CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

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Project Title: CYY Biopower Wastewater treatment plant including biogas reuse for thermal oil replacement and electricity generation Project, Thailand

Version no. and Date: Version 3, dated 09 March 2009

A.2. Description of the project activity:

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The proposed project entails the installation of an upflow anaerobic sludge blanket technology (UASB) biogas reactor and up to a 2.72[1] MWel gas engines at an existing starch manufacturing plant for:

a) the extraction of methane (biogas) from the wastewater stream through the biogas reactor,
b) the reuse of biogas as fuel in existing thermal oil boilers within the plant for starch drying, and
c) the reuse of biogas as fuel for power generation (using up to 2.72 (1.36 x 2) MWel gas engines- to be constructed).

The project introduces a new biogas reactor with methane capture and utilisation for energy purposes into the existing open anaerobic lagoon based wastewater treatment system. As a consequence of the new anaerobic reactor, the organic load entering the lagoon system is drastically reduced because most of the organic matter is converted to biogas in the reactor. The project activity avoids the release of methane into the atmosphere, which would occur due to the anaerobic digestion of the organic content in the open lagoon based wastewater treatment system (anaerobic conditions, leading to methane generation within the lagoon are the result of a lagoon depth greater than 1m and an average atmospheric temperature of about 28C).

In addition, the biogas reactor produces sufficient quantities of biogas to fuel thermal oil boilers for starch drying, replacing the use of heavy fuel oil, and to fuel a gas engine for the production of power for both in-house use and sale to the electricity grid. This will replace the production of power from the Thai national grid. Two 1.36 MWel biogas gensets (total 2.72 MWel) will be installed in June 2008. The replacement of heavy fuel oil in the thermal oil boilers and displacement of electricity from the national grid, which is generated by fossil fuel fired power plants to a large extent, will lead to further reductions of greenhouse gases.

In accordance with the project owner plans, the electricity generated will be sold to PEA[2] under a firm power purchase agreement under the Very Small Power Producer[3] (VSPP) program. However, the

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[1] In the first version of the PDD hosted at the UNFCCC website for the global stakeholder consultation, the installed capacity of the gas engine was 2.6 MWel (assuming two engines of 1.3 MWel each). In the second version of the PDD, the exact installed capacity of each engine has been corrected to 1.36 MWel, adding up to a total installed capacity of 2.72 MWel.

[2] The Provincial Electricity Authority is a government enterprise under the Ministry of Interior. The authority's responsibility is primarily concerned with the generation, distribution, sales and provision of electric energy services

requesting period for the VSPP program might take around 7-8 months to be completed. Thus, until the VSPP program registration is formalized, the electricity generated by the project activity will be used for in-house consumption at the tapioca starch processing plant, displacing electricity that would have been drawn from the grid.

The proposed project will be implemented at the Chok Yuen Yong Industry Co Ltd Industry facility with a total expected wastewater flow-rate of 2400 m3/day and an average COD concentration of 30,000 mg/l.

Sustainable Development Benefits of the Project

According to the definition of sustainable development criteria for CDM projects by Thai DNA[4], 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 odour;
- Reduction in usage of non-renewable energy, i.e. fossil fuel for grid electricity generation;
- Improvement of the quality of water discharged into the environment;

Social benefits

- Involvement of local communities through a public participation meeting, in which people accepted the project;
- Increased employment by employing 12 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 power 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;
- Demonstrating the use of CDM as an incentive for bringing about an energy efficiency project;

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to the business and industrial sectors as well as to the general public in provincial areas, with the exception of Bangkok, Nonthaburi and Samut Prakran provinces.

[3] A Very Small Power Producer (VSPP) can be any private entity, government or state-owned enterprise that generates electricity either (a) from non-conventional sources such as wind, solar and mini-hydro energy or fuels such as waste, residues or biomass, or (b) from conventional sources provided they also produce steam through cogeneration. As per the VSPP program, the VSPP is limited to sell no more than 10MW of its electrical power output to the designated distribution utility, such as Metropolitan Electricity Authority (MEA) and/or Provincial Electricity Authority (PEA).

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

A.3. Project participants:

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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)	CYY Bio Power Co Ltd	No
Switzerland	South Pole Carbon Asset Management Ltd	No
Austria	Kommunalkredit Public Consulting GmbH	No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

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Thailand

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

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Khamtalesor District, Nakhorn Ratchasima Province

A.4.1.3. City/Town/Community etc:

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Amphur

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

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The proposed project is site located 20 km east of Nakhorn Ratchasima, about 6 km north of the main road connecting Nakhorn Ratchasima with Bangkok in Nakorn Ratchasima Province in the northeast of Thailand. Nakorn Ratchasima, about 250 km away from Bangkok, is one of the five biggest cities in Thailand. Most of the tapioca starch plants in Thailand are located in this province.

The coordinates of the project, are: Latitude 14°59’55”N and Longitude 101°54’42”E

A.4.2. Category(ies) of project activity:

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The project’s sectoral scope, as defined by the UNFCCC, is: 13 - Waste handling and disposal

A.4.3. Technology to be employed by the project activity:

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Process and technology description

The wastewater flows from the factory by gravity sewer into a storage lagoon (made from an existing lagoon, retention time 1-2 days). The influent first passes through a new screen extractor, in order to remove coarse particles (roots, pulp, peels). After the screening the wastewater flows into an equalization and settling lagoon (in concrete, sloped) for removal of settleable solids. This lagoon is divided in two parts, one in operation, one in standby or cleaning.

Water from the equalization lagoon 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 with lime and/or caustic soda (for fine tuning, standby). Lime powder is directly added in a lime mixing basin, which receives the wastewater from the pre-treatment.

In a third adjacent basin, grit (including impurities present in the lime) is trapped and removed periodically. There are two grit traps. One is in operation, while the other one is being cleaned or on stand-by. From the grit trap the effluent flows into a pump sump.

The wastewater is then pumped into the methane reactors through an influent distribution system at the bottom of the reactor. The methane reactors are of the UASB (Upflow Anaerobic Sludge Blanket) type, with a special "3 phase separator" device at the top of the reactor.

In the UASB, the wastewater rises through an expanded bed of anaerobic active methanogenic sludge (the so called "sludge blanket") and an internal device at the top of the reactor, which results in a separation of the mixed liquor into clarified wastewater, biogas and sludge. The absence of any mechanical agitation allows a natural selection towards heavy flocs of active methanogenic sludge.

Excess sludge can eventually, from time to time, be withdrawn from the bottom of the reactor. This excess sludge is extremely thick (5-10% Dissolved Solids), stable, and can be dumped without problems, but it is widely sought after to start-up new reactors elsewhere. The effluent of the anaerobic treatment will be further treated in some of the existing lagoons, receiving only 2% to maximum 10% of the original COD load.

Part of the resulting biogas will be used in the factory as fuel in an existing thermal oil boiler used for starch drying. A Scherrer duel fuel burner able to fire oil and gas will be employed to burn biogas instead of heavy fuel oil. The biogas meter will be equipped to record the biogas consumption of the burner.

The rest of the biogas will be used as fuel in two power generators (gensets) consisting of a biogas fired engine and an alternator each, with a total installed capacity of 2.72 MWel. Before use in the power generators, the biogas has to be treated to reduce the sulphur content of the biogas from tapioca starch factory effluent using a biogas "sweetening" plant, based on a proprietary sulphur removal system, which does not use chemicals (except for pH control in the oxidation phase). In practice min. 90% removal is obtained. The scrubber is placed on top of the aeration basin, so as to allow gravitational flow of the washing water back into the inlet of the aeration basin. From the aeration basin, water is continuously pumped into the scrubber tower.

The effluent of the scrubber is treated by intense aeration in an aeration basin, in order to reduce the sulphide concentration. Intense aeration reduces the sulphide concentration by chemical + biological oxidation. The sulphides are slowly oxidised (mainly chemically) by dissolved oxygen, resulting in a mixture of elementary sulphur, thiosulphate, sulphite and sulphate. A small part is also stripped out of the wastewater. Due to the high pH of the wastewater (8-8.5), the amount stripped out is quite low. Only very small amounts of sulphide are left in the aerated effluent at concentrations (0-10 mg/l) low enough to be reused as scrubber inlet liquid.

After the scrubber the biogas goes to an optional proprietary biogas drier, to reduce most of the moisture content of the biogas, because some generator engine suppliers impose limits (not known at this moment) on the % humidity of the biogas, whereas when it comes from the anaerobic reactor it is (over) saturated with water vapour.

The biogas drier package unit used consists of a stainless steel biogas/refrigerant heat exchanger, and a refrigerant cooling group with a compressor, a condenser, a storage tank, and an evaporator. The biogas at typically 30-40 °C is cooled to 10-15°C, after which ca. 60-70% of the water vapor (35 g/m3) condenses to water, which is separated from the gas in and after the heat exchanger. The remaining moisture in the biogas is about 10-15 g/m3, and acceptable, considering the fact that the biogas is heated again in the biogas compressor and then cools off to an ambient temperature which is higher than 20 °C.

After the biogas drier the biogas is sent to thermal oil boiler and to the power generators with biogas blowers. H_2S and CH_4 content of the biogas are continuously measured in line. For safety and start-up reasons a flare is also foreseen.

Figure: System boundaries

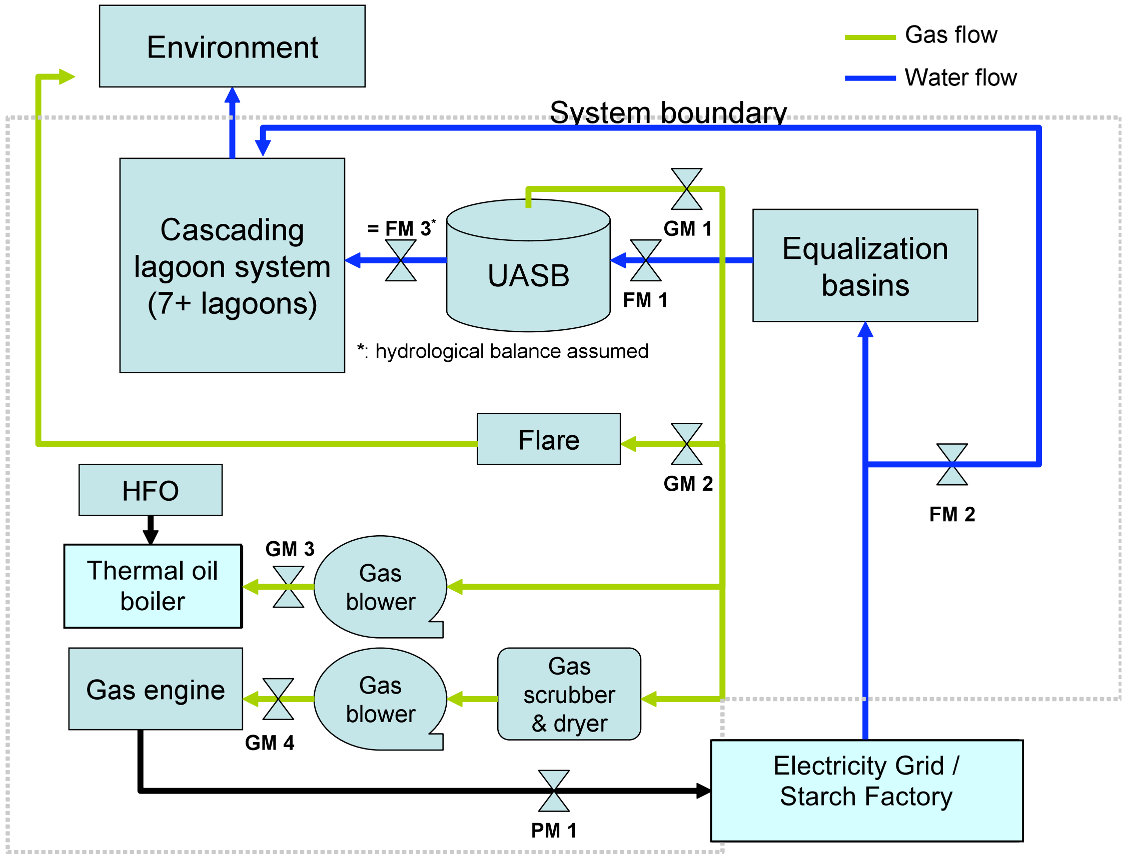

Figure: Pictures of thermal oil boiler that will use biogas plus existing wastewater treatment lagoon system

A.4.4 Estimated amount of emission reductions over the chosen crediting period:

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Table 1: Estimated amount of emissions reductions

Years	Annual estimation of emission reductions in tonnes of CO2e
Year 1	97,468
Year 2	97,468
Year 3	97,468
Year 4	97,468
Year 5	97,468
Year 6	97,468
Year 7	97,468
Year 8	97,468
Year 9	97,468
Year 10	97,468
Total estimated reductions (tonnes of CO2 e)	**974,681**
Total number of crediting years	**10**
Annual average over the crediting period of estimated reductions (tonnes of CO2 e)	**97,468**

Year 1 starts after successful registration of the project at UNFCCC, which is expected in October 2008.

A.4.5. Public funding of the project activity:

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No public funding is involved in the project.

SECTION B. Application of a baseline and monitoring methodology

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

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AM0022 Avoided Wastewater and On-site Energy Use Emissions in the Industrial Sector, Version 4. (AM0022 version 04). It is hereafter referred to as the baseline methodology.

Within AM0022 following tools/methodologies are used for this project activity:

- The "Tool to determine project emissions from flaring gases containing methane" (EB 28 version) is used to calculate project emissions from flaring of a residual gas stream containing methane.
- The "Tool to calculate the emission factor for an electricity system" (Version 01) is used to calculate the Carbon Emission Factor (CEF) of the electricity grid, required for determination of baseline emissions due to displacement of grid electricity.

B.2 Justification of the choice of the methodology and why it is applicable to the project activity:

AM0022 version 04 has been chosen because the Project activity involves the installation of an anaerobic treatment system in an existing open lagoon-based wastewater treatment facility and meets all the applicability conditions stated in the baseline methodology as follows:

Requirement 1: Project is implemented in existing lagoon-based industrial wastewater treatment facilities for wastewater with high organic loading;

Project: The Project is implemented in an existing lagoon-based industrial wastewater treatment facility in a tapioca starch manufacturing plant. The wastewater in the Project plant treats high organic loading materials (compounds).

Requirement 2: The organic wastewater contains simple organic compounds (mono-saccharides).

- The primary organic compound contained in the tapioca processing wastewater is starch, which is a poly-saccharide, a more complex organic compound compared to mono-saccharides, which is expected to yield a higher CH4 emissions factor per kg of COD digested.

  As the baseline methodology stipulates, an alternative CH4 emission factor is estimated and applied for the project activity. The maximum CH4 producing capacity (B0), 0.21 kg CH4/kg COD, stated in approved baseline methodology AM0013 "Avoided methane emissions from organic waste-water treatment" is selected for the Project. As discussed in AM0013, this value is based on the default IPCC value for B_0, 0.25 kg CH4/kg COD, taking account of the 50 – 100% uncertainty range, and it is applicable to all organic wastewater types. Considering that this value has been established as the result of comprehensive discussions among the methodology panel as well as the CDM Executive Board, it is a conservative and transparent approach for the project participant to adopt this value for the methane emission factor. The choice of this value is also justified by the research conducted for the tapioca starch wastewater[5]. According to the results from the research, CH4 emissions factor is estimated as a range of 0.22 ~ 0.24 kgCH4/kgCOD. The selected value of 0.21 kgCH4/kgCOD for CH4 emission factor is lower than the lowest range of the results from the research.

Requirement 3: The methodology is applicable only to the improvement of existing wastewater treatment facilities. It is not applicable for new facilities to be built or newly built to extend current site capacity;

- The Project is implemented in existing wastewater treatment facilities, not in new facilities to be built or newly built to extend the current site capacity of the tapioca starch manufacturing plant.

Requirement 4: It can be shown that the baseline is the continuation of a current lagoon system for managing wastewater. In particular, the current lagoon based system is in full compliance with existing rules and regulations;

- As described in section B.4 below, the baseline is the utilization of the current lagoon system for managing wastewater. Also, the current lagoon based system is in full compliance with existing rules and regulations of Thailand.

Requirement 5: The depth of the anaerobic lagoons should be at least 1m;

- The depth of the of all lagoons within the lagoon based treatment system is always greater than 1 m.

Requirement 6: The temperature of the wastewater in the anaerobic lagoons is always at least 15 degrees Celsius

- Annual minimum temperature of the wastewater in the anaerobic lagoon varies between 25 and 35 degrees Celsius.

Requirement 7: In the project, the biogas recovered from the anaerobic treatment system is flared and/or used on-site for heat and/or power generation, surplus biogas is flared;

- The Project utilizes the biogas recovered from the UASB system for heat generation, power production and surplus biogas is flared.

Requirement 8: Heat and electricity needs per unit input of the water treatment facility remain largely unchanged before and after the project;

- Before and after the Project implementation, heat and electricity needs per unit input of the water treatment facility remain largely unchanged. Water flows in the lagoon systems are operating on gravitational flow basis, the installed electric capacity of the UASB reactors is below 100 kW. Not only is the required amount of electricity for wastewater treatment relatively small, but also the electricity produced by the Project activity surpasses the electricity requirements. Therefore, it

[5] Ajit P. Annachhatre and Prasanna L. Amatya (2000), "UASB Treatment of Tapioca Starch Wastewater", Journal of Environmental Engineering, December 2000, 1149 ~ 1152

can be considered that the energy needs per unit input of the water treatment facility remain largely unchanged before and after the Project.

Requirement 9: Data requirements as laid out in the related Monitoring Methodology are fulfilled. In particular, organic materials flow into and out of the considered lagoon based treatment system and the contribution of different removal processes can be quantified (measured or estimated)

- As described in section B.7 below, data requirements will be fulfilled. Organic materials flow into and out of the considered lagoon based treatment system and the contribution of different removal processes will be measured and quantified.

The baseline methodology will be used in conjunction with the approved monitoring methodology AM0022 Version 04.

B.3. Description of the sources and gases included in the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Direct emissions from the waste water treatment process	CH_4	Included	The major source of emissions in the baseline.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted.
		N_2O	Excluded	Negligible and excluded.
	Emissions from electricity consumption / generation	CO_2	Included	Electricity is consumed from the grid in the baseline scenario.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	Emissions from thermal energy consumption	CO_2	Included	Thermal energy is generated in the project activity.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
Project Activity	Direct emissions from the waste water treatment process	CH_4	Included	Emissions from non-combusted methane and leakage from anaerobic digesters is included. Emissions from dewatering and land application are insignificant.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted.
		N_2O	Excluded	Excluded for simplification. Not and important emission source.
	Emissions from electricity consumption / generation	CO_2	Included	Emissions from electricity generation from biogas are included.
		CH_4	Included	Emissions from electricity generation from biogas are included.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from thermal energy consumption	CO_2	Included	Emissions from continued use of heavy fuel oil are included for cross-checking.
		CH_4	Excluded	Excluded for simplification. This emission

				source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.

The figure provided under Section A.4.3 provides an overview of the project emission boundaries.

Both decision trees 1 and 2 were used to identify and determine baseline boundaries and emission sources to be quantified in baseline emission calculations.

According to decision tree 1 the baseline boundaries are set around the discrete site of the existing anaerobic lagoons at the project site. The flow of organic material which would be directed into and out of the baseline system boundaries in the absence of the project activity, is represented by the flow of organic material that flows into the installed anaerobic reactor and can be quantified after implementation of the project activity. The amount of organic material being degraded through oxidative processes and removed through deposition/sedimentation is estimated based on specific wastewater characteristics determined through laboratory tests of wastewater samples collected at the project site. The justification of the applied values is provided under Section B.6.1 and B.6.2.

According to decision tree 2 the baseline boundaries include also the HFO fired boilers that would produce heat in the absence of the project activity. Furthermore, fossil fuel based power plants supplying electricity to the Thai national electricity grid are also included in the baseline system boundaries since the project activity will displace grid electricity. Further details on the quantification of heat and electricity baseline emissions are provided in Section B.6.

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

As discussed in detail below, the continuation of current practices (existing anaerobic lagoon based wastewater treatment system without biogas use of flaring of the biogas) is confirmed as baseline scenario using the six-step process defined in AM0022, Version 04:

Step 1: List a range of potential baseline options

Alternative 1: Status-quo: open anaerobic lagoon based wastewater treatment system
Alternative 2: Methane recovery and utilization for heat generation and flaring of remaining methane (proposed project without CDM assistance).
Alternative 3: Aerobic waste water treatment
Alternative 4: Direct discharge
Alternative 5: Methane recovery and flaring

Step 2: Select the barriers from the range of potential barriers

The following barriers that may prevent the implementation of the considered alternatives are selected.

1. Legal barriers
2. Technical barriers
3. Financial barriers

4. Social barriers
5. Business culture barriers

Step 3: Score the barriers

Each barrier selected in Step 2 is scored by addressing a range of potential questions.

1. Legal barriers

Scoring Criteria:

- Does the practice violate any host country laws or regulations or is it not in compliance with them?

Performance of alternatives:

Alternatives 1, 2, 3 and 5 are in compliance with current law in Thailand which allows the use of open lagoon systems and other waste treatment technologies that meet effluent standards for the discharge of treated wastewater into the environment. There is no other regulatory requirement for the implementation of a specific wastewater treatment technology such as anaerobic digester or aerobic treatment system to tapioca starch processing plants for effluent treatment. Therefore, alternative 1, 2, 3 and 5 do not face any legal barriers.

Alternative 4 is in violation of the effluent discharge standards set by the laws and regulations of Thailand. Therefore, alternative 4 cannot be considered the baseline and is excluded from further assessment.

2. Technical barrier

Scoring Criteria:

- Is this technology option currently difficult to purchase through local equipment suppliers?
- Are skills and labor to operationalize and maintain this technology in country insufficient?
- Is this technology outside common practice in similar industries in the country?
- Is performance certainty not guaranteed within tolerance limits?
- Is there real, or perceived, technology risk associated with the technology?

Performance of alternatives:

Alternative 1 has been a common practice of handling wastewater from tapioca starch production in Thailand. Most of the tapioca starch production facilities in the project region (Korat Region) utilize open lagoon based systems for treating wastewater. The related technology, skills and labour are readily available in Thailand and there are few risks associated with this technology. Therefore, Alternative 1 does not face technical barriers.

Alternative 2 is currently being constructed at an increasing number of tapioca starch processing facilities using domestically available as well as imported technology. A high percentage of these projects are being developed as CDM projects, indicating the existence of barriers that otherwise could not be overcome: in a usual case, the project operators have to acquire (through contracting or in-sourcing) the skills and labour to operate and maintain such a facility properly. Personnel for the operation of these plants need to go through extensive training. Early alternative 2 projects have faced substantial performance problems due to the inexperience with operation. Under baseline conditions, substantial technical barriers remain.

Alternative 3 is well established and commonly used for both domestic and industrial wastewater treatment in many parts of the world. However, there is no experience with this type of technology in the tapioca starch industry in Thailand and no starch factory operator considers the use of this technology at this point in time (due to commercial reasons – see financial barrier). Considering lack of interest in this technology, technical barriers are deemed irrelevant.

Alternative 4 is already excluded.

Alternative 5 is not considered by project operators due to commercial reasons as it creates no income streams and is not required by law. Technical reasons are deemed irrelevant.

3. Financial barriers

Scoring Criteria:

- Is the technology intervention financially less attractive in comparison to other technologies (taking into account potential subsidies, soft loans or tax windows available)?
- Is equity participation difficult to find locally?
- Is equity participation difficult to find internationally?
- Are site owners/ project beneficiaries carrying any risk?
- Is technology currency (country) denomination a risk?
- Is the proposed project exposed to commercial risk?

Performance of alternatives:

Alternative 1 is currently in operation and creates acceptable operational costs to achieve compliance with domestic effluent regulation. It does not face any financial barrier.

Alternative 2 entails high investment and O&M costs and uncertain commercial returns (from the production and use of biogas). Prior to implementation of the project, the project owner assessed the costs, potential returns and the risks of the proposed activity and came to the conclusion that, given the high investment costs and insecure returns to due to technological risks, the company would not be able to implement the project without the long term financial returns linked to CERs and potential investment from CER buyers. The proposed project activity could only reach financial closure due to upfront CER payments released from the CER buyer to CYY Biopower Co. Ltd. The owners of CYY biopower faced difficulties to attract both equity and debt to finance the project. The credit line of the company with its commercial bank was exhausted and the project owners saw no other way to finance the project except with the upfront CDM payment provided by Kommunalkredit GmbH on behalf of the Austrian government. Evidence of the upfront payment and on the financial background of the project has been provided to the DOE.

Alternative 3 entails high investment and very high O&M costs. The major reason for high O&M costs for treating wastewater with high organic content in aerobic systems is the very high electricity demand for forced aeration and high costs associated to sludge disposal as compared to anaerobic treatment systems. Due to high investment and O&M costs and the lack of commercial returns from energy production or energy saving (as no biogas is produced), the financial barrier for this type of technology is not surmountable and the alternative is excluded from further analysis.

Alternative 4 is already excluded.

Alternative 5 also entails high investment and O&M costs and no commercial return as the produced biogas is destroyed without use. The financial barriers are not surmountable and the alternative is excluded from further analysis.

4. Social barrier

Scoring Criteria:

- Is the understanding of the technology low in the host country/ industry considered?

Performance of alternatives:

Alternative 1 is currently used at the Project site and is common practice in Thailand, no social barriers are identified.

Alternative 2 faces certain social barriers associated with the low understanding of the technology. While there is a lot of talk about the technology, technical understanding of the involved processes (biological, chemical and physical) are poorly understood and therefore decision-making is uninformed, slowing the uptake of this technology. Furthermore, it is known that many biogas projects in Thailand did not perform as expected and others even failed. However, there is no market study, which could provide an accurate analysis of the status quo of installed projects and the perception of the technology in Thailand. With the increased availability of operational experience, this barrier is also likely to become less relevant in the future. Given the lack of studies to confirm this barrier, it was decided to judge this barrier as non-existing for Alternative 2 in order to be on the conservative side.

Alternatives 3 to 5 have been excluded already.

5. Business Culture barriers

Scoring Criteria:

- Is there reluctance to change to alternative management practices in the absence of regulations?

Performance of alternatives:

Alternative 1 is currently used for wastewater treatment and meets all regulatory requirements of Thailand. Therefore there is no barrier caused by the change of the management practice.

Interest in alternative 2 as an alternative management practice is largely driven by the prospect to generate and use biogas in conjunction with the production of carbon credits. There is no foreseeable regulatory change that could stimulate such change as alternative 1 usually exceeds regulatory requirements for water effluent discharge. Therefore, Business Culture barriers exist due to existing and future lack of regulatory pressure to adopt alternative 2.

Step 4: Compare which is the most plausible baseline option

As discussed above, Alternative 1, continuation of the current situation, does not have any significant barriers while all other Alternatives (2 to 5) face some legal, technical, financial, social or business culture barriers, which prevent the implementation of these alternatives under baseline conditions.

Therefore, Alternative 1, continuation of the current situation, is considered to be the only plausible baseline scenario, and, based on the above arguments, continuation of the current open lagoon based wastewater treatment system is considered the baseline scenario in the absence of the CDM project activity.

Summary of Barrier Scoring Performance

The table bellow summarizes the results of the barrier analysis conducted above.

	Baseline alternatives				
Barrier tested	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Legal	**N**	**N**	**N**	**Y**	**N**
Does the practice violate any host country laws or regulations or is it not in compliance with them?	N	N	N	Y	N
Technical	**N**	**Y**	**NA**	**NA**	**NA**
Is this technology option currently difficult to purchase through local equipment suppliers?	N	Y	NA	NA	NA
Are skills and labor to operationalize and maintain this technology in country insufficient?	N	Y	NA	NA	NA
It this technology outside common practice in similar industries in the country?	N	Y	NA	NA	NA
Is performance certainty not guaranteed within tolerance limits?	N	Y	NA	NA	NA
Is there real, or perceived, technology risk associated with the technology?	N	Y	NA	NA	NA
Financial	**N**	**Y**	**Y**	**NA**	**Y**
It the technology intervention financially less attractive in comparison to other technologies (taking into account potential subsidies, soft loans or tax window available)?	N	Y	Y	NA	Y
Is equity participation difficult to find locally?	NA	Y	Y	NA	Y
Is equity participation difficult to find internationally? Are site owners/ project beneficiaries carrying any risk?	NA	Y	Y	NA	Y
Is technology currency (country) denomination risk?	NA	Y	Y	NA	Y

Is the proposed project exposed to commercial risk?	NA	Y	Y	NA	Y
Social	**N**	**N**	**NA**	**NA**	**NA**
Is the understanding of the technology low in the host country/ industry considered?	N	N	NA	NA	NA
Business Culture	**N**	**Y**	**NA**	**NA**	**NA**
Is there a reluctance to change to alternative management practices in the absence of regulation?	N	Y	NA	NA	NA

Step 5: Investment Analysis

Since there is only one baseline option, this step is not required by the baseline methodology.

Step 6: Conclusion

Based on the above arguments, the "continuation of the use of the installed open anaerobic lagoon based wastewater treatment system throughout the crediting period" represents the most plausible baseline scenario for this project. The existing lagoons are sufficient to meet wastewater treatment needs of the facility, no additional capacity expansion is planned and there is no incentive to change to a more costly technology nor does the facility need to comply with stricter discharge limits. The only rationale for the investment is the availability of additional incentives from the production of power and carbon credits as well as reduction of energy costs.

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 CDM project activity (assessment and demonstration of additionality):

According to AM0022, Version 04 (p. 13), the project is deemed additional since the identified baseline scenario is different from the proposed project activity not undertaken as a CDM project activity. In the absence of the project activity, effluent from the plant will continue to be treated by the existing open anaerobic lagoon based wastewater treatment system, emitting a large amount of methane into the atmosphere.

As per the "Guidelines for Completing the Project Design Document (CDM-PDD), and the Proposed New Baseline and Monitoring Methodologies (CDM-NM)", Version 06.2, it is required to provide evidence that the incentive from CDM was seriously considered in the decision to proceed with the project activity since the starting date of the project is before the date of validation.

Before the implementation of the project, the project owner analysed the viability of the project in early 2006 and came to the conclusion that the proposed project activity was not feasible without consideration of CDM revenues, which is documented in a decision by the board of Chokeyoenyong Industries Co. Ltd. (CYY Industries Co. Ltd.) from February 25th, 2006. Also prior to project start, a CDM service agreement for CDM project development and transaction of CERs has been signed between CDM Solutions and CYY Biopower Co. Ltd. on March 20th, 2006.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

As per methodology AM0022, Version 4, emission reductions of the project activity are equal to baseline emissions minus project emissions. Leakage is considered to be negligible. In order to quantify emission reductions achieved by the project activity, procedures to calculate project and baseline emissions defined in the methodology (and in the "Tool to determine project emissions from flaring gases containing methane") are applied as follows:

Project emissions

Total estimated project emissions are the sum of fugitive methane emissions from the existing lagoon-based water treatment system, from possible methane emissions from the new anaerobic waste water treatment facility, from incomplete biogas combustion and biogas leaks.

Formula (1) AM0022 v4, project scenario:

$$E_{project} = E_{CH4\_lagoons} + E_{CH4\_NAWTF} + E_{CH4\_IC+Leaks}$$

Where:
$E_{project}$ are the Total Project Emissions (tCO_2e)
$E_{CH4\_lagoons}$ are the fugitive methane emissions from lagoons from equations 2 (tCO_2e)
E_{CH4_NAWTF} are the fugitive methane emissions from the new anaerobic waste water treatment facility (tCO_2e)
$E_{CH4\_IC+leakss}$ are the methane emissions from inefficient combustion and leaks (tCO_2e)

The calculations for each component of equation (1) are provided below.

1) Fugitive Methane Emissions from Lagoons in the project scenario ($E_{CH4\_lagoons}$)

The treated digester effluent is discharged into the old lagoon based system for final treatment. While the residual organic load of the digester is low and removal of the residual COD in the lagoons is expected to occur under aerobic conditions, Fugitive Methane Emissions from the lagoons are calculated assuming mostly anaerobic conditions, which is conservative.

Formula (2) AM0022 v4, project scenario:

$$E_{CH4\_lagoons} = M_{lagoon\_anaerobic} \cdot EF_{CH4} \cdot GWP_{CH4} / 1000$$

where:

$M_{lagoon\_anaerobic}$	is the amount of organic material removed by anaerobic processes in the lagoon system (kgCOD)
EF_{CH4}	is the methane emission factor ($kgCH_4/kgCOD$). 0.21kg $CH_4/kgCOD$ of COD to Methane conversion factor is used.
GWP_{CH4}	is the Global Warming Potential of methane (GWP_{CH4}= 21)

Amount of organic material removed by anaerobic processes in the lagoon system ($M_{lagoon\_anaerobic}$)

Formula (3) AM0022 v4, project scenario:

$$M_{lagoon\_anaerobic} = M_{lagoon\_total} - M_{lagoon\_aerobic} - M_{lagoon\_chemical\_ox} - M_{lagoon\_deposition}$$

where:

M_{lagoon_total}	is the total amount of organic material removed in the lagoon system from equation (5) (kg COD)
$M_{lagoon\_aerobic}$	is the amount of organic material degraded aerobically in the lagoon system (kg COD). Surface aerobic losses of organic material in pond-based systems equal to 254kg COD per hectare of pond surface area and per day is assumed to be lost through aerobic processes.
$M_{lagoon\_chemical\_ox}$	is the amount of organic material lost through chemical oxidation in the lagoon system (kg COD).
$M_{lagoon\_deposition}$	is the amount of organic material lost through deposition in the lagoon system from equation (6) (kg COD)

Amount of organic material removed in the lagoon system (M_{lagoon_total})

Formula (5) AM0022 v4, project scenario:

$$M_{lagoon\_total} = M_{lagoon\_input} \cdot R_{lagoon}$$

with Formula (4) AM0022 v4, project scenario:

$$M_{lagoon\_input} = M_{input\_total} \cdot (1 - R_{NAWTF})$$

where:

M_{lagoon_input}	is the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system (kg COD)
R_{lagoon}	is the total organic material removal ratio of the lagoon. It is a project specific factor, and is equal to the proportion of organic material removed (through all route) within the boundaries of the lagoon system under consideration.
M_{input_total}	is the total amount of organic material fed into the new project wastewater treatment facility (kg COD)
R_{NAWTF}	is the total organic material removal efficiency of the new project wastewater treatment facility. The manufacture's guaranteed COD removal ratio of 90% (according to the technical proposal) is used as a project specific value.

The Total Organic Removal Ratio (R_{lagoon}) factor has been determined according to Appendix 2 of AM0022, Version 04 by undertaking a series of chemical analyses based on COD samples at the inlet and the outlet of the lagoon system boundary. Based on the results of the chemical analysis, the Total Organic Removal Ratio is calculated as average value of the test series as follows:

$$R_{lagoon} = \left(\frac{COD_{in} - COD_{out}}{COD_{in}} \right)_{average}$$

where:

COD_{in}	is the COD concentration of the wastewater at the inlet of the lagoon system
COD_{in}	is the COD concentration of the wastewater at the outlet of the lagoon system

The series of collected COD samples at the inlet and outlet of the lagoon system indicate an average Total Organic Removal Ratio (R_{lagoon}) of 98.9% (see Annex 3 of the PDD for more details).

Amount of organic material degraded aerobically in the lagoon system ($M_{lagoon\_aerobic}$)

The amount of organic material degraded aerobically in the lagoon system is calculated as the product of the AM0022, Version 04 default value for surface aerobic losses of organic material in pond based systems (254 kg COD/ha/day), total surface area of the lagoons (25.18 ha) and number of days in a year (365 days). Although no explicit equation is provided in AM0022, Version 04, following formula is applied:

$$M_{lagoon\_aerobic} = COD_{loss\_aerobic} \text{ x } A_{lagoon\_surface} \text{ x } dd_{year}$$

Where:

$COD_{loss\_aerobic}$	is the default value for surface aerobic losses of organic material (254 kg COD/ha/day)
$A_{lagoon\_surface}$	is the total surface area of the lagoon based wastewater treatment system (in ha)
dd_{year}	is the number of days per year (in days)

$M_{lagoon\_aerobic}$ = 254 (kg COD/ha/day) x 25.18 (ha) x 365 day/yr = 2,334,438 kg COD/year

As per the methodology, sensitivity analysis was conducted in order to determine the effect of change in the surface aerobic loss of COD to the emission reductions. The results of the sensitivity analysis indicate that the default value of 254 kg COD/ha/day) is appropriate for emission reduction calculations (see Annex 3 for details).

Amount of organic material lost through chemical oxidation in the lagoon system ($M_{lagoon\_chemical\_ox}$)

The amount of organic material lost through chemical oxidation in the lagoon system is calculated based on guidance provided in Appendix 2 of AM0022, Version 04. Although no explicit equation is provided, following formula is applied:

$$M_{lagoon\_chemical\_ox} = WW_{in} \text{ x } SO_4^{2-}\text{\_concentration x } COD_{loss\_chem\_ox}$$

Where:

WWin	wastewater flow entering system boundaries in m3/yr
SO_4^{2-}_concentration	sulphate (Q_{ox}) concentration in kg Q_{ox}/m3
$COD_{loss\_chem\_ox}$	COD removal factor in kg COD/kg Qox (0.651 kg COD/kg SO_4^{2-})

According to a lab analysis conducted on wastewater samples collected at the inlet of the system boundaries (untreated effluent), there is only a small amount of SO_4^{2-} in the wastewater, amounting to 75.87 mg/l (0.07587 kg/m3).

Amount of organic material lost through deposition in the lagoon system ($M_{lagoon\_deposition}$)

Formula (6) AM0022 v4, project scenario:

$$M_{lagoon\_deposition} = M_{lagoon\_input} \cdot R_{deposition}$$

Where:

$R_{deposition}$ is the organic material deposition ratio of the lagoon. It is equal to the proportion of organic material physically sedimented in lagoons within the project boundaries. It is a project specific factor derived by assessing the relative ability of COD in the waste water stream to sediment in the project boundaries, through pre project analysis.

A series of experiments described in detail under Annex 3 of the PDD show that the average Organic Material Deposition Ratio ($R_{deposition}$) is determined based on a conservative approach as 7.05%.

2) Methane emissions from new anaerobic waste water treatment facility ($E_{CH4\ NAWTF}$)

Methane emissions from the specific anaerobic wastewater treatment facilities that are installed by the Project, are assessed and estimated based on monitoring measurements, technology supplier data and expert estimates. They may be disregarded if documented evidence for their insignificance is given.

The technology provider, GLOBAL WATER ENGINEERING (GWE) LTD., has estimated based on their experience that the physical leakage from the UASB system is less than 1% for systems with similar size and design to the project activity. To ensure conservativeness, physical leakage factor of 1% of total biogas production is used for the Project activity.

Although no explicit formula is provided under AM0022, Version 04 for calculation of methane emissions from the new anaerobic wastewater treatment facility (E_{CH4_NAWTF}), following formula is applied:

$$E_{CH4\_NAWTF} = (E_{CH4\_lagoon\_BL} - E_{CH4\_lagoon}) \times F_{leakage\_NAWTF}$$

Where:

$E_{CH4\_lagoon\_BL}$	are the fugitive methane emissions from lagoons in the baseline scenario (t CO2e)
E_{CH4_lagoon}	are the fugitive methane emissions from lagoons in the project scenario (t CO2e)
$F_{leakage\_NAWTF}$	is the leakage factor for the new wastewater treatment system (1%)

3) Methane emissions from inefficient combustion emissions ($E_{CH4\_IC+Leaks}$)

The project involves on site heat and electricity generation and biogas flaring (in case of excess biogas production or technical problems related to the heat and electricity generation equipment).

Formula (7) AM0022 v4, project scenario:

$$E_{CH4\_IC+Leaks} = (\sum_r V_r \cdot C_{CH4\_r} \cdot (1 - f_r) \cdot GWP_{CH4}) + PE_{flare}$$

Where:

the sum is made over two routes *r* for methane destruction (heating and power generation);

Vr	is the biogas combustion process volume in route r (Nm3)
C_{CH4}	is the methane concentration in biogas (tCH4/Nm3)[6]
f_r	is the proportion of biogas destroyed by combustion (-)
PE_{flare}	are the project emissions from flaring of the residual gas stream (tCO2e) calculated following the procedures described in the "Tool to determine project emissions from flaring gases containing Methane". PE_{flare} can be calculated on an annual basis or for the required period of time using this tool.

The values applied as "proportion of biogas destroyed by combustion" are 98.5% for the heat generation equipment (f_{boiler}) and 99% for the electricity generation equipment (f_{engine}).

Among the options for flaring systems, an open flare system is chosen by the project participants. For the determination of the flare efficiency, the default values for open flares proposed in the "Tool to determine project emissions from flaring of gases containing methane" will be used for the calculation of project emissions from flaring gases. Following equations from the flaring tool are used to determine the project emissions from flaring of the residual gas stream.

[6] Both AM0022 and the flaring tool suggest different methane concentration measurement methods. For the sake of consistency, methane concentration is calculated as being measured on a dry basis, as suggested in the flaring tool. Given the low temperature of the biogas at the reactor outlet, methane concentration measurements on a dry basis seem to be more appropriate. In case of deviations from this approach in the monitoring period (measurement on wet basis), the methane concentration value shall be adapted.

Calculation of flare emissions PE_{flare}

STEP 1: Determination of the mass flow rate of the residual gas that is flared

$$FM_{RG,h} = \rho_{RG,n,h} \times FV_{RG,h}$$

where:

$FM_{RG,h}$	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)

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

where:

$\rho_{RG,n,h}$	Density of the residual gas at normal conditions in hour h (kg/m^3)
P_n	Atmospheric pressure at normal condition (101325 Pa)
R_u	Universal ideal gas constant (8314 Pa.m^3/kmol.K)
$MM_{RG,h}$	Molecular mass of the residual gas in hour h (kg/kmol)
T_n	Temperature at normal condition (273.15 K)

$$MM_{RG,h} = \sum_i (fv_{i,h} \times MM_i)$$

where:

$MM_{RG,h}$	Molecular mass of the residual gas in hour h (kg/kmol)
$fv_{i,h}$	Volumetric fraction of component i in the residual gas in the hour h
MM_i	Molecular mass of residual gas component i
i	The components CH_4, CO, CO_2, O_2, H_2, N_2

STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

$$fm_{j,h} = \frac{\sum_i fv_{i,h} \cdot AM_j \cdot NA_{j,i}}{MM_{RG,h}}$$

where:

$fm_{j,h}$	Mass fraction of element j in the residual gas in hour h
$fv_{i,h}$	Volumetric fraction of component i in the residual gas in the hour h
AM_j	Atomic mass of element j (kg/kmol)
$NA_{j,i}$	Number of atoms of element j in component i
$MM_{RG,h}$	Molecular mass of the residual gas in hour h (kg/kmol)
j	The elements carbon, hydrogen, oxygen and nitrogen
i	The components CH_4, CO, CO_2, O_2, H_2, N_2

STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis

This step is skipped since a default value will be used for the determination of the methane combustion efficiency of flare.

STEP 4: Determination of methane mass flow rate in the exhaust gas on a dry basis

This step is skipped since default value will be used for the determination of the methane combustion efficiency of flare.

STEP 5: Determination of methane mass flow rate in the residual gas on a dry basis

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas (FVRG,h), the volumetric fraction of methane in the residual gas (fvCH4,RG,h) and the density of methane (_CH4,n,h) in the same reference conditions (normal conditions and dry or wet basis). Considering that the residual gas (biogas leaving the anaerobic UASB reactor) is cooler than 60 degrees Celsius, the measured volumetric flow of the biogas and the volumetric fraction of methane in the biogas is expressed on a dry basis.

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,n}$$

where:

$TM_{RG,h}$	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 (m^3/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/m^3)

STEP 6: Determination of the hourly flare efficiency

The determination of the hourly flare efficiency depends on the operation of the flare (e.g. temperature), the type of flare used (open or enclosed).

In case of open flares, the flare efficiency in the hour h ($\eta_{flare,h}$) is:

- 0% if the flame is not detected for more than 20 minutes during the hour h
- 50%, if the flame is detected for more than 20 minutes during the hour h

For ex-ante calculations, the 50% default is applied. Ex-post calculations will be based on the monitored period of flare activity as described above.

STEP 7: Calculation of annual project emissions from flaring

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:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} x(1 - \eta_{flare,h}) x \frac{GWP_{CH4}}{1000}$$

Where:
$TM_{RG,h}$: Mass flow rate of methane in the residual gas in the hour h
$\eta_{flare,h}$: Flare efficiency in hour h
GWP_{CH4}: Global Warming Potential of methane valid for the commitment period

It should be noted that, although not explicitly mentioned in the flaring tool, Steps 1 and 2 are not required for calculation of Steps 5 to 7, since all input values required in Steps 5 to 7 are either measured during the monitoring of the project or are calculated without use of the parameters defined under Steps 1 and 2. Hence, ex-ante and ex-post project emissions from flaring are calculated on the basis of Steps 5 to 7 described above.

The project activity has the aim to convert 100% of the generated biogas to energy in the form of heat and electricity. The flare is used rather as a safety device in order to burn the gas whenever the gas engine or the boiler system cannot use the gas. For the purpose of the ex-ante calculation of flaring emissions, it is assumed that the volumetric biogas flow to the flare is zero. For ex-post determination of flaring emissions, the amount of biogas sent to the flare and flare activity (flame detection) will be monitored on a continuous basis.

4) Methane Emissions from Leaks in Biogas System

Leaks in the biogas system include leaks from the anaerobic digester and leaks from the biogas pipeline delivery system. The UASB reactor gas collection system consists of a gas-tight concrete, coated gas dome and the biogas pipeline is made of stainless steel (AISI 304) and approximately 385 m long. Given the short length of the biogas pipeline (as compared to the reference value of 2 km provided in AM0022, Version 04) and the utilisation of high quality materials, emissions from leaks in the biogas system are assumed to be negligible.

The pipeline will undergo regular maintenance and monitoring in order to ensure that leakage remains negligible.

Baseline emissions

The baseline scenario, identified under Section B.4, is based on what would have happened in the absence of the project activity. In this case, the baseline scenario will be continued operation of the open anaerobic lagoon system, consumption of HFO for thermal energy generation and of electricity from the grid:

Formula (8) AM0022 v4, baseline scenario:

$$E_{BL} = E_{CH4\_lagoons\_BL} + E_{C02\_heat\_BL} + E_{CO2\_power\_BL}$$

Where:

E_{BL} are the Total Baseline Emissions (tCO_2e)

$E_{CH4\_lagoons\_BL}$ are the fugitive methane emissions from lagoons in the baseline case (tCO_2e). They are calculated with baseline data based on equation 2 in the section on project emissions.

$E_{CO2\_heat+powers\_BL}$ are the CO_2 emissions from on site fossil heat and/or power generation in the baseline case (tCO_2) that are displaced by generation based on biogas collected in the anaerobic treatment facility.

$E_{CO2\_grid\_BL}$ are the CO_2 emissions related to electricity supplied by the grid in the baseline case (tCO_2) that are displaced by generation based on biogas collected in the anaerobic treatment facility.

1) Fugitive methane emissions from lagoons ($E_{CH4\_lagoon\_BL}$)

Methane emissions from lagoons are calculated using equations (2), (3), (5) and (6). In the baseline case, without the new anaerobic treatment facility, no wastewater material degrades before entering the lagoon system and all the organic material to be treated enters the lagoons system. Therefore, equation (4) has to be changed for the baseline calculations as shown below:

Formula (11) AM0022 v4, baseline scenario:

$$M_{lagoon\_input\_BL} = M_{input\_total}$$

Where:

$M_{lagoon\_input\_BL}$	is the input of organic material from the new project anaerobic wastewater treatment facility into the lagoon system (kg COD)
M_{input_total}	is the total amount of organic material fed into the baseline wastewater treatment facility (kg COD) It is the same amount as fed into the project wastewater treatment facility.

All emission factors for surface aerobic losses of organic material, aerobic degradation, deposition or removal as well as chemical oxidation are determined in the same way as described for project emissions calculations.

2) On site heat generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility ($E_{CO2\_heat\_BL}$)

In calculating CO2 emissions from on site heat displaced by biogas collected in the anaerobic treatment, the use of fossil fuels (HFO) is considered:

Formula (9) AM 22 v4, baseline scenario

$$E_{C02\_heat} = F \cdot NCV \cdot EF$$

Where:

F is the corresponding amount of fossil fuel used for on-site heat generation (tons of HFO)

NCV is the net calorific value of the fossil fuel considered (HFO) in (TJ/t). The default IPCC value of 0.0404 TJ/t from the 2006 IPCC guidelines for National GHG Inventories is applied.
EF is the carbon emission factor of the fossil fuel considered (HFO) in (t CO2/TJ). According to the 2006 IPCC guidelines for National GHG Inventories, this value is 77.40 t CO2/TJ

In order to calculate the quantity of fuel that is displaced by biogas, the two fuels are substituted on the basis of equivalent delivered energy (NCV). The following energy densities are used:

- 1 m3 biogas at 65% concentration of methane = 23.2 MJ
- 1 kg of heavy fuel oil = 40.40 MJ
- Therefore: 1 m3 biogas = 0.5743 kg of HFO = 0.0005743 tons of HFO

Since biogas is combusted in the same boilers that used HFO prior to the project activity, it is assumed that the thermal efficiency of HFO as well as biogas is 86% based on manufacturer's specifications of the boiler. Assuming the same thermal efficiency for both fuels, the amount of HFO displaced by biogas can be calculated on the basis of the values provided above. Therefore, in order to determine the volume of HFO displaced by biogas, multiply the volume of biogas (measured in m3) by 0.0005743 tons of heavy fuel oil.

For ex-ante estimation of emission reductions the amount of heavy fuel displaced is based on the historic average annual HFO demand of 1,466 t HFO per year[7]. Based on the historic average annual HFP consumption of 1,466 t HFO/year and on the historic average dry starch production (44,376 t starch/yr), the specific heavy fuel oil consumption is determined as 0.03303 t HFO/t dry starch. The historic average specific heavy fuel oil consumption shall be used as reference value during the monitoring period in order to avoid an overestimation of baseline emissions.

3) Off-site grid power generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility ($E_{CO2\_power\_BL}$)

Formula (10) AM 22 v4, baseline scenario

$$E_{CO2\_power} = EL \cdot CEF \quad (10)$$

where:

EL is the amount of electricity displaced by the electricity generation from the biogas collected from the anaerobic treatment facility. This is estimated as product of: (1) average specific electricity consumption for the output of the facility, estimated using 3 years historical data: and (2) the annual production.

CEF is the carbon emission factor for the electricity displaced by the electricity generated from the biogas. (tCO_2e/MWh).

[7] According to annual reports the average historic HFO consumption amounts to 1,473,133 litres/year, which multiplied by the HFO density of 0.995 kg/l (based on national statistics for (fuel oil type 5, extracted from http://www.dede.go.th/dede/fileadmin/usr/wpd/static/oil_and_thailand_2006/41Table36.pdf) and converted to tons leads to 1,466 t HFO/year.

Given the fact that the project activity will displace electricity (either on-site usage or supply to grid) from the Thai national grid EL is determined based on the electricity generation from the gen set installed as the part of the Project activity (as opposed to the approach based on historic specific electricity consumption at the starch plant proposed in AM0022, Version 04 as described above).

As the gas engines to generate electricity from biogas at the project site have an installed capacity of less than 15 MW_{el}, the Carbon Emission Factor (CEF) of the electricity grid is calculated according to the approved CDM small-scale methodology under category I.D. The most recent version of AMS.I.D. (Version 13) proposes two methods to develop the CEF of an electricity grid such as the Thai national grid:

1. 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', or
2. The weighted average emissions (in kg CO2e/kWh) of the current generation mix. The data of the year in which project generation occurs must be used.

In this PDD, the combined margin approach is applied. Both the operating margin and the build margin were calculated according to the 'Tool to calculate the emission factor for an electricity system' (as determined by AMS.I.D, Version 13). For details on the calculation of CEF, please refer to Annex 3.

Leakage

As determined in AM0022, Version 04, leakage is considered to be negligible.

Emission reductions

Emission reductions, ER (tCO2e) are calculated as the difference between the total baseline emissions (E_{BL}) (equation (8)) and the total project emissions ($E_{project}$) (equation (1)). Leakage is considered to be negligible.

Formula (12) AM0022 v4

$$ER = E_{BL} - E_{project}$$

It must be verified this equation delivers a conservative estimate of emission reductions i.e. that theemissions of CH4 from the lagoons in the baseline situation are not higher than the total emissions ofbiogas from the digester and the lagoons in the project situation. For this purpose, following equation is applied:

Formula (13) AM0022 v4

$$E_{\text{CH4\_lagoon\_BL}} - \left(E_{\text{CH4 lagoon}} + E_{\text{CH4\_nawtf}} + E_{\text{CH4\_coll}}\right)$$

Where:
E_{CH4_coll} is the amount of methane expressed in (tCO_2e) contained in the biogas collected from the anaerobic treatment facility (i.e. the sum of the biogas sent to heaters, the biogas sent to the gen sets and the biogas sent to the flare).

If the result of the equation (13) is positive, it will be deducted from the result obtained through the equation (12) in order to obtain the final estimation of the emission reductions.

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

Data / Parameter:	EF_{CH4}
Data unit:	kg CH4 / kg COD
Description:	Methane emission factor
Source of data used:	Estimated based on IPCC default value and available scientific literature
Value applied:	0.21
Justification of the choice of data or description of measurement methods and procedures actually applied :	The primary organic compound contained in the tapioca processing wastewater is starch, which is a poly-saccharide, a more complex organic compound compared to mono-saccharides, which is expected to yield a higher CH4 emissions factor per kg of COD digested. As the baseline methodology stipulates, an alternative CH4 emission factor is estimated and applied for the project activity. The maximum CH4 producing capacity (B0), 0.21 kg CH4/kg COD, stated in approved baseline methodology AM0013 "Avoided methane emissions from organic waste-water treatment" is selected for the Project. As discussed in AM0013, this value is based on the default IPCC value for B0, 0.25 kg CH4/kg COD, taking account of the 50 – 100% uncertainty range, and it is applicable to all organic wastewater types. Considering that this value has been established as the result of comprehensive discussions among the methodology panel as well as the CDM Executive Board, it is a conservative and transparent approach for the project participant to adopt this value for the methane emission factor. The choice of this value is also justified by the research conducted for the tapioca starch wastewater. According to the results from the research, CH4 emissions factor is estimated as a range of 0.22 ~ 0.24 kgCH4/kgCOD. The selected value of 0.21 kgCH4/kgCOD for CH4 emission factor is lower than the lowest range of the results from the research.
Any comment:	

Data / Parameter:	**Rlagoon**
Data unit:	%
Description:	Organic material removal ratio
Source of data used:	Chemical analysis of effluent samples at inlet and outlet of lagoon system boundaries
Value applied:	98.90
Justification of the	Determined in accordance with AM0022 using historical COD data of

choice of data or description of measurement methods and procedures actually applied :	wastewater entering and leaving the open anaerobic lagoon treatment system.
Any comment:	Data provided in Annex 3

Data / Parameter:	**Surface Aerobic Losses Factor**
Data unit:	Kg COD/ha/day
Description:	Surface aerobic losses factor per hectare of pond surface area per day
Source of data used:	Default value AM0022, Version 04
Value applied:	254 kg COD/ha/day
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value proposed by AM0022, Version 04 and confirmed by sensitivity analysis provided in Annex 3.
Any comment:	Sensitivity analysis provided in Annex 3

Data / Parameter:	**Chemical Oxidation Losses Factor**
Data unit:	Kg COD/m3
Description:	Chemical oxidation losses factor per cubic meter of effluent entering the lagoon based treatment system
Source of data used:	Default value AM0022, Version 04
Value applied:	0.07587 * 0.651 = 0.0494 kg COD/m3
Justification of the choice of data or description of measurement methods and procedures actually applied :	According to a wastewater sample analysis collected at the inlet of the system boundaries (untreated effluent), the concentration of sulphate ions (SO_4^{2-}) in the wastewater amounts to 75.87 mg/l, which according to Appendix 2 of AM0022, Version 4, translates to a COD loss of 0.0494 kg COD/m3 of effluent entering the system boundaries (as calculated above).
Any comment:	

Data / Parameter:	**Rdeposition**
Data unit:	%
Description:	Organic material deposition ratio
Source of data used:	Project developer
Value applied:	7.05
Justification of the choice of data or description of measurement methods and procedures actually applied :	Determined in accordance with AM0022 based on comparison of total COD concentration vs. soluble COD concentration of wastewater entering the open lagoon treatment system.
Any comment:	Data provided in Annex 3

Data / Parameter:	**$E_{CH4\ NAWTF}$**
Data unit:	%
Description:	Proportion of methane emitted from UASB digesters
Source of data used:	Information provided by technology provider
Value applied:	1
Justification of the choice of data or description of measurement methods and procedures actually applied :	The technology provider, GLOBAL WATER ENGINEERING (GWE) LTD., has estimated based on their experience that the physical leakage from the UASB system is less than 1% for systems with similar size and design to the project activity. To ensure conservativeness, physical leakage factor of 1% of total biogas production is used for the Project activity.
Any comment:	NA

Data/Parameter	**R_{NAWTF}**
Data unit:	%
Description:	Total organic material removal efficiency of the new project wastewater facility.
Source of data used:	Technical proposal prepared by technology provider.
Value applied:	90
Justification of the choice of data or description of measurement methods and procedures actually applied :	The technology provider, GLOBAL WATER ENGINEERING (GWE) LTD, has guaranteed to reach 90% COD removal.
Any comment	NA

Data/Parameter	**f_{boiler}**
Data unit:	%
Description:	Proportion of biogas destroyed by combustion in the boilers used for heat generation.
Source of data used:	Technical literature
Value applied:	98.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	This value is based on technical literature and manufacturer's specifications of similar boilers. The factor is assumed to conservative given the fact that the oxidation default value used for gaseous fuels in the 1996 IPCC Guidelines for National GHG Inventories was 100%.
Any comment	NA

Data/Parameter	**f_{engine}**
Data unit:	%
Description:	Proportion of biogas destroyed by combustion in the engine used for electricity generation.
Source of data used:	Technical literature

Value applied:	99
Justification of the choice of data or description of measurement methods and procedures actually applied :	This value is based on technical literature and manufacturer's specifications of similar engines. The factor is assumed to conservative given the fact that the oxidation default value used for gaseous fuels in the 1996 IPCC Guidelines for National GHG Inventories was 100%.
Any comment	NA

Data / Parameter:	**CEF**
Data unit:	tCO2/MWh
Description:	Carbon emission factor for the electricity displaced by the electricity generated from the biogas
Source of data used:	Electricity Generation Authority of Thailand (EGAT), "Tool to calculate the emission factor for an electricity system"
Value applied:	0.52
Justification of the choice of data or description of measurement methods and procedures actually applied :	CEF is calculated according to the "Tool to calculate the emission factor for an electricity system" as determined in the respective small-scale methodology for grid connected electricity generation(AMS-I.D v.13).
Any comment:	NA

Data / Parameter:	**EF**
Data unit:	tCO2/TJ
Description:	Carbon emission factor of heavy fuel oil
Source of data used:	2006 IPCC guidelines for National GHG Inventories
Value applied:	77.40
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value
Any comment:	NA

Data / Parameter:	**NCV**
Data unit:	TJ/t
Description:	Net calorific value of heavy fuel oil
Source of data used:	2006 IPCC guidelines for National GHG Inventories
Value applied:	0.0404
Justification of the choice of data or description of measurement methods and procedures actually	Default value

applied :	
Any comment:	NA

Data / Parameter:	**Density of CH4**
Data unit:	kgCH4 / Nm3 CH4
Description:	Density of methane at standard condition (0 degree Celsius, 1,013 bar)
Source of data used:	UNFCCC Methodological tool to determine project emissions from flaring gases containing methane, Table 1, page 12
Value applied:	0.716
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value
Any comment:	NA

Data / Parameter:	**Lagoon surface area**
Data unit:	Hectare
Description:	Total lagoon area
Source of data used:	Project owner
Value applied:	25.18
Justification of the choice of data or description of measurement methods and procedures actually applied :	Facility operates 22 lagoons. Surface area data from the project owner.
Any comment:	Details provided in Annex 3

Data / Parameter:	**Flare efficiency**
Data unit:	%
Description:	Flare efficiency for open flare
Source of data used:	Tool to determine project emissions from flaring gases containing methane
Value applied:	0% if the flame is not detected for more than 20 minutes during the hour h. 50%, if the flame is detected for more than 20 minutes during the hour h.
Justification of the choice of data or description of measurement methods and procedures actually applied :	The project activity uses an open flare, therefore the default values described above are used.
Any comment:	When the flare is active, a flame can be visibly observed.

Data / Parameter:	**Specific heavy fuel oil consumption**
Data unit:	t HFO/t starch

Description:	Historic average heavy fuel oil consumption per ton of output (ton of dry starch)
Source of data used:	Historic fuel consumption of 2006/2007
Value applied:	0.033
Justification of the choice of data or description of measurement methods and procedures actually applied :	Value is based on historic HFO consumption and starch production data from 2006 and 2007. The starch plant started operation in 2005, entering regular operation only in 2006. Hence, only two complete year records can be used to estimate this value. The average historic HFO consumption amounts to 1,473,133 litres per year, whereas the average historic starch production was 44,376 tons of starch per year. The applied HFO density for conversion of litres of HFO to kg (0.995 kg/l) is based on national oil statistics for fuel oil category 5 Source:http://www.dede.go.th/dede/fileadmin/usr/wpd/static/oil_and_thailand_2006/41Table36.pdf
Any comment:	NA

Data / Parameter:	**Specific electricity consumption**
Data unit:	MWh/t starch
Description:	Historic average electricity consumption per ton of output (ton of dry starch)
Source of data used:	Historic electricity consumption of 2006/2007
Value applied:	0.222
Justification of the choice of data or description of measurement methods and procedures actually applied :	Value is based on historic electricity consumption and starch production data from 2006 and 2007. The starch plant started operation in 2005, entering regular operation only in 2006. Hence, only two complete year records can be used to estimate this value.
Any comment:	This value is not relevant for calculations of emission reductions since the electricity is exported to the grid.

B.6.3 Ex-ante calculation of emission reductions:

Project emissions

Formula (1) AM0022 v4, project scenario:

$$E_{project} = E_{CH4\_lagoons} + E_{CH4\_NAWTF} + E_{CH4\_IC+Leaks}$$

Formula 1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$E_{project}$ (tCO_2e)	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925
$E_{CH4\_lagoons}$ (tCO_2e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E_{CH4_NAWTF} (tCO_2e)	858	858	858	858	858	858	858	858	858	858
$E_{CH4\_IC+Leaks}$ (tCO_2e)	1,068	1,068	1,068	1,068	1,068	1,068	1,068	1,068	1,068	1,068

1) Fugitive Methane Emissions from Lagoons in the project scenario ($E_{CH4\_lagoons}$)

Formula (2) AM0022 v4, project scenario:

$$E_{CH4\_lagoons} = M_{lagoon\_anaerobic} \cdot EF_{CH4} \cdot GWP_{CH4} / 1000$$

Formula 2 (project)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$E_{CH4\_lagoons}$ (tCO_2e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$M_{lagoon\_anaerobic}$ (kg COD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EF_{CH4} (kg CH_4/kg COD)	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210
GWP_{CH4} (tCO_2e/tCH_4)	21	21	21	21	21	21	21	21	21	21

Amount of organic material removed by anaerobic processes in the lagoon system ($M_{lagoon\_anaerobic}$)

Formula (3) AM0022 v4, project scenario:

$$M_{lagoon\_anaerobic} = M_{lagoon\_total} - M_{lagoon\_aerobic} - M_{lagoon\_chemical\_ox} - M_{lagoon\_deposition}$$

Formula 3 (project)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$M_{lagoon\_anaerobic}$(kg COD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M_{lagoon_total}(kg COD)	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831
$M_{lagoon\_aerobic}$(kg COD)	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438
$M_{lagoon\_chemical\_ox}$ (kg COD)	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118
$M_{lagoon\_deposition}$(kg COD)	167,564	167,564	167,564	167,564	167,564	167,564	167,564	167,564	167,564	167,564

Amount of organic material removed in the lagoon system (M_{lagoon_total})

Formula (5) AM0022 v4, project scenario:

$$M_{lagoon\_total} = M_{lagoon\_input} \cdot R_{lagoon}$$

with Formula (4) AM0022 v4, project scenario:

$$M_{lagoon\_input} = M_{input\_total} \cdot (1 - R_{NAWTF})$$

Formula 5 (project)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
M_{lagoon_total}(kg COD)	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831	2,349,831
M_{lagoon_input}(kg COD)	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000
R_{lagoon}(%)	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%

Formula 4 (project)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
M_{lagoon_input}(kg COD)	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000
M_{input_total}(kg COD)	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000
R_{NAWTF}(%)	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%

Amount of organic material degraded aerobically in the lagoon system ($M_{lagoon\_aerobic}$)

$M_{lagoon\_aerobic} = COD_{loss\_aerobic}$ x $A_{lagoon\_surface}$ x dd_{year} =

= 254 (kg COD/ha/day) x 25.18 (ha) x 365 day/yr = 2,334,438 kg COD/year

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Mlagoon_aerobic (kg COD)	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438

Amount of organic material lost through chemical oxidation in the lagoon system ($M_{lagoon\_chemical\_ox}$)

$M_{lagoon\_chemical\_ox} = WW_{in}$ x SO_4^{2-}_concentration x $COD_{loss\_chem\_ox}$

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Mlagoon_chemical_ox (kg COD)	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118
WW_input (m3)	792,000	792,000	792,000	792,000	792,000	792,000	792,000	792,000	792,000	792,000
Sulphate concentration (kg Qox/m3)	0.0759	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
COD loss chem ox (kg COD/kg Qox)	0.651	0.651	0.651	0.651	0.651	0.651	0.651	0.651	0.651	0.651

Amount of organic material lost through deposition in the lagoon system ($M_{lagoon\_deposition}$)

Formula (6) AM0022 v4, project scenario:

$$M_{lagoon\_deposition} = M_{lagoon\_input} \cdot R_{deposition}$$

Formula 6 (project)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$M_{lagoon\_deposition}$ (kg COD)	167,564	167,564	167,564	167,564	167,564	167,564	167,564	167,564	167,564	167,564
M_{lagoon_input} (kg COD)	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000	2,376,000
$R_{deposition}$ (%)	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%

2) Methane emissions from new anaerobic waste water treatment facility (E_{CH4_NAWTF})

$E_{CH4\_NAWTF} = (E_{CH4\_lagoon\_BL} - E_{CH4\_lagoon})$ x $F_{leakage\_NAWTF} = (E_{CH4\_lagoon\_BL} - E_{CH4\_lagoon})$ x 0.01

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
E_{CH4_NAWTF} (tCO_2e)	858	858	858	858	858	858	858	858	858	858
$E_{CH4\_lagoons\_BL}$ (tCO_2e)	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771
$E_{CH4\_lagoons}$ (tCO_2e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$F_{CH4\_leakage\_NAWTF}$ (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%

3) Methane emissions from inefficient combustion emissions ($E_{CH4\_IC+Leaks}$)

Formula (7) AM0022 v4, project scenario:

$$E_{CH4\_IC+Leaks} = (\sum_{r} V_r \cdot C_{CH4\_r} \cdot (1 - f_r) \cdot GWP_{CH4}) + PE_{flare}$$

Formula 7	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$E_{CH4\_IC+leaks}$ (tCO_2e)	1,068	1,068	1,068	1,068	1,068	1,068	1,068	1,068	1,068	1,068
$E_{CH4\_IC\_heat}$ (tCO_2e)	374	374	374	374	374	374	374	374	374	374
V_{heat} (Nm^3)	2,551,907	2,551,907	2,551,907	2,551,907	2,551,907	2,551,907	2,551,907	2,551,907	2,551,907	2,551,907
f_{heat} (%)	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%
$E_{CH4\_IC\_elec}$ (tCO_2e)	694	694	694	694	694	694	694	694	694	694
V_{elec} (Nm^3)	7,097,083	7,097,083	7,097,083	7,097,083	7,097,083	7,097,083	7,097,083	7,097,083	7,097,083	7,097,083
f_{elec} (%)	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%
PE_{flare} (tCO_2e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GWP_{CH4} (tCO_2e/tCH_4)	21	21	21	21	21	21	21	21	21	21
C_{CH4_r} (tCH_4/Nm^3)	0.00047	0.00047	0.00047	0.00047	0.00047	0.00047	0.00047	0.00047	0.00047	0.00047

Project emissions from flaring (based on Steps 7, 6 and 5 of the "Tool to determine project emissions from flaring of gases containing methane"):

Faring tool, Step 7, Equation 15:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} x (1 - \eta_{flare,h}) x \frac{GWP_{CH4}}{1000}$$

Flaring tool: 15	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$PE_{flare,y}$ (tCO_2e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$TM_{RG,h}$ (kg/h)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\eta_{flare,h}$ (%)	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
GWP_{CH4} (tCO_2e/tCH_4)	21	21	21	21	21	21	21	21	21	21

Faring tool, Step 5, Equation 13:

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,n}$$

Flaring tool: 13	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$TM_{RG,h}$(kg/h)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$FV_{RG,h}$(Nm^3/h)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$fv_{CH4RG,h}$(%)	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
$\rho_{CH4,n}$(kg/Nm^3)	0.716	0.716	0.716	0.716	0.716	0.716	0.716	0.716	0.716	0.716

4) Methane Emissions from Leaks in Biogas System

Given the short length of the biogas pipeline (as compared to the reference value of 2 km provided in AM0022, Version 04) and the utilisation of high quality materials, emissions from leaks in the biogas system are assumed to be negligible for ex-ante calculation of project emissions.

The pipeline will undergo regular maintenance and monitoring in order to ensure that emission due to leaks in the biogas system are taken into account in the ex-post calculation of project emissions.

Baseline emissions

The baseline scenario was identified as the continued operation of the open anaerobic lagoon system, consumption of HFO for thermal energy generation and of electricity from the grid:
Formula (8) AM0022 v4, baseline scenario:

$$E_{BL} = E_{CH4\_lagoons\_BL} + E_{C02\_heat\_BL} + E_{CO2\_power\_BL}$$

Total baseline emissions are calculated as:

Formula 8 (baseline)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
E_{BL}(tCO_2e)	99,394	99,394	99,394	99,394	99,394	99,394	99,394	99,394	99,394	99,394
$E_{CH4\_lagoons\_BL}$(tCO_2e)	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771
$E_{CO2\_heat\_BL}$(tCO_2)	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583
$E_{CO2\_power\_BL}$(tCO_2)	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040

1) Fugitive methane emissions from lagoons ($E_{CH4\_lagoon\_BL}$)

Formula (2) AM0022 v4, baseline scenario:

$E_{CH4\_lagoons\_BL} = M_{lagoon\_anaerobic\_BL}$ x EF_{CH4} x $GWP_{CH4}/1000$

Formula 2 (baseline)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$E_{CH4\_lagoons\_BL}$(tCO_2e)	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771
$M_{lagoon\_anaerobic\_BL}$(kg COD)	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122
EF_{CH4}(kg CH_4/kg COD)	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210
GWP_{CH4}(tCO_2e/tCH_4)	21	21	21	21	21	21	21	21	21	21

Amount of organic material removed by anaerobic processes in the lagoon system ($M_{lagoon\_anaerobic\_BL}$)

Formula (3) AM0022 v4, baseline scenario:

$$M_{lagoon\_anaerobic\_BL} = M_{lagoon\_total\_BL} - M_{lagoon\_aerobic\_BL} - M_{lagoon\_checmical\_ox\_BL} - M_{lagoon\_deposition\_BL}$$

Formula 3 (baseline)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$M_{lagoon\_anaerobic\_BL}$(kg COD)	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122	19,449,122
$M_{lagoon\_total\_BL}$(kg COD)	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314
$M_{lagoon\_aerobic\_BL}$(kg COD)	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438
$M_{lagoon\_chemical\_ox\_BL}$(kg COD)	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118
$M_{lagoon\_deposition\_BL}$(kg COD)	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637

Amount of organic material removed in the lagoon system ($M_{lagoon\_total\_BL}$)

Formula (5) AM0022 v4, baseline scenario:

$$M_{lagoon\_total\_BL} = M_{lagoon\_input\_BL} \times R_{lagoon}$$

with Formula (11) AM0022 v4, baseline scenario:
(corresponding to Formula (4) AM0022 v4, in the project scenario)

$$M_{lagoon\_input\_BL} = M_{input\_total}$$

Formula 5 (baseline)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$M_{lagoon\_total\_BL}$(kg COD)	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314	23,498,314
$M_{lagoon\_input\_BL}$(kg COD)	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000
R_{lagoon}(%)	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%	98.90%

Amount of organic material degraded aerobically in the lagoon system ($M_{lagoon\_aerobic\_BL}$)

$M_{lagoon\_aerobic\_BL} = COD_{loss\_aerobic} \times A_{lagoon\_surface\_BL} \times dd_{year} =$
= 254 (kg COD/ha/day) x 25.18 (ha) x 365 day/yr = 2,334,438 kg COD/year

(baseline)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Mlagoon_aerobic_BL (kg COD)	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438	2,334,438

Amount of organic material lost through chemical oxidation in the lagoon system ($M_{lagoon\_chemical\_ox\_BL}$)

$$M_{lagoon\_chemical\_ox\_BL} = WW_{in\_BL} \times SO_4^{2-}\_concentration \times COD_{loss\_chem\_ox}$$

(baseline)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Mlagoon_chemical_ox_BL (kg COD)	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118	39,118
WW_input_BL (m3)	792,000	792,000	792,000	792,000	792,000	792,000	792,000	792,000	792,000	792,000
Sulphate concentration (kg Qox/m3)	0.0759	0.0759	0.0759	0.0759	0.0759	0.0759	0.0759	0.0759	0.0759	0.0759
COD loss chem ox (kg COD/kg Qox)	0.651	0.651	0.651	0.651	0.651	0.651	0.651	0.651	0.651	0.651

Amount of organic material lost through deposition in the lagoon system ($M_{lagoon\_deposition\_BL}$)

Formula (6) AM0022 v4, baseline scenario:

$$M_{lagoon\_deposition\_BL} = M_{lagoon\_input\_BL} \times R_{deposition}$$

Formula 6 (baseline)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
$M_{lagoon\_deposition\_BL}$(kg COD)	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637	1,675,637
$M_{lagoon\_input\_BL}$(kg COD)	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000	23,760,000
$R_{deposition}$(%)	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%	7.05%

2) On site heat generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility ($E_{CO2\_heat\_BL}$)

Formula (9) AM 22 v4, baseline scenario

$$E_{C02\_heat} = F \cdot NCV \cdot EF$$

Formula 9 (baseline)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
E_{CO2_heat} (tCO_2)	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583
F (t)	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466
NCV (TJ/t)	0.0404	0.0404	0.0404	0.0404	0.0404	0.0404	0.0404	0.0404	0.0404	0.0404
EF (tCO_2/TJ)	77.400	77.400	77.400	77.400	77.400	77.400	77.400	77.400	77.400	77.400

3) Off-site grid power generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility ($E_{CO2\_power\_BL}$)

Formula (10) AM 22 v4, baseline scenario

$E_{CO2\_power} = EL \times CEF$

Formula 10 (baseline)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
E_{CO2_power} (tCO_2)	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040	9,040
EL (MWh)	17,384	17,384	17,384	17,384	17,384	17,384	17,384	17,384	17,384	17,384
CEF (tCO_2/MWh)	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52

Leakage

As determined in AM0022, Version 04, leakage is considered to be negligible.

Leakage = 0 (t CO_2e)

Emission reductions

Emission reductions are calculated using

Formula (12) AM0022 v4

$$ER = E_{BL} - E_{project}$$

Formula 12	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
ER (tCO_2e)	97,468	97,468	97,468	97,468	97,468	97,468	97,468	97,468	97,468	97,468
E_{BL} (tCO_2e)	99,394	99,394	99,394	99,394	99,394	99,394	99,394	99,394	99,394	99,394
$E_{project}$ (tCO_2e)	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925

It must be verified wether the equation above delivers a conservative estimate of emission reductions i.e. that the emissions of CH4 from the lagoons in the baseline situation are not higher than the total emissions of biogas from the digester and the lagoons in the project situation:

Formula (13) AM0022 v4

$$E_{\text{CH4\_lagoon\_BL}} - \left(E_{\text{CH4 lagoon}} + E_{\text{CH4\_nawtf}} + E_{\text{CH4\_coll}}\right)$$

Formula 13	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
=	-9,391	-9,391	-9,391	-9,391	-9,391	-9,391	-9,391	-9,391	-9,391	-9,391
$E_{CH4\_lagoon\_BL}$(tCO_2e)	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771	85,771
E_{CH4_lagoon}(tCO_2e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E_{CH4_NAWTF}(tCO_2e)	858	858	858	858	858	858	858	858	858	858
E_{CH4_Coll}(tCO_2e)	94,303	94,303	94,303	94,303	94,303	94,303	94,303	94,303	94,303	94,303

The result of the equation above is negative, confirming the conservativeness of the emission reduction calculations.

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

Year	Estimation of project activity emissions (tonnes of CO2eq)	Estimation of Baseline emissions (tonnes of CO2eq)	Estimation of leakage (tonnes of CO2eq)	Estimation of overall emission reductions (tonnes of CO2eq)
1	1,925	99,394	0	97,468
2	1,925	99,394	0	97,468
3	1,925	99,394	0	97,468
4	1,925	99,394	0	97,468
5	1,925	99,394	0	97,468
6	1,925	99,394	0	97,468
7	1,925	99,394	0	97,468
8	1,925	99,394	0	97,468
9	1,925	99,394	0	97,468
10	1,925	99,394	0	97,468
Total	**19,254**	**993,936**	**0**	**974,681**

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

B.7.1 Data and parameters monitored:

Data/Parameter	**AM0022 ID 1** **Wastewater flows entering the project treatment facility**
Data unit	m3
Description	Daily wastewater flow entering into the new anaerobic digestion system
Source of data to be used	Measured by project operator
Value of data applied for the purpose of calculating expected emission reductions in section B.5	2,400 m3/day @ 330 operating days/year => 792,000 m3/year
Description of measurement methods and procedures to be applied:	Measured continuously by flow meters.
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards.
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	**AM0022 ID 2** **Wastewater flows leaving the project treatment facility**
Data unit	m3
Description	Daily wastewater flow leaving the new anaerobic digestion system
Source of data to be used	Established using ID 1 and assuming hydrological balance
Value of data applied for the purpose of calculating expected emission reductions in section B.5	2,400 m3/day @ 330 operating days/year => 792,000 m3/year
Description of measurement methods and procedures to be applied:	Assumed hydrological balance and using metered data from ID 1.
QA/QC procedures to be applied:	
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	**AM0022 ID 3** **Wastewater organic material concentration entering the project treatment facility**
Data unit	kg COD / m3
Description	COD concentration of the wastewater entering the new anaerobic digestion system
Source of data to be used	Measured by project operator
Value of data applied for the purpose of calculating expected emission reductions in section B.5	30 (30 kg/m3 = 30,000 mg/l)

Description of measurement methods and procedures to be applied:	Daily sampling of the UASB reactor effluent. COD concentration is analyzed daily at the Project site. The Reactor Digestion Method is applied for wastewater analysis.
QA/QC procedures to be applied:	The Standard Solution Method is used for accuracy check of the on-site measurements. Periodic tests will be carried out by accredited laboratory (ISO/IEC 17025) in order to provide quality assurance.
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	**AM0022 ID 4** **Wastewater organic material concentration leaving the project treatment facility**
Data unit	kg COD / m3
Description	COD concentration of the wastewater leaving the new anaerobic digestion system
Source of data to be used	Measured by project operator
Value of data applied for the purpose of calculating expected emission reductions in section B.5	3 (3 kg COD/m3 = 3,000 mg/l)
Description of measurement methods and procedures to be applied:	Daily sampling of the UASB reactor effluent. COD concentration is analyzed daily at the Project site. The Reactor Digestion Method is applied for wastewater analysis.
QA/QC procedures to be applied:	The Standard Solution Method is used for accuracy check of the on-site measurements. Periodic tests will be carried out by accredited laboratory (ISO/IEC 17025) in order to provide quality assurance.
Any comment	The value applied for the purpose of ex-ante estimation is based on the COD removal efficiency of 90% guaranteed by the technology provider.

Data/Parameter	**AM022 ID 5** **Volume of biogas sent to facility heaters**
Data unit	Nm3 biogas
Description	Volume of biogas sent to facility heaters
Source of data to be used	Measured continuously (normalized to take into account pressure and temperature) by gas flow meters.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	2,551,907
Description of measurement methods and procedures to be applied:	Measured continuously by flow meter GM3
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards. In case of technical problems with the meter, value can be calculated based on a mass balance using the other installed gas meters (biogas sent to heaters = total biogas produced – biogas sent to flare – biogas sent to engine).
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	**AM0022 ID 7** **Electricity generated from collected biogas**
Data unit	MWh
Description	Electricity generated from the biogas collected in the anaerobic treatment facility and consumed on site or sent to the grid
Source of data to be used	Meter readings
Value of data applied for the purpose of calculating expected emission reductions in section B.5	17,384
Description of measurement methods and procedures to be applied:	Continuous measurement using calibrated meter.
QA/QC procedures to be applied:	Electricity meters would undergo maintenance / calibration subject to appropriate industry standards.
Any comment	

Data/Parameter	**AM0022 ID 8** **Fossil fuel volume equivalent to generate same amount of heat generated from the biogas collected in the anaerobic treatment facility**
Data unit	m3
Description	Fossil fuel volume equivalent to generate same amount of heat generated from the biogas collected in the anaerobic treatment facility
Source of data to be used	Calculated based on amount of biogas sent to the boilers and crosschecked using historic specific heavy fuel oil consumption as determined in Section B.6.2.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1,473 m3/yr (1,466 t/yr)
Description of measurement methods and procedures to be applied:	Calculated based on approach described in Section B.6.1: The amount of biogas combusted in the boiler is converted per energy equivalence to the respective heavy fuel oil amount, which divided by the production of dry starch in the respective monitoring period provides the specific fossil fuel consumption per unit of output (dry starch). This figure is then compared to the figure determined in Section B.6.2 in order to check, whether there is a potential overestimation of baseline emissions.
QA/QC procedures to be applied:	NA
Any comment	This value is calculated based on other monitoring parameters such as ID 5 and ID 19.

Data/Parameter	**AM0022 ID 9** **Biogas sent to flares (V1)**
Data unit	Nm3 biogas
Description	Surplus biogas sent to flare system (dry basis)

Source of data to be used	Measured continuously (normalized to take into account pressure and temperature) by gas flow meters.
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:	Measured continuously by flow meter.
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards. In case of technical problems with the meter, value can be calculated based on a mass balance using the other installed gas meters (biogas sent to flare = total biogas produced – biogas sent to boiler – biogas sent to engine).
Any comment	

Data/Parameter	**AM0022 ID 10** **Biogas sent to generation**
Data unit	Nm3 biogas
Description	Biogas sent to generation facility and used for electricity generation
Source of data to be used	Measured continuously (normalized to take into account pressure and temperature) by gas flow meters. In case of technical problems with the meter, value can be calculated based on a mass balance using the other installed gas meters (biogas sent to engine = total biogas produced – biogas sent to flare – biogas sent to engine).
Value of data applied for the purpose of calculating expected emission reductions in section B.5	7,097,083
Description of measurement methods and procedures to be applied:	Measured continuously by flow meters
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards
Any comment	

Data/Parameter	**AM0022 ID11** **Biogas methane concentration**
Data unit	%
Description	Methane concentration in biogas
Source of data to be used	Measured using infrared spectrometry.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	65%
Description of measurement methods and procedures to be applied:	Continuous measurement will be based on near infrared spectrometry.
QA/QC procedures to be applied:	A near infrared spectrometry, to be installed, will undergo maintenance / calibration subject to appropriate industry standards

Any comment	Ex-ante value based on technical proposal by technology provider.

Data/Parameter	**AM0022 ID 12** **Project emissions from flaring of the residual gas stream (PEflare)**
Data unit	t CO2e
Description	Project emissions from flaring of the residual gas stream
Source of data to be used	Measured/Calculated using ID 9, ID 11 and the parameters "Flame detection period" and "Period of biogas being sent to the flare" at the bottom of this section based on calculation procedure determined in the Tool to determine project emissions from flaring gases containing methane"..
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:	Calculated using ID 9, ID 11 according to the "Tool to determine project emissions from flaring gases containing methane".
QA/QC procedures to be applied:	
Any comment	No gas flaring assumed in ex-ante calculations.

Data/Parameter	**AM0022 ID 13** **Amount of chemical oxidising agents entering system boundary**
Data unit	tonnes/m3
Description	Amount of chemical oxidising agents entering system boundary
Source of data to be used	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.07587 * 0.651 = 0.0494 kg COD/m3
Description of measurement methods and procedures to be applied:	Continuously monitored whether oxidative chemical species are utilized in the process.
QA/QC procedures to be applied:	Regular samples will test for concentration of oxidising agents where they are identified as being likely to be present in wastewater when they are part of the process
Any comment	According to a wastewater sample analysis collected at the inlet of the system boundaries (untreated effluent), the concentration of sulphate ions (SO_4^{2-}) in the wastewater amounts to 75.87 mg/l, which according to Appendix 2 of AM0022, Version 4, translates to a COD loss of 0.0494 kg COD/m3 of effluent entering the system boundaries (as calculated above).

Data/Parameter	**AM0022 ID 14** **Gen set combustion efficiency (f)**
Data unit	%
Description	Proportion of biogas combusted by generation facility
Source of data to be used	Measured by project developer

Value of data applied for the purpose of calculating expected emission reductions in section B.5	99%
Description of measurement methods and procedures to be applied:	Measured during regular O&M cycle (minimum annually)
QA/QC procedures to be applied:	Measurements to be conducted on the basis of standard industry practice.
Any comment	

Data/Parameter	**AM0022 ID 15** **Heating system combustion efficiency**
Data unit	%
Description	Combustion efficiency of boilers using biogas for heat generation.
Source of data to be used	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	98.55%
Description of measurement methods and procedures to be applied:	Measured during regular O&M cycle (minimum annually)
QA/QC procedures to be applied:	Measurements to be conducted on the basis of standard industry practice.
Any comment	

Data/Parameter	**AM0022 ID 16** **Flow of wastewater directly to the current wastewater treatment system**
Data unit	m3
Description	Volume of flow of wastewater directly to the current wastewater treatment system and bypassing the new wastewater treatment facility
Source of data to be used	Measured by project developer
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:	Bypass flow is measured by an electromagnetic flow meter.
QA/QC procedures to be applied:	Monitoring equipment will undergo maintenance / calibration subject to appropriate industry standards. The bypass flow can also be calculated in a conservative manner as the difference between total wastewater flow produced at the tapioca starch plant and the wastewater flow directed to the anaerobic digestor (assuming that the difference is treated 100% in the lagoon system).
Any comment	Used to calculate project emissions. No bypass is expected during regular operation.

Data/Parameter	**AAM0022 ID 17** **Loss of biogas from pipeline**
Data unit	%
Description	Loss of biogas from pipeline
Source of data to be used	Estimated, spot checks using mobile leak detector
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:	Integrity of biogas pipeline agianst losses is checked using mobile gas leak detector. If necessary volume of losses are then estimated through pressurizing the system and measuring pressure drops throughout the pipeline system.
QA/QC procedures to be applied:	Checks to be carried out according to international standards.
Any comment	

Data/Parameter	**AM0022 ID 18** **Organic material removed from wastewater facility**
Data unit	t COD
Description	Organic material removed from wastewater facility
Source of data to be used	Measured by project developer
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:	Removal of COD after monitoring and prior to entry to the lagoon system should be recorded to ensure CH4 emissions are not overestimated. This may be material screened out after the wastewater concentration is recorded.
QA/QC procedures to be applied:	
Any comment	Such removal is not expected to take place.

Data/Parameter	**AM0022 ID 19** **Biogas calorific value**
Data unit	J/Nm3
Description	Calorific value of biogas
Source of data to be used	Measured/calculated through ID11 and calculation using perfect gas equation, assuming that only the methane content contributes to the NCV of the biogas.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	23,205,000 (= 23.205 MJ/Nm3)
Description of measurement methods and procedures to be applied:	The calculation based on the methane content of the gas is conservative since it would lead to an underestimation of the NCV, which will result in lower baseline emissions. On-site NCV measurement of gaseous fuels would be very cost intensive and complicated to arrange since not many laboratories have the right equipment for such measurements. Therefore, the conservative

	alternative approach is proposed.
QA/QC procedures to be applied:	NVC of biogas can be crosschecked by carrying out an energy balance based on the amount of biogas combusted, the efficiency of the engine (according to manufactures specifications) and the amount of electricity supplied to the grid.
Any comment	

Data/Parameter	**Flame detection period**
Data unit	min
Description	Amount of minutes per hour where a flame is detected, whenever biogas is sent to the flare. If flame is detected for less than 20 minutes in an hour (whenever biogas is sent to flare), flare efficiency is assumed to be 0%. Otherwise flare efficiency is assumed to be 50%.
Source of data to be used	Measured based on flame detection signals by flare.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	100% (for ex-ante calculations of flare emissions it is assumed that the flare operates normally whenever biogas is sent to the flare.
Description of measurement methods and procedures to be applied:	The flame detection period shall be compared to the period of biogas being sent to the flare. The flare efficiency is determined based on the ratio of these two values in analogy to the default value determination method described above.
QA/QC procedures to be applied:	
Any comment	

Data/Parameter	**Period of biogas being sent to the flare**
Data unit	min
Description	Amount of minutes per hour where biogas is sent to the flare.
Source of data to be used	Measured/calculated based on SCADA records of biogas flow meter at the entrance of the flare.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	- (for ex-ante calculations it is assumed that the biogas is used 100% in the boiler and engine)
Description of measurement methods and procedures to be applied:	Whenever biogas flow is registered by the SCADA system of the biogas plant, the time will be also recorded, which allows for a calculation of the time period of biogas being sent to the flare.
QA/QC procedures to be applied:	
Any comment	

B.7.2 Description of the monitoring plan:

1. Monitoring Management

The required monitoring equipment is installed by the technology provider. Flow meters are regularly calibrated according to recognized procedures by the plant operator and sampling is carried out by the onsite chief of the wastewater monitoring department according to appropriate industrial standards.

Data acquisition for the gas and waste water flow meters is executed through the process control unit of the biogas plant and the plant operations software. Lab data is fed into the operations software through a manual data entry user interface.

The plant is operated by two trained operators for each shift who also collect data under the supervision of the chief of the Q.C. department who is in charge of filing and processing data.

2. Quality Assurance and Quality Control

The chief of the Q.C. department monitors overall performance of the plant, ensures proper and timely calibration, data acquisition and storage.

3. On-site Procedures

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

Procedures for Calibration of Equipment
The plant operator carries out calibration according to international standards.

4. Data Storage and Filing – Electric Workbook

All relevant data is stored electronically with the process control computer unit, external storage media and transferred. A daily log is printed.

The monitored data shall be kept as hard copies and electronic documents for two years after the end of the crediting period or the last issuance of CERs, whichever occurs later.

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

>>
Completion date: 30/07/2008

by
Patrick Bürgi
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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:

04/08/2006

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

30 years

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:

01/10/2008 or the date after registration, whichever is later.

C.2.1.2. Length of the first crediting period:

10 years

SECTION D. Environmental impacts

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D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

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The project does not lead to any additional emissions, since the sludge from the new biogas plant is fed back into the existing lagoons.

The proposed project is not required to undertake an Environmental Impact Assessment according to Thailand regulations (http://www.onep.go.th/eia/).

However, under the rules of the Thai DNA an initial environmental evaluation (IEE) has to be conducted and is to be submitted together with the PDD for approval. Based on project particulars and existing environmental conditions, potential impacts have been indentified that are likely to result from the proposed project activity, and where possible, these have been quantified. The positive and negative impacts are listed below:

Positive Environmental Impacts

- Wastewater is treated in a more efficient and robust way.
- The water resources are unlikely to be contaminated due to the proposed wastewater treatment structures and foundation.
- The project contributes to reduce GHG emissions that would otherwise be released into the atmosphere, and reduce undesirable odors by collecting and combusting biogas.
- Generating incomes to the local community through additional local employment.
- Reduction in usage of non-renewable energy.

Negative Environmental Impacts

- Noise: the main source of noise from the operation is the engine noise, 70-dB(A). However, due to the project being located far way from the community, the noise level at the closest community will be below the standard of the Department of Industrial Works (DIW).
- Accidental Hazards: in view of the potential hazards involved due to system failure or accident, on- and off-site emergency measures have been formulated and will be implemented.

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:

>>

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

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

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CYY Bio Power Co., Ltd (CYY) invited a number of stakeholders to attend a public participation event, conducted at Khamthaleso Wittaya School, Nakorn Ratchasima, near the project activity, on July 26, 2007. The invitation letters were sent out to local people impacted by the project, local and national NGOs, local policy maker, and others. The main purpose of the stakeholder's meeting was to present an overview of the project and its environmental impacts and mitigation measures.

The meeting was preceded according to the following agenda:

- Opening
- Purpose of the consultation
- Greenhouse gas and Clean Development Mechanism
- Description of projects and environmental impacts
- Answering of questions
- Completing checklists
- General feedback

Annex 5 presents a description in more details.

E.2. Summary of the comments received:

>>

The overall response to the project, from all invited stakeholders, was encouraging and positive. Most of the questions from the participant are more concern on the environmental impact regarding the bad odour from the current open lagoon which was clarified during the meeting.

In all, no adverse reaction/comments/clarifications have been sought/received during the Initial Stakeholder Consultation process. The participants of the meetings and Gold Standard supporting NGOs 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 the AEP, CYY owner with additional explanation on technical details by the technology supplier, Re-Tech. The questions and answers are listed in the following sections:

- *After the project is finished, will the odour from the waste water be reduced?*

Yes, it will. Because of the new system; UASB is a closed system and the biogas produced is utilized for electricity and heat generation, so there is no biogas released to the environmental and the odour is reduced. There will still be an odour sometimes from the wastewater from UASB system that releases to the open lagoon, but the odour will be less than the past because the COD in wastewater is only 10-20% of the wastewater input.

- *How can we have confidence in the performance of the biogas system? Are there any site references for this technology?*

Biogas systems have been developed and implemented since 10 years in many sectors. For biogas in starch plants: out of the 83 starch plants in Thailand, 3 plants have installed this technology with a positive track record.

- *In the future, when the villagers move to live near the starch plant, will they have a dust problem from the starch plant?*

There is no risk of dust problem from the starch plant, because we have the house for packaging and keeping the starch. We try to do the best to protect the starch dust flow out of the keeping house, because it is our product and it is our money. So the dust problem from the starch plant is very low.

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

>>

No negative comments have been The comments received do not create the need to modify project design.

Annex 1

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funding is involved in the project.

Annex 3

BASELINE INFORMATION

Detail of calculation for grid emission factor

According to the methodology selected, AMS-I.D v.13 Grid connected renewable electricity generation, the baseline case regarding the electricity displacement will be the GHG emitted by the Electricity grid of Thailand to generate the electricity. The method of option (A) of item 9 of AMS-I.D v.13, the combined margin (in kg CO_2e/kWh) of the weighted average of the operating margin (OM) and build margin (BM) according to the procedures prescribed in the 'Tool to calculate the emission factor for an electricity system', is chosen for this purpose and its value was calculated by the following steps:

Identifying the relevant electric power system

As mention in section A.2.1, the electricity generated by the project activity will be sold to the Provincial Electric Authority (PEA) under "the Very Small Power Producer scheme" of Thailand. Hence, the project activity can be classified as a 'project electricity system', and a 'connected electricity system' is the 'national electricity system', where the Thai DNA does not provide information on an emission of national electricity system.

Selecting an operating margin (OM) method

For the Operating Margin, 'Tool to calculate the emission factor for an electricity system' allows to choose four different methods:
(a) Simple OM,
(b) Simple Adjusted OM,
(c) Dispatch Data Analysis OM,
or (d) Average OM.

For this proposed project activity, (a) the Simple OM is applied.

However, according to the 'Tool to calculate the emission factor for an electricity system', the simple OM method can only be sued in case that the Low Cost Must Run resources constitute less than 50% of the total grid generation in average of the 5 most recent years. The following table illustrates that the LCMR resources has been counted for the 5 years average at 5.6 % of the grid.

Table: National grid generation by energy sources and Low-cost/must run constitution

National Grid Generation By Energy Sources

Unit : GWh

Year	Hydro	Fuel Oil	Diesel Oil	Coal & Lignite	Natural Gas	Others (a)	SPP, VSPP (b)	VSPP (c)	Total	Net import	Grand Total
2002	7,471	2,616	168	16,652	69,538	2	12,566	-	109,013	2,539	111,552
2003	7,299	2,941	180	16,807	76,332	2	13,422	-	116,983	2,183	119,166
2004	6,040	7,138	551	17,993	80,489	2	13,513	1	125,727	3,016	128,743
2005	5,798	8,244	414	18,334	85,703	2	13,700	2	132,197	3,777	135,974
2006	8,125	8,350	143	22,051	86,339	3	13,721	10	138,742	4,409	143,151
Remark	(1)	(1)	(1)	(1)	(1)	(1)	(2)	(2)		(3)	

1. Source: Electric Power in Thailand 2006 Report, DEDE, Table 17 page 21
2. Source: Electric Power in Thailand 2006 Report, DEDE, Table 16 page 20
3. Source: Electric Power in Thailand 2006 Report, DEDE, Table 21 page 25

a. Including geothermal, solar cell and wind turbine, etc.
b. Fuel used in SPP, VSPP (Co-generation): NG., coal, lignite, fuel oil, diesel, renewable & others
c. Fuel used in VSPP: Gas engine: Renewable & biogas

Low-cost/must run resources

Unit : GWh

Year	Hydro	Other (a)	Total LCMR	Total	LCMR constitution
2002	7,471	2	7,473	109,013	6.9%
2003	7,299	2	7,301	116,983	6.2%
2004	6,040	2	6,042	125,727	4.8%
2005	5,798	2	5,800	132,197	4.4%
2006	8,125	3	8,128	138,742	5.9%
Average of LCMR constitution					**5.6%**

Besides, for the simple OM, the simple adjusted OM and the average OM, the emission factor can be calculated using one of the two methods mentioned in the tool. The first method is chosen which is:

- Ex-ante option: A 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation, without requirement to monitor and recalculate the emissions factor during the crediting period.

Calculating the operating margin emission factor according to the selected method

According to the tool on how to calculate (a) Simple OM, option A should be preferred and must be used if fuel consumption data is available for each power plant/unit. Therefore, option A is used, the simple OM emission factor is calculated as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_{i,m} FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_{m} EG_{m,y}}$$

Where :

$EF_{grid,OMsimple,y}$ = Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)

$FC_{i,m,,y}$ = Amount of fossil fuel type *i* consumed by power plant/unit *m* in year *y*, (mass or volume unit)

$NCV_{i,y}$ = Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ/mass or volume unit)

$EF_{CO2,I,y}$ = CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)

$EG_{m,,y}$ = Net electricity generated and delivered to the grid by power plant / unit *m* in year *y* (MWh)

i = All fossil fuel types combusted in power plant / unit *m* in year *y*

y = Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex-ante option) or the applicable year during monitoring (ex-post option), following the guidance on data vintage

For this approach (simple OM) to calculate the operating margin, the subscript *m* refers to the power plants/units delivering electricity to the gird, not including low-cost/must run power plant/units, and including electricity imports to the grid. Electricity imports should be treated as one power plant *m*.

Simple OM data used and calculations

Power sources delivering electricity to the grid, not including LC/MR, including imports

Unit : GWh

Year	Fuel Oil	Diesel Oil	Coal & Lignite	Natural Gas	SPP, VSPP *(b)*	VSPP *(c)*	Net import	Total
2004	7,138	551	17,993	80,489	13,513	1	3,016	122,701
2005	8,244	414	18,334	85,703	13,700	2	3,777	130,174
2006	8,350	143	22,051	86,339	13,721	10	4,409	135,023
Sum (2004 - 2006)								**387,898**

The amount of fuel *i* consumed by the relevant power plant *m*, $FC_{i,m,,y}$

Fuel consumption for electric generation to national grid

Year	Fuel Oil (million litres)	Diesel Oil (million litres)	Coal Lignite (thousand tons)	Natural Gas (MMscf)	SPP, VSPP *(b)*	VSPP *(c)*	Net import
2004	1,697	120	16,537	724,560	-	-	-
2005	1,996	83	16,571	764,118	-	-	-
2006	2,030	41	17,166	857,103	-	-	-
Remark	*(4)*	*(4)*	*(4)*	*(4)*	*(5)*	*(5)*	

4. Source: Electric Power in Thailand 2006 Report, DEDE, Table 19, page 23
(excluding fuel consumption from SPP and VSPP)
5. As the amount of fuel consumption in SPP and VSPP is not available, therefore it is not taken into account. This is conservative.

Fuel consumption for electric generation to national grid (tons)

Year	Fuel Oil (tons)	Diesel Oil (tons)	Coal & Lignite (tons)	Natural Gas (tons)
2004	1,578,210	100,800	16,537,000	14,774,376
2005	1,856,280	69,720	16,571,000	15,580,996
2006	1,887,900	34,440	17,166,000	17,477,037

Remark: density of fuel

Fuel oil	0.93	kg/l	source: DEDE, IEA
Diesel oil	0.84	kg/l	source: DEDE, IEA
NG	0.72	kg/m3	source: PTT PCL, Thailand

NCV and EF_{CO2} of fuel *i*

CO2 emission coefficient of fuel 'i' , COEF i

Parameter	Fuel Oil	Diesel Oil	Coal & Lignite	Natural Gas
NCV i (TJ/Gg)	40.4	43.0	11.9	48.0
EF CO2,i (kg/TJ)	77,400	74,100	101,000	56,100
COEF i (tCO2/ton)	**3.13**	**3.19**	**1.20**	**2.69**

Remark
As no local CO2 emission factor per unit of energy is available, 2006 IPCC default values are used.

The Simple OM, $EF_{grid,OMsimple,y}$

Calculation of (FCi,m,y * NCVi,y * EFco2,i,y)

Year	Fuel Oil (tCO2)	Diesel Oil (tCO2)	Coal & Lignite (tCO2)	Natural Gas (tCO2)	Total (tCO2)
2004	4,935,000	321,179	19,875,820	39,784,438	64,916,437
2005	5,804,513	222,149	19,916,685	41,956,505	67,899,852
2006	5,903,388	109,736	20,631,815	47,062,164	73,707,103
Sum	**16,642,901**	**653,064**	**60,424,321**	**128,803,108**	**206,523,393**

Simple OM emission factor (EF OM,y)

Year	Total (GWh)	Total (tCO2)	EF OM,y (tCO2/MWh)
2004	122,701	64,916,437	0.529
2005	130,174	67,899,852	0.522
2006	135,023	73,707,103	0.546
Sum (2004 - 2006)	387,898	206,523,393	
EF OM,y (2004 - 2006)			**0.532**

From the table, $EF_{grid,OMsimple,y}$ = 0.53 tCO_2/MWh

Identifying the cohort of power units to be included in the build margin

According to the 'Tool to calculate the emission factor for an electricity system', the sample group of power unit m used to calculate the build margin consists of either:

- (a) The set of five power units that have been built most recently, or
- (b) The set of power capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

The following table shows the list of most recently built five power plants which also comprise more than 20% (at 20.2 %) of the system generation (in KWh). Besides, all these five power plants are not registered as CDM project activity and not built more than 10 years ago from the date that the proposed project started to supply electricity to the grid.

Plant name (sample group m)	Commercial Operation Date COD	Plant Capacity (MW)	Generation in 2006 (GWh)
Krabi	Aug 2003	340.0	1,126
Ratchaburi, Cogeneration	April 2002	2,041.0	15,002
EPEC	Mar 2003	350.0	2,385
Glow	Jan 2003	713.0	5,425
BLCP	Aug 2006	673.3	4,024
Total			**27,962**
Total grid generation			138,742
Generation of group m is part of total grid generation			**20.2%**

Calculating the build margin emission factor

The Build Margin is calculated as the generation-weighted average emission factor of a sample of power plant m, as follows

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2/MWh)

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y*

$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)

m = Power unit included in the build margin

y = Most recent historical year for which power generation data is available

The CO_2 emission factor of each power plant unit m ($EF_{EL,m,y}$) should be determined as per the simple OM.

Option B2 is used to calculate it, as we have data on electricity generation, fuel types and the efficiency of the power unit:

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

Where:

$EF_{EL,m,y}$ =CO2 emission factor of power unit *m* in year *y* (tCO_2/MWh)

$EF_{CO2,,mi,y}$ = Average CO2 emission factor of fossil fuel type *i* in power unit *m* in year *y* (tCO_2/GJ)

$\eta_{m,y}$ = Average net energy conversion efficiency of power unit *m* in year *y* (%)

y =Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option), following the guidance on data vintage in step 2

Plant name (sample group m)	Commercial Operation Date COD	Plant Capacity (MW)	Generation in 2006 (GWh)	Type of Fuel	Efficiency (Btu/kWh)	efficiency %	$EF_{EL,m}$ (tCO2/MWh)	Emissions (tCO2)	EF BM,y (tCO2/MWh)
Krabi	Aug 2003	340.0	1,126	Fuel oil	8,918	38%	0.73	819,817	
Ratchaburi, Cogeneration	April 2002	2,041.0	15,002	Natural Gas	7,214	47%	0.43	6,404,103	
EPEC	Mar 2003	350.0	2,385	Natural Gas	7,020	49%	0.42	990,737	
Glow	Jan 2003	713.0	5,425	Natural Gas	6,979	49%	0.41	2,240,402	
BLCP	Aug 2006	673.3	4,024	Coal	8,910	38%	0.95	3,819,682	
Total			**27,962**					**14,274,740**	**0.51**
Total grid generation			138,742						
Generation of group m is part of total grid generation			**20.2%**						

From the table, $EF_{grid,BMsimple,y}$ = **0.51 tCO_2/MWh**

Calculating the combined margin emission factor

The combined margin emissions factor is calculated as fellows:

$EF_{grid,CM,y} = EF_{gird,OM,Y} * w_{OM} + EF_{grid,BM,Y} * w_{BM}$

Where:
$EF_{BM,Y}$ = Build margin CO_2 emission factor in year *y* (tCO2/MWh)
$EF_{OM,Y}$ = operation margin CO_2 emission factor in year *y* (tCO2/MWh)
w_{OM} = Weight of operating margin emission factor (%)
w_{BM} = Weight of build margin emission factor (%)

The following default value should be used for w_{OM} and w_{BM}:

- Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods.
- All other project: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period, and w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period, unless otherwise specified in the approved methodology which refer to this tool.

For this project activity, which 10 year crediting period non renewable, where the electricity is generated from biomass residues, w_{OM} = 0.5 and w_{BM} = 0.5 is chosen.

The Baseline Emission Factor EFy

Parameter		Emission Factor (tCO2/MWh)	Weights
Simple OM	EF OM,y	0.53	0.50
Bulid Margin	EF BM,y	0.51	0.50
Combined Margin	**EF y**	**0.52**	

Therefore, the baseline emission factor EF_y = 0.52 tCO2/MWh

Laboratory results and calculation of project specific parameters required to determine baseline and project emissions related to anaerobic COD removal in the lagoon based wastewater treatment system

Total Organic Removal Ratio

Table 3 Organic material removal ratio

Sample No.	Parameter	Unit	Method	Waste water inlet	Waste water outlet	Organic mat. Removal ratio (Rlagoon)	Remarks
1	COD total	mg/L	Open Reflux, Titrimetric	16286	201	98.77%	sample16/11/07
2	COD total	mg/L	Open Reflux, Titrimetric	17048	201	98.82%	sample17/11/07
3	COD total	mg/L	Open Reflux, Titrimetric	17303	201	98.84%	sample15/11/07
4	COD total	mg/L	Open Reflux, Titrimetric	18168	207	98.86%	sample 13/11/07
5	COD total	mg/L	Open Reflux, Titrimetric	35385	393	98.89%	sample 04/06/08
6	COD total	mg/L	Open Reflux, Titrimetric	33846	374	98.89%	sample 02/06/08
7	COD total	mg/L	Open Reflux, Titrimetric	34359	377	98.90%	sample 31/05/08
8	COD total	mg/L	Open Reflux, Titrimetric	36410	397	98.91%	sample 06/06/08
9	COD total	mg/L	Open Reflux, Titrimetric	37949	374	99.01%	sample 29/05/08
10	COD total	mg/L	Open Reflux, Titrimetric	22510	205	99.09%	sample14/11/07
Average	**COD total**	**mg/L**	**Open Reflux, Titrimetric**	**26926.4**	**293**	**98.90%**	

Average Total Organic Remval Ratio (R_{lagoon}) based on the test series above:
R_{lagoon} **= 98.9 %**

COD lost by deposition

The procedure for the measurement of COD lost by deposition is as follows:

(1) Samples of untreated effluent are collected at the inlet of the system boundaries.
(2) COD is measured for each sample taken before any deposition occurs.
(3) The wastewater is put in a funnel-shaped flask and left until the level of sediment does not change.
(4) After removing the sediment, COD is measured again.
(5) The difference between COD before the sedimentation and after the sedimentation is considered as the COD lost by deposition.

This approach is considered to be conservative since the non-soluble COD content of the effluent is allowed to sediment without any disturbance in the flask, leading to an ideal deposition rate. In reality, anaerobic pond dynamics would lead to mixing within the lagoon, which would disturb he sedimentation process keeping the organic material in the anaerobically active zone of the lagoon. Quote from AM0022, Appendix 2, p. 32: "In parallel the conditions in the pond system under investigation must also be assessed to characterise the pond dynamics in relation to mixing. Some ponds will be so anaerobically active as to keep alls material that would sediment in a state of permanent suspension, this material is then anaerobically degraded."

The Organic Material Deposition Ratio ($R_{deposition}$) has been determined based on the test results provided in the table below:

COD lost by deposition

Table 4 COD lost by deposition

Sample No.	COD before deposition	COD after deposition	COD lost by deposition	COD deposition ratio (Rdeposit)	Remarks
	mg/L	mg/L	mg/L	%	
1	23738	22349	1389	5.85%	sample 22/10/07
2	20265	19445	820	4.05%	sample 23/10/07
3	22727	19886	2841	12.50%	sample 24/10/07
4	22349	20707	1642	7.35%	sample 25/10/07
5	22917	20707	2210	9.64%	sample 26/10/07
6	17303	16285	1018	5.88%	sample15/11/07
7	16286	15522	764	4.69%	sample16/11/07
8	17048	16285	763	4.48%	sample17/11/07
9	37949	35385	2564	6.76%	sample 29/05/08
10	34359	31154	3205	9.33%	sample 31/05/08
Average	23494	21773	1721.6	7.05%	

Test by : Test Tech Co.,Ltd

Average Organic Material Deposition Ratio ($R_{deposition}$) based on the test series above:
$\boldsymbol{R_{deposition} = 7.05\%}$

Aerobic COD removal at the lagoon surface

As suggested in Appendix 1 of AM0022, Version 04, a sensitivity analysis is conducted in order to analyze the impact of the chosen default value (254 kg COD/ha/day) for aerobic decomposition of COD at the lagoons surface. The results of the sensitivity analysis are provided in the table below:

Surface aerobic losses	Error factor applied	Project emissions from lagoons	Sensiitivity	Baseline emissions from lagoons	Sensiitivity	Emission reductions	Sensiitivity
kg COD/ha/day	%	(tCO2e)	%	(tCO2e)	%	(tCO2e)	%
127	-50%	4,303	na	90,918	6%	98,301	1%
190	-25%	1,730	na	88,344	3%	98,301	1%
229	-10%	186	na	86,800	1%	98,301	1%
254	0%	-	-	85,771	-	97,466	-
279	10%	0	0%	84,741	-1%	96,447	-1%
318	25%	0	0%	83,197	-3%	94,918	-3%
381	50%	0	0%	80,623	-6%	92,370	-5%

It can be observed that a variation of the parameter towards a lower aerobic removal efficiency does not have a significant impact on the emission reduction calculations. A variation of plus 50% in the default value leads to a slight decrease in emission reductions in the range of -5%. Even though, a discount of 5% in emission reduction calculations is not negligible, the project participants are of the opinion that the standard default value of 254 kd COD/ha/day) is appropriate and conservative due to following reasons:

- The major reason for the results displayed in the table above is the lack of project emissions from he lagoons for all positive variations of the default value. When analyzing the parameters behind the equation to estimate the aerobic decomposition route and comparing the numbers to the other two registered starch effluent treatment projects (Korat Waste to Energy Project, CDM Ref. 1040 and PT Budi Acid Jaya Tapioca Starch Project, CDM Ref. 1176), it becomes evident that the very large surface area of the 22 ponds at the CYY project site is the main cause for the results displayed above.

As opposed to the other two projects, CYY Starch Ltd. does not have a license to discharge the treated effluent in local wastewater streams. Hence the project owner needs to operate the effluent treatment system as a zero discharge system, always building new lagoons whenever the flow rate of the incoming effluent into the lagoon system surpasses the water evaporation rate. Therefore, many of the ponds at the end of the flow line are rather reservoirs of clean treated water with negligible quantities of COD. Hence, the active anaerobic-aerobic treatment in the lagoons takes only part in a fraction of the 22 existing lagoons.

- As described in Appendix 1 of AM0022, Version 04, the default value is based on an "ultra-conservative" estimate and is comparable to values of facultative lagoons with an average depth of 1 to 2.5 m, which fosters the aerobic decomposition process. The average depth of the existing lagoons at the project site is 5 m, with a clear tendency towards anaerobic processes. Given the long residence time of the effluent in each lagoon and the depth of the first lagoons, it s very likely that most of the COD entering the lagoon system is decomposed mostly anaerobically in the first lagoons along the flow line. This is confirmed by the high activity (bubbles and foam formation typical of anaerobic lagoons) of the first lagoons at the project site.

General Wastewater Characteristics

Table 5 Wastewater characteristics

COD removal efficiency of new waste water treatment system	90.00%	%
COD (before WWT)	30,000	mg/liter
COD (after WWT)	3,000	mg/liter
Effluent flow rate	2,400	m3/day
Annual COD load to lagoons before UASB system implementation	23,760,000	Kg COD/a
Annual COD load to lagoons after UASB system implementation	23,760,000	Kg COD/a
Sulphate concentration	75.87	mg/liter
Plant operation	330	Days/a

Table 6 Lagoon characteristics & organic removal ratio for lagoons (historical data)

Lagoon Depth	5	m
Area	25.18	ha
Minimum Lagoon Temperature (2005)	28	Degree Celsius
Minimum Ambient Temperature (2005)	28	Degree Celsius
Average COD in to the lagoon	30,000	mg/l
Average COD out from the lagoon	330	mg/l
Average COD removal ratio	98.9%	%

Wastewater produced per ton of starch produced	7.3	m3 per ton of starch
Heavy fuel oil consumption	35	liters per ton of starch
Electricity consumption	0.28	MWh per ton of starch
Fraction of COD likely to degrade in Pond 1 - 22 (anaerobic ponds) of open lagoon	98.90%	
Pond surface areas	251,780	m2
Pond 1	4,870	m2
Pond 2	10,953	m2
Pond 3	7,140	m2
Pond 4	4,242	m2
Pond 5	1,960	m2
Pond 6	12,277	m2
Pond 7	1,180	m2
Pond 8	13,152	m2
Pond 9	15,011	m2
Pond 10	6,543	m2
Pond 11	5,929	m2
Pond 12	10,395	m2
Pond 13	3,850	m2
Pond 14	13,040	m2
Pond 15	15,524	m2
Pond 16	14,835	m2
Pond 17	13,475	m2
Pond 18	23,625	m2
Pond 19	8,750	m2
Pond 20	14,858	m2
Pond 21	17,640	m2
Pond 22	32,531	m2
Surface COD loss	254	kgCOD/day/ha
Surface Oxidation of Organic Material	6395.212	kgCOD per day

Annex 4

MONITORING PLAN

Monitoring will be conducted in accordance with the monitoring plan outlined in section B.7 of the PDD.

In addition to the monitoring plan, the proponent has prepared a responsibility chart for the involved stakeholders and summarized it as below:

Installation of monitoring equipments and comprehensive on-the-job training of client's personnel shall be done by turn-key operator (GWE). Monitoring parameters are collected at the appropriate monitoring frequency by the plant's operators; such data and records are cross-checked by the chief of the Q.C. department whose role is not limited to only identify possible errors or omissions but also to assure the overall performance of the monitoring plan. Data and records will then be transferred to South Pole Carbon Asset Management for a periodic data analysis to arrive at the project performance, in terms of expected delivery of emission reduction units, prior to any verification. Performance check and calibration services for all necessary instruments within the project boundary shall also be done under the supervision of South Pole Carbon Asset Management to ensure the accuracy of measurements.

An overview of the roles and responsibilities relevant in this monitoring plan is shown in the table below:

Responsibilities	CYY Operation staffs	CYY Chief of QC department	CYY	GWE	Southpole Carbon Asset Management
Installation of monitoring equipments	-	-	R	A	
Training of client's personnel	-	-	R	A	I
Data acquisition and archiving	R	A	I	-	I
Monitor overall performance	-	R	A	-	I
Compilation of monthly and annually report	-	-	R/A	-	I
Periodic data analysis	-	-	I	-	R/A
Periodic check and calibration of equipments	-	-	R	-	A

Responsible
A = Accountable
I = To be informed

Annex 5

PUBLIC PARTICIPATION EVENT SUMMARY

AIMS OF THE EVENT

A public consultation event was held on July 26, 2007 at Khamthaleso Wittaya School, Nakorn Ratchasima, near the project activity. The event, organized by Advance Energy Plus Co., Ltd. (AEP) and CYY Bio Power Co., Ltd. (CYY) had the following aims:

1. To explain the stakeholders about Green House Gas effect, Kyoto protocol and the CDM process.
2. To present the project to the local stakeholders.
3. To describe what the CDM means for this project.
4. To describe the environmental impacts from this project.
5. To allow the stakeholders an opportunity to express their concerns regarding the project, to ask questions and to clarify issues if any.

EVENT VENUE

Khamthaleso Wittaya School, Nakornratchasima Province, Thailand
July 26, 2007

In the public consultation meeting, detailed information about the project and its benefits were presented by the project advisor and the project owner to the participants who attended the meeting. The event provided a forum for all stakeholders to raise questions about pollution, safety and any other issues regarding the project and to share opinions. The tapioca-based starch production plant and brief of existing wastewater treatment, was presented by the factory. Advance Energy Plus Co., Ltd. (AEP) represented the CDM project advisor. The technology supplier was also present to answer questions regarding the UASB technology and CDM-related issues respectively.

BRIEF INTRODUCTION OF THE PROJECT

In its introductory presentation, AEP explained the greenhouse gas effect, the Kyoto protocol, project details, and illustrated the UASB technology through several photographs and figures. The advantages and key features of the technology over existing methods of wastewater treatment were highlighted. The impact of the new technology to the community and global environment at large were also discussed.

LIST OF ATTENDEES

AEP and CYY invited a number of stakeholders to attend the Public Consultation event. The participants included representatives of the government, local officials, NGOs, academic institutions, members from the local community living in the project area and others. Major institutions represented are listed below:

- **Thai Government Entities**
  - National Science and Technology Development Agency (NSTDA)
  - Office of Natural Resources and Environmental Policy and Planning
  - IIEC (International Institute for Energy Conservation)
  - Sheriff of Amphur Khamthaleso

- Director of Police station
- Subdistric Administrative Organization
- Leader of Thambol Khamthaleso
- Leader of Subdistric Administrative Organization Thambol Pongdang
- Leader of Subdistric Administrative Organization Thambol Pandung
- Leader of Subdistric Administrative Organization Thambol Bungao
- Ministry of Agriculture and Co-operative
- Lord Mayor of Thambol Khamthaleso
- Leader of Ban Moo 3
- Leader of Ban Moo 4
- Leader of Ban Moo 5
- Leader of Ban Bungao
- Leader of Thumbol Pongdang
- Leader of Thambol Bungao
- Leader of Thambol Pandung
- Leader of Thambol Hangsong

- **NGOs**
  - Green Leaf Foundation
  - Green World Foundation (GWF)
  - IIEC (International Institute for Energy Conservation)
  - WWF Thailand
  - Thailand Development Research Institute (TDRI)
  - Appropriate Technology Association
  - Environmental Engineering Association of Thailand
  - Thai Environmental and Community Development
  - Thailand Environment Institute (TEI)

- **Academia**
  - Faculty of Engineering, Khon Kaen University
  - Faculty of Engineering, Chulalongkorn University
  - Faculty of Engineering, King Mongkut's University of Technology Thonburi
  - Faculty of Engineering, Suranaree University of Technology
  - Faculty of Engineering, Thammasat University
  - Faculty of Engineering, Kasetsart University
  - Faculty of Engineering, Dhurakijpundit University
  - Faculty of Environment and Resource Studies, Mahidol University

- **Others**
  - South Pole Carbon Asset Management Ltd.
  - Retech Energy Co., Ltd

Following is the list of stakeholders from the above entities, who attended the meeting:

1. Mr. Pitsawong Sanprasert Subdistric Administrative Organization Thambol Pongdang

2.	Mr. Shob Sherdsungnern	Leader of Thumbol Pongdang
3.	Mr. Shoosak Shunkao	Bailiff of Amphur Khamthaleso Officer
4.	Mr. Somporn Srichumnong	Manager of Electricity Officer
5.	Mr. Trachak Kisantera	Subdistric Administrative Organization Thambol Pondung
6.	Mr. Ingo Pule	South Pole Carbon Asset Management Ltd.
7.	Mr. Le Than Tung	South Pole Carbon Asset Management Ltd.
8.	Mr. Suvit Kakhuntod	Subdistric Administrative Organization Thambol Khamthaleso
9.	Mr. Somkeach Patcharasuntorn	Subdistric Administrative Organization of Thambol Bungao
10.	Mr. Manoch Marikhaow	Lord Mayor of Thambol Khamthaleso Officer
11.	Mr. Samart Shoonsantea	Subdistric Administrative Organization of Thambol Bungao
12.	Mr. Tavee Mathawirat	Subdistric Administrative Organization of Thambol Bungao
13.	Ms. Supawadee Phothikamoon	Managing Director of Retech Energy Co., Ltd.
14.	Mr. Tuchsanai Poksantea	Leader of Ban Moo 3
15.	Mr. Po Rodpandung	Leader of Thambol Bungao
16.	Mr. Saychoon Kisantea	Leader of Ban Moo 4
17.	Mr. Sungwan Chapandung	Leader of Thambol Pandung
18.	Mr. Chumnong Ponsantea	Prolocutor of Subdistric Administrative Organization
19.	Mr.Anan Poomkokrak	Subdistric Administrative Organization of Thambol Bungao
20.	Mr. Way Khumsantea	Leader of Ban Moo
21.	Ms. Naruchoon Sirirodchanakul	Villager of Ban Khamthaleso
22.	Ms. Natthinich Pongsuwan	Villager of Changwat Nakhonrachasrima
23.	Ms. Samaree Wachon	Villager of Ban Khamthaleso
24.	Ms. Uncharee Chitsuk	Villager of Ban Khamthaleso
25.	Ms. Phatcharaporn Boonru	Villager of Changwat Nakhonrachasrima
26.	Ms. Noppharath Reabthavee	Villager of Ban Bungao
27.	Ms. Khanittha Aorsantea	Villager of Ban Bungao
28.	Mr. Boonsom Deemarerng	Villager of Ban Bungao
29.	Mr. Yuthapong Trithong	Villager of Ban Bungao
30.	Mr. Wisuth Maneethong	Villager of Ban Khamthaleso
31.	Mr. Wisan Phromnasath	Subdistric Administrative Organization Thambol Khamthaleso
32.	Mr. Sanith Booranapiyasakhul	Leader of Thambol Hangsong
33.	Mr. Sirichai Phiboon	Subdistric Administrative Organization Thambol Bungao
34.	Mr. Sukhol Wongvilai	Villager of Ban Khamthaleso
35.	Mr. Somphan Trithong	Asst. of Leader of Thambol Bungao

36.	Ms. Khanyarath Peasantea	Villager of Ban Bungao
37.	Ms. Wanchai Nasri	Villager of Ban Bungao
38.	Mr. Khunthung Kansakool	Villager of Ban Bungao
39.	Mr. Pramoch Putharaksa	Villager of Ban Bungao
40.	Mr. Dong Chapandung	Leader of Ban Moo 5
41.	Mr. Withaya Niziyok	Director of Police station
42.	Mr. Manop Yunyong	Director of CYY Biopower Co,.Ltd
43.	Mr. Surasak Charuthavai	CYY Industry Co. Ltd

THE MINUTES

At the start of the event, the project advisor, technology suppliers and project advisors were introduced. Then two presentations were made by the project advisors, namely Mr. Jetsada Falert, Manager, AEP and project owner, namely Mr. Thawatchai Yoenyong, Managing Director, CYY. All presentations were made in Thai language.

The presentation can be divided into three sections;
(i) Greenhouse gases and Clean Development Mechanism
(ii) CYY project introduction
(iii) How the CYY project is related to CDM and how the project can reduce greenhouse gases

Summary of presentation by Mr. Jetsada Fahlert

(i) Greenhouse gases and Clean Development Mechanism

What is Green House Gas effect and what is CDM or Clean Development Mechanism? In our daily life, people have many activities that produce Carbon Dioxide (CO_2). The CO_2 which is released to the atmosphere causes the atmospheric temperature to rise, which is called the greenhouse effect. In the 1997 Kyoto Protocol (a part of the United Nations agreement), a number of nations reached an agreement to reduce the emissions of greenhouse gases into the atmosphere. As per the agreement, some countries are obliged to reduce the emission of greenhouse gases over the coming several years. These are called Annex I countries, which include Europe, North America, other OECD nations, the former Soviet Union and Eastern Europe. To allow them to do this, a flexible mechanism called Clean Development Mechanism (CDM) was introduced. CDM permits the activities to be undertaken in non-Annex I countries. The CDM will allow Annex 1 countries to develop projects in non-Annex 1 countries, which will reduce greenhouse gas emission. The CYY project is developed as one of such projects in Thailand. The gases that are defined as greenhouse gases are:

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Hydro fluorocarbons (HFCs)
- Per fluorocarbons (PFCs) and
- Sulphur Hexafluoride (SF_6)

The actual issuance of the credits or CERs (Certified Emission Reductions) is made by the CDM Executive Committee of the United Nations.

The steps involved in implementing a CDM project are as follows:

Step1. Preparation of Project Idea Note (PIN)
Step2. Project Design Document (PDD) development
Step3. Host Country Approval
Step4. Validation
Step5. Registration
Step6. Monitoring
Step7. Verification and Certification
Step8. CERs issuance

Now we are in step 2 : Project Design Document (PDD) development

Summary of presentation by Mr. Thawatchai Yoenyong

(ii) CYY project introduction

CYY Biopower Co., Ltd. (CYY) was registered on March 28, 2006 to produce biogas from wastewater of Chokeyoenyong Industries Co. Ltd., located at Thambol Pong Dang, Amphur Khamtalesor, Nakornrachasima Province. Chokeyoenyong Industries Co. Ltd. has been operating the starch production plant since 2003. The approximate production capacity is 250 tonnes of native starch per day. The processing generates about 2.4 million litres of wastewater every day. The energy sources for Chokeyoenyong Industries Co. Ltd. are electricity, supplied by PEA and the thermal energy that is generated in-house from a fuel oil boiler.

CYY Biopower Co., Ltd. will treat wastewater from Chokeyoenyong Industries Co. Ltd. and produce biogas. The biogas produced will be utilized for electricity generation and will replace fuel oil at the boiler for heat generation to the starch plant.

Summary of presentation by Mr. Jetsada Fahlert

(iii) How the CYY project is related to CDM and how the project can reduce greenhouse gases

What will happen when the wastewater flows through the open lagoon? The bacteria in the lagoon act upon and digest the organic materials in the wastewater. Aerobic digestion takes place on the surface of the lagoon while anaerobic digestion takes place beneath the surface. Anaerobic digestion reaction will generate Biogas which is composed of methane (CH_4), carbon dioxide (CO_2) and Hydrogen Sulphide (H_2S) gases. The biogas has a heating value of approximately 9,000 kcal/ m^3; therefore 1 m^3 of biogas can generate electricity 1.85 kWh or replace 0.6 litre of bunker oil, 0.5 litre of gasoline, 0.6 kg of LPG, or 1.9 kg of rice husk as fuel. In the process of treating wastewater through the open lagoons, there are two issues. One is the natural discharge of biogas from the pond system, which will be considered as GHGs, into the atmosphere. This is a naturally occurring by-product of organic decomposition. The second is the odour from the biogas that is immediately apparent as a result of aeration.

To tackle the above issues, Chokeyoenyong Industries Co. Ltd. and CYY Biopower Co., Ltd. have decided to construct a new wastewater treatment system based on an Upflow Anaerobic Sludge Blanket (UASB) system. This technology will use anaerobic bacteria to digest the organic materials in the wastewater. The system will use bacteria that already exist in the wastewater in a natural biological process. We can see this process occurring in all wastewater ponds, animal farms and kitchens where food is allowed to decay. The UASB system is a closed system where the gas generated in the process is not allowed to escape. Biogas is collected and then used as a fuel to generate electrical energy in a gas engine-generator system and replaces fuel oil at the boiler.

The UASB system has a number of benefits: it reduces the release of methane (which is one of the GHG) into the atmosphere; generates biogas as a by product (which can be used as a fuel in the plant); and maximizes the conversion of organic material into biogas, thereby accelerating the digestion process. The technology has a high reliability and requires low maintenance.

The environmental effects of the UASB system are very beneficial: cleaner wastewater within a shorter period of time; no odour; no leakage of wastewater to the ground water.

Thank you everyone and if anybody has any questions, please feel free to ask.