thermic fluid from boiler to the process plant.
Source of data to be used:	The project proponent will install the flow measurement device to monitor the flow of thermic fluid oil.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods and procedures to be applied:	The parameter will be measured continuously using flow meter. The data will be recorded hourly and aggregated daily.
QA/QC procedures to be applied:	The flow meter shall be subject to regular calibration as per manufacturer specification or at least once in three years.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$FV_{RG,h}$
Data unit:	Nm^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*
Source of data to be used:	Measured by project developer using a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.5	57.31 Nm3/h – for ex-ante estimation
Description of measurement methods and procedures to be applied:	The parameter is measured continuously on dry basis. The values will be averaged every hour.
QA/QC procedures to be applied:	The flow meter will be calibrated as per manufacturer's specifications.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$fv_{CH4,RG,h}$, $w_{CH4,y}$
Data unit:	-(fraction)
Description:	Volumetric fraction of component *methane* in the residual gas in the hour h
Source of data to be used:	Measured by project developer using a continuous gas analyser
Value of data applied for the purpose of calculating	65% - for ex-ante estimation.

expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Measure continuously. Value to be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	The gas analyser will be periodically calibrated according to manufacturer's specifications/recommendation.
Any comment:	The data will be stored for the crediting period + 2 years.

Parameter:	T_{flare}
Unit:	°C
Description:	Temperature in the exhaust gas of the flare
Source of data:	Measurement by the project participant
Value of data:	-
Brief description of measurement methods and procedures to be applied:	The flame temperature will be continuously measured using a Thermocouple.
QA/QC procedures to be applied (if any):	Thermocouple should be replaced or calibrated every year.
Any comment:	The data will be stored for the crediting period + 2 years.

Data / Parameter:	$\eta_{flare-h}$
Data unit:	%
Description:	Flare efficiency
Source of data used:	Default value - Tool to determine project emissions from flaring gases containing methane
Value applied:	90% - Default value for ex-ante estimation
Brief description of measurement methods and procedures to be applied:	Default flare efficiency for enclosed flare is used as per step 6 “determination of the hourly flare efficiency” of the flaring tool: • 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. Other flare specific parameters, which might be required to monitor whether the flare operates within the specified range of operating conditions shall be monitored according to the manufacturer’s specifications.
QA/QC procedures to be applied (if any):	Maintenance of the flare system shall be conducted periodically as per supplier’s specifications to ensure optimal operation.

Any comment:	-

B.7.2 Description of the monitoring plan:

1. Monitoring Management

The required monitoring equipments will be installed and monitoring procedures will be followed as mentioned in section B.7.1. The data will be recorded on a continuous basis or as indicated in section B.7.1 and fed into the log books and the SCADA system. The data will be kept in both soft and hard copy format and proper data backups will be maintained. The calibration of monitoring equipments will be done on regular intervals.

All biogas plant staff will be trained by the Papop Co., Ltd., prior to full commissioning of biogas plant. Figure 5 outlines the structure of operation and management of the Project activity.

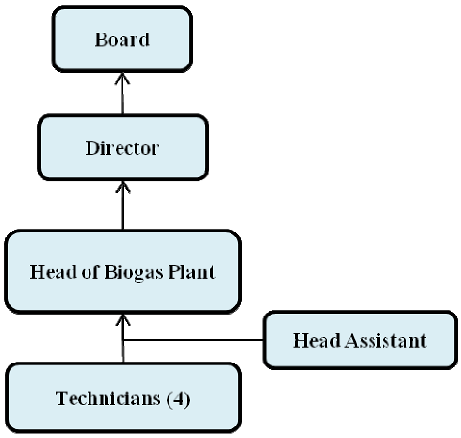

Figure 5: Organisation chart showing the responsible persons in the project activity

2. Quality Assurance and Quality Control

The head of the biogas plant will monitor the overall biogas plant's performance, ensuring proper and timely calibration (in accordance with the manufacturer specifications) of systems, data acquisition and storage. Either erroneous data or uncertainties found in measurement of the monitoring devices for the biogas plant (i.e. flow rate, methane analyzer, etc.) are included in the quality assurance and quality control procedures for individual monitoring parameters as per Section B.7.1.

3. Data Storage and Filing

All monitoring data will be stored in the log-books and electronically. The monitoring records shall be archived for a period of the crediting period plus 2 years.

4. Emergency preparedness

The project activity is not expected to result in any emergency that can result in substantial emissions.

However, leakages, if any, in the piping or digester shall come to the attention of the plant operator either instantly on the control screen, or at the time of data logging. The team shall take necessary action to stop any such leakage etc. and put plant operation back on track.

5. Uncertainty in data

Some uncertainties may result due to malfunction of meters, calibration issues and wrong data collection (gaps in manual log sheets, human errors by plant operators). The operator is expected to put best efforts to prevent such errors, however regular internal audits shall rectify any such uncertainty in the monitored data.

B.8 Date of completion of the application of the baseline and monitoring methodology and the name of the responsible person(s)/entity(ies)

Completion date: 02/04/2010

by
Patrick Bürgi
South Pole Carbon Asset Management Ltd.
Technoparkstrasse 1
CH-8005 Zurich
Switzerland

The above mentioned entity is a project participant as mentioned in Annex 1.

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

02/06/2009 – First payment to technology provider

C.1.2. Expected operational lifetime of the project activity:

15 years 00 months

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

01/10/2011 or the date of CDM registration whichever is later.

C.2.1.2. Length of the first crediting period:

7 years 00 months

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

Not applicable.

C.2.2.2. Length:

Not applicable.

SECTION D. Environmental impacts

D.1. If required by the host Party, documentation on the analysis of the environmental impacts of the project activity:

The proposed Project is not required to undertake an Environmental Impact Assessment according to the Thailand regulations (http://www.onep.go.th/eia/). Initial Environmental Evaluation (IEE) has been done as part of the requirement of the Thai DNA[25]. The IEE report must be approved in relation to Thai sustainable development criteria for CDM. This process ensures that a project with a negative impact to the environment is considered in parallel with GHG reductions of the project. The main conclusion of IEE reports are;

- The air pollutants from the thermal and power generation process will be treated before releasing into the atmosphere. The value of air emission after the treatment system is under the Thai industrial regulation standard. According the utilization of biogas, no harmful pollutants or smoke/soot will be emitted. Also, fugitive methane emissions and odour from the existing open pond system will be eliminated. The impact on air quality is very low.
- The report evaluated the noise level generated by the project activity is lower than the standard as following.

Parameters	National standard[26]
Lmax	< 115 dB(A)
Leq 24 hr	< 70 dB(A)
Annoyance	< 10 dB(A)

[25] Outline of CDM project approval process. Thailand Greenhouse Gas Management Oranization (Public Organization). Source: http://www.tgo.or.th/english/index.php?option=com_content&task=view&id=60&Itemid=52

[26] Notification of the Ministry of Industry on Specification of Annoyance Noise and Noise Level from the Factory. B.E. 2548 (2005)

Noise

- The quality of effluent after the wastewater treatment system is under the Thai industrial regulation standard. The UASB system enhances COD reduction in the wastewater. The discharged water quality is improved. The effluent will be utilized for agricultural purpose and reused in the starch production process.

The preventive and mitigation measures to the environmental impact have been prepared. The IEE report also recommended monitoring measures of pollutants other than the greenhouse gases covered under the Kyoto Protocol (CO, NO_2, PM, etc). All the recommendations from the IEE report will be adopted by the project developer.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

No relevant negative environmental effects are expected from the implementation of the Project. According to the initial environmental evaluation (IEE) described above, no significant environmental impacts are expected as a consequence of the Project activity.

SECTION E. Stakeholders' comments

E.1. Brief description how comments by local stakeholders have been invited and compiled:

Procedure followed to invite stakeholder comments

Public hearing for local stakeholders:

Invitation procedure
The Initial Stakeholder Consultation has been conducted by MGE with assistance from South Pole Carbon Asset Management Limited (Switzerland based company responsible for CDM project development).

Stakeholder groups were identified and informed through oral and written means about the meeting. The invitation letter was sent by fax to participants located far from the project site, in person to participants without access to a fax and there was also an announcement of the meeting posted at the community hall for people who had not received an invitation letter. This invitation process was done two weeks before the meeting date.

The persons or organizations invited were as follows:

Government Sector, State Agency, Independent Entity and Private Organization
- National Science and Technology Development Agency (NSTDA)
- Thailand Environment Institute (TEI)
- Office of Natural Resources and Environmental Policy and Planning
- Ministry of Agriculture and Cooperatives

- Green Leaf Foundation
- International Institute for Energy Conservation (IIEC)
- Thailand Development Research Institute (TDRI)
- The Environmental Engineering Association of Thailand (EEAT)
- Thailand Greenhouse Gas Management Organization (TGO)
- NGOs supporting the GS, which are The Climate Group, Appropriate Technology Association (ATA), Dhammanart Foundation, Renewable Energy Institute of Thailand (REIT), Greenpeace International, Mercy Corps and WWF international, Indonesia Forum for Environment, Sibol ng Agham at Teknolohiya, REEEP, and KLIMA Climate Change Center
- Department of Environmental Engineering of Chulalongkorn University
- Department of Environmental Engineering of King Mongkut's University of Technology Thonburi (KMUTT)
- Faculty of Environment and Resource Studies of Mahidol University
- Local Gold Standard Expert (South East Asia and China)

Local Participants

- Assistant district officer
- Mayor
- Superintendent
- Provincial Electricity Authority
- Headman in surrounding area of the project
- Village headman in surrounding area of the project
- Villager

Place and date of the meeting

The local stakeholder consultation was held at Phet Hotel , 189 Bumrungraj Road, Amphur Muang, Kamphaengphet province, 62000, Thailand on September 22, 2009.

Meeting Participants

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

1. Local residents/farmers
2. Local government representatives
3. Local entrepreneurs
4. Employee

There were 47 participants who accepted the invitation, attended the meeting and returned the questionnaire.

Language

The documentation and meeting were in Thai which is the local language.

Meetings procedure

- Registration (30 min)
- Opening (15 min)
- Introduction the Metro Group Energy Company Limited (15 min)
- Description of the project and environmental impacts (30 min)
- Purpose of CDM, and relation of the project and CDM (30 min)
- Questions and Answers session (10 min)
- Completing questionnaire (20 min)

Meeting documents and protocols

On completion of the various components of the meeting, the following documents were collected and attested by the signatures of the stakeholders that were present at the time:

1. Presence list with name, address and occupation.
2. Non-technical description of the project.
3. Questionnaire.

These documents are available as hardcopies and will be handed over to the Designated Operational Entity (DOE).

E.2. Summary of the comments received:

The overall response to the Project, from all invited stakeholders, was encouraging and positive. There were two questions during the meeting; one of these questions was related to concerns on the environmental impact of odour from the implementation of the Project, the other question was related to employment. Both questions were clarified during the meeting. The greatest asset for the project will be positive effect on the environment. Stakeholders acknowledge that the improvement of wastewater treatment technology will reduce odours released to the surrounding area. This Project is viewed as a positive environmental plan that is important for local water resources and the community's quality of life.

To sum up the sustainability of the Project, the various benefits (as reported by local stakeholders) are listed below.

1. The installed technology contributes to clean water and reduced odours.
2. Use of biogas represents a sustainable way for generating energy.
3. While the system operates within strict environmental standards there will be no negative impacts to the environment due to the Project.
4. The Project is well designed and not producing additional pollution.
5. The Project will create new jobs at the plant.

In all, no adverse reaction/comments/clarifications have been received during the Initial Stakeholder Consultation process. The participants of the meetings have not raised any significant concerns related to potential impacts of the Project.

Summary of comments received during forum:

A Q&A session was conducted at the event, where questions were invited from the related parties. The questions were answered by MGE. The questions and answers are listed below:

- *Will the project be effected air pollution?*

No. As the wastewater system, UASB, is a closed system, the implementation of the biogas plant will reduce air pollution significantly.

- *How will the company employ the staff?*

The company will hire people from the local area.

- Concerns about the safety of the biogas system

The biogas system is implemented in accordance to relevant safety standards and as per the manufacturer specification. In addition to this, the operation team will be trained to operate the plant in a safe and sound manner.

E.3. Report on how due account was taken of any comments received:

As no major environmental concerns were raised during the entire initial stakeholder consultation process, it was neither necessary to make any changes to the Project design, nor to incorporate any additional measures to limit or avoid negative environmental impacts. The same applies to socio-economic concerns, which were not raised.

It is evident from the stakeholder consultation process, that the Project is perceived as a positive example for the tapioca starch factories in Thailand, and that it contributes to sustainable development in the region.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Direct FAX:	-
Direct tel:	-
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funds have been utilised in the project activity.

Annex 3

BASELINE INFORMATION

Grid emission factor

The emission factor of the Thai national grid has been taken from the most recent data made available by the Thailand DNA[27].

CDM project type	Emission Factor (tCO_2/MWh)		
	$EF_{grid,OM}$	$EF_{grid,BM}$	$EF_{grid,CM}$
General project	0.6147	0.5477	0.5812
Wind and solar power generation project	0.6147	0.5477	0.5980

COD campaign data for the baseline wastewater treatment system:

Sampling date	COD_{in} (mg/l)	COD_{out} (mg/l)	$\%COD_{removal}$
04/02/2010	15711.00	156.00	99.01%
05/02/2010	15195.00	144.00	99.05%
06/02/2010	15468.00	137.00	99.11%
07/02/2010	15033.00	118.00	99.22%
08/02/2010	17930.00	138.00	99.23%
09/02/2010	14540.00	152.00	98.95%
10/02/2010	14606.00	131.00	99.10%
11/02/2010	15157.00	137.00	99.10%
12/02/2010	14627.00	139.00	99.05%
13/02/2010	14509.00	127.00	99.12%
14/02/2010	14240.00	127.00	99.11%
15/02/2010	14369.00	142.00	99.01%
16/02/2010	15023.00	175.00	98.84%
17/02/2010	14336.00	133.00	99.07%
Average	**15053.14**	**139.71**	**99.07%**
Uncertainity factor			0.89
$COD_{removed\_BL}$			88.17%

The above measurement was conducted by ALS Laboratory Group (Thailand) Co. Ltd. The samples were taken in 250 ml plastic bottle with Sulfuric acid as preservative. The testing was based on APHA 2005, 5220 D method.

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[27] http://www.tgo.or.th/index.php?option=com_content&task=view&id=359&Itemid=1

Annex 4

MONITORING INFORMATION

Detailed monitoring plant and information is provided in section B.7.1 and B.7.2.

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