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:

Title of project activity : "KI Biogas Co.,Ltd.
Wastewater Treatment and Energy Generation, Nakhon Ratchasima"
Current version number of the document: version 1
The date of the document was complete : February 23, 2009

A.2. Description of the project activity:

Purpose of the project activity, reduction of greenhouse gases
KI Ethanol Co., Ltd. is licensed by the Ministry of Energy to produce ethanol for energy sector in Nakhon Ratchasima Province in Pimai District, North Eastern part of Thailand. From 2008, the factory started producing ethanol for the national market and for export at a capacity of 100,000 liter ethanol per day by using molasses as a raw material. The wastewater from the production process is currently stored in an open pond system in the factory area. Since the wastewater is high organic laden, the methane gas is produced and emitted directly into the atmosphere. (This existing activity is considered as baseline scenario in B.4).
In 2008, KI Ethanol initiated a voluntary process under Clean Development Mechanism scheme in order to reduce Green House Gas emission by implementing a more advanced waste management system using digester wastewater treatment system called Continuous Mixed Tank Reactor (CMTR). The system is expected to digest most organic matter in the wastewater, thus the COD in the treated water is dramatically reduced while collecting the produced biogas with high methane content to generate electricity for utilizing in future project activity and supplying to the grid.

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

The proposed project activity is expected to foster sustainable development on the local, regional and national scale in several regards:
Impacts on the local and regional level

- The project activity will improve working conditions of staff and the living conditions of the local community through biogas emissions reduction and avoidance of offensive smells from the operation of an open pond wastewater treatment plant.
- Produced biogas can be used to generate electricity which otherwise is used from grid and supply the generated electricity to the grid. This will reduce the grid emission.
- The significant reduction of COD of treated wastewater compared to the treatment in a simple open-lagoon system helps to protect natural water resources and thus to improve the water quality supplied to the local community. In addition, it will be possible to re-use a considerable amount of treated wastewater in the production process.
- The construction, operation and maintenance of the anaerobic wastewater and biogas system will create additional employment opportunities.

Impacts on the national level

- The project activity reduces the host country's dependency on electricity generation, as the produced biogas is an autonomous, renewable energy. The project activity might constitute a positive example for other ethanol plants in Thailand.
- Additionally, such decentralized types of power generation help assure the stability of local

power production system.

- The project activity serves the industrial pollution prevention scheme of the government according to the 10th National Economic and Social Development Plan (NESDP) 2007 - 2011[1]. The NESDP focuses, amongst others, on the promotion on renewable energy, improving energy conservation, fighting air pollution and promoting eco-efficiency of the agro-industry of Thailand.

On the global level, the project activity reduces emissions of greenhouse gases, primarily of methane.

Host country eligibility criteria

The eligibility criteria for CDM projects of the Thai DNA 'Thai Greenhouse Gas Organization (TGO)' are fulfilled by the planned project activity. National requirements are summarized in Table 1:

Table 1: Thai eligibility criteria[2]

Eligibility criterion as defined by Thai DNA,[3] (TGO)	Criterion met by project activity
Project category: Renewable Energy, Energy Efficiency, or Energy Reduction and GHGs	YES
Project operation consistent with Thai National Development Strategy	YES
Voluntary participation, agreement of all parties involved	YES
Contribution to the requirements on environmental, social, economic and technical sustainable development	YES
Contribution to capacity building, technology transfer and know-how	YES
Consistency with Thai legislation and regulations	YES
There shall be Environment and Technical Assessment of the project as it should involve public participation	YES

Sustainable development screen

According to requirements of the Gold Standard, the project activity must be assessed against a matrix of sustainable development indicators. The contribution of the proposed project activity to the sustainable development of the country is based on indicators for the broad components of local/global environmental sustainability, social sustainability and development and economic and technological development. A summary of the matrix is presented in Table 2. The entire and comprehensive sustainable development screen is part of the Gold Standard documents. Thus the consolidated Sustainable Development Matrix can be reviewed in the Gold Standard Passport. The Sustainable Development Screen has been used as well for screening the fulfilment of the requirements of the Thai DNA on project's contribution to national sustainable development.

[1] The National Economic and Social Development Plan (NESDP) 2007 - 2011, National Economic and Social Development Board (NESDB), Office of the Prime Minister, Bangkok 2007

[2] Eligibility Criteria for CDM project, The office of Natural Resouces and Environmental Policy and planning, www.onep.go.th /CDM/CDM_approve.html cited on 22/09/08

[3] Personal meeting with Dr. Chaiwat Muncharoen, TGO Deputy Executive officer, on September 11, 2008

Component Indicators of sustainable development	Negative impact: score '–' in case negative impact is not fully mitigated score 0 in case impact is planned to be fully mitigated No change in impact: score 0 Positive impact: score '+'
Local/regional/global environment	
Water quality and quantity	+
Air quality (emissions other than GHGs)	+
Other pollutants: (including, where relevant, toxicity, radioactivity,	0
POPs, stratospheric ozone layer depleting gases)	0
Soil condition (quality and quantity)	0
Biodiversity (species and habitat conservation)	0
Sub total	+2
Social sustainability and development	
Employment (including job quality, fulfilment of labour standards)	+
Livelihood of the poor (including poverty alleviation, distributional equity, and access to essential services)	0
Access to energy services	+
Human and institutional capacity (including empowerment, education, involvement, gender)	+
Sub total	+3
Economic and technological development	
Employment (numbers)	+
Balance of payments (sustainability)	+
Technological self reliance (including project replicability, hard currency liability, skills development, institutional capacity, technology transfer)	+
Sub total	+3
TOTAL	+8

Table 2: Evaluation of the project activity based on sustainable development indicators

Remarks on Table 2

To be eligible under the Gold Standard the project must contribute positively to at least two of the three categories and neutral to the third category[4].

[4]Gold Standard Toolkit 2.0 July 2008, T2.4 Sustainability Assessment page 43

A.3. Project participants:

Name of Party involved (*) (host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Thailand (host)	Private entity: KI Biogas Co., Ltd., Nakhon Ratchasima, Thailand	No
		No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

The project is located at approximate 260 km. at North Eastern direction from BKK.
The complete address is as follows:
222/1 M.18, Nongravieng subdistrict, Pimai District, Nakhon Ratchasima, Thailand 30110

A.4.1.1. Host Party(ies):

Thailand

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

Nakhon Ratchasima province in North Eastern part of Thailand

A.4.1.3. City/Town/Community etc.:

Nongravieng Subdistrict, Pimai District

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

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

The project activity belongs to category 13: Waste handling and disposal as listed in the sectoral scopes for accreditation of the operational entities (http://cdm.unfccc.int/DOE/scopes.html).
According to Gold Standard, the project activity is part of category A.1 Renewable Energy (Electricity, Heat) with the subcategory A.1.1.2 'Biogas from wastewater treatment projects.' The project activity does not use genetically modified organisms (GMO).

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

KI Biogas Co., Ltd. is planning anaerobic wastewater treatment systems and covered lagoons, to treat about 1,195 m^3/day of high organic laden wastewater that is produced from the ethanol production process in the Northeastern Province Nakhon Ratchasima in Thailand.
The ethanol factory has daily average production rates of 100,000 liter ethanol per day for industrial use, partly for national market and for export.
Based on molasses feedstock, which is processed at 330 days per year, measured COD in the open lagoon is 120,000 mg/l on average. Thus there is a high potential of methane production for energy utilization.
Table 3 gives an overview of the plant parameters:

Table 3 Technical data for developing CDM project

Item	Molasses
Ethanol production	100,000 liters/day
Yearly operation	24 hr/day 330 days
Wastewater Flow ... per day ... per year	 1,195 m^3 394,350 m^3
COD (mg/l)	Approx. 120,000 mg/l
Biogas Utilization	1st stage (Jan-2010 to Dec-2010) feed into the grid with 3 MW 2nd stage (Start Jan-2011) feed into the grid with 4 MW
Methane content in biogas	Approx. 50-55%
Biogas production rate	Estimated 46,605 (42,136 (based on 365 days per year)) m^3/day
COD reduction rate	65% ± 5

The existing wastewater treatment system of KI Ethanol is an open pond system operated since 2007. A Continuous Mixed Tank Reactor (CMTR), an anaerobic biomethanation system, has been chosen to treat wastewater from the ethanol factory by converting organic matter into energy in the form of biogas. The biological process of conversion takes place at mesophilic temperature in a controlled atmosphere to maximize conversion efficiency & production of biogas. The treatment process is described as follow;
Wastewater from the distillery is collected in a pit to settle suspended solid before entering the biodigester. This pre-settling system ensures consistent operation by reducing the suspended solids in the waste water; the sludge are used in the secondary treatment process i.e. wastewater treatment clarification process. After that, wastewater is pumped to the biodigester. A heat exchanger reduces the water temperature down to 38 – 40^o C. Utilizing the cooling water, mixed with the recycled treated effluent the pH of the waste water will be adjusted to 6.5-7.0. The mixing system operates through re-circulation of sludge and produced gas to enhance degradation and generation of biogas. Various sample points on the shell are for measuring the concentration of sludge in the biodigester. Draining points are considered for

releasing excess sludge. The wastewater will be kept for an adequate period of time in the digester to reduce the effects of shock loads and making the process firm. The digested effluent from biodigester flows to a parallel plate clarifier via degassing pond. The entrapped gases in the digested effluent are released into the degassing pond. The sludge is settled in the parallel plate clarifier, which is recycled to increase the solid retention time in the biodigester. The supernatant liquid from the clarifier is sent for further treatment. Excess biomass & sludge is removed from the bottom of the biodigester periodically to avoid excess accumulation of solids inside the rector.

The biogas produced in the biodigester is collected from the gas dome provided on top of the biodigester. The biogas is transferred to the boiler house by using biogas blowers. A water seal type flare unit is provided for excess gas burning which also act as a pressure control device.

For safe operation, Flame Arresters are provided on gas lines to protect the biodigester from backfire & pressure relief valves are provided on biodigester and gasholder to protect the system from excess pressure or vacuum. Temperature, pH, volatile acidity and alkalinity of wastewater in the system is controlled by the operating instructions using various control features provided.

In absence of the CDM project activity, the wastewater from the ethanol production would be treated in the existing open lagoon system (indicated in green colour in Figure 1). The expected effluent of waste water from the ethanol plant will be 394,350 m^3/year, the total capacity of the six lagoons (shown in **Table 3**) is 512,585 m^3, thus the retention time would be approx. 1.3 years without considering evaporation and wastewater utilization for fertilizer.

Thus, the capacity of these existing open lagoons is sufficient to handle the complete expected wastewater volume from the ethanol production.

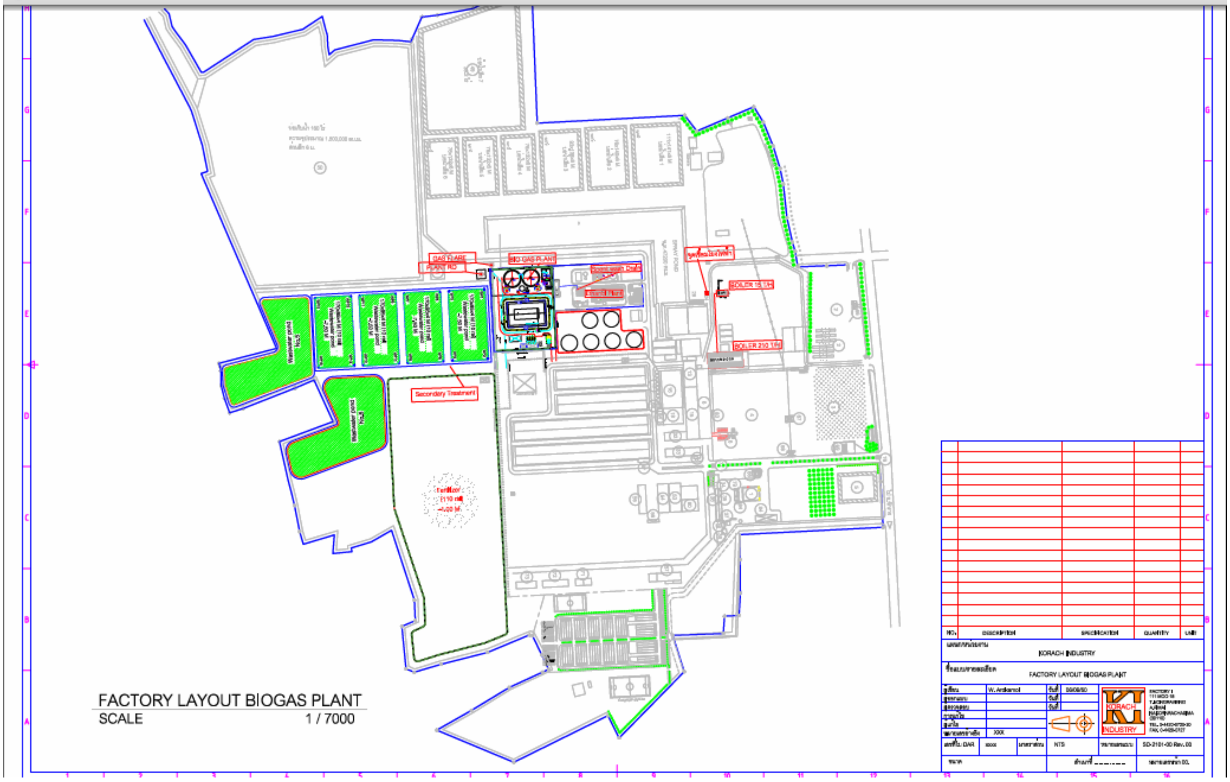

Figure 1 Biogas system layout in the factory area

Table 3 Area, capacity and depth of ponds

Pond No.	Area [m²]	Capacity [m³]	Depth [m]	note
1	16,150	71,375	5.0	Existing pond
2	16,150	71,375	5.0	Existing pond
3	16,150	71,375	5.0	Existing pond
4	16,150	71,375	5.0	Existing pond
5	29,200	120,000	5.0	New existing pond
6	27,664	107,085	5.0	New existing pond
sum	121,464	512,585	-	Total pond capacity

Source: KI biogas Co., Ltd, 2008

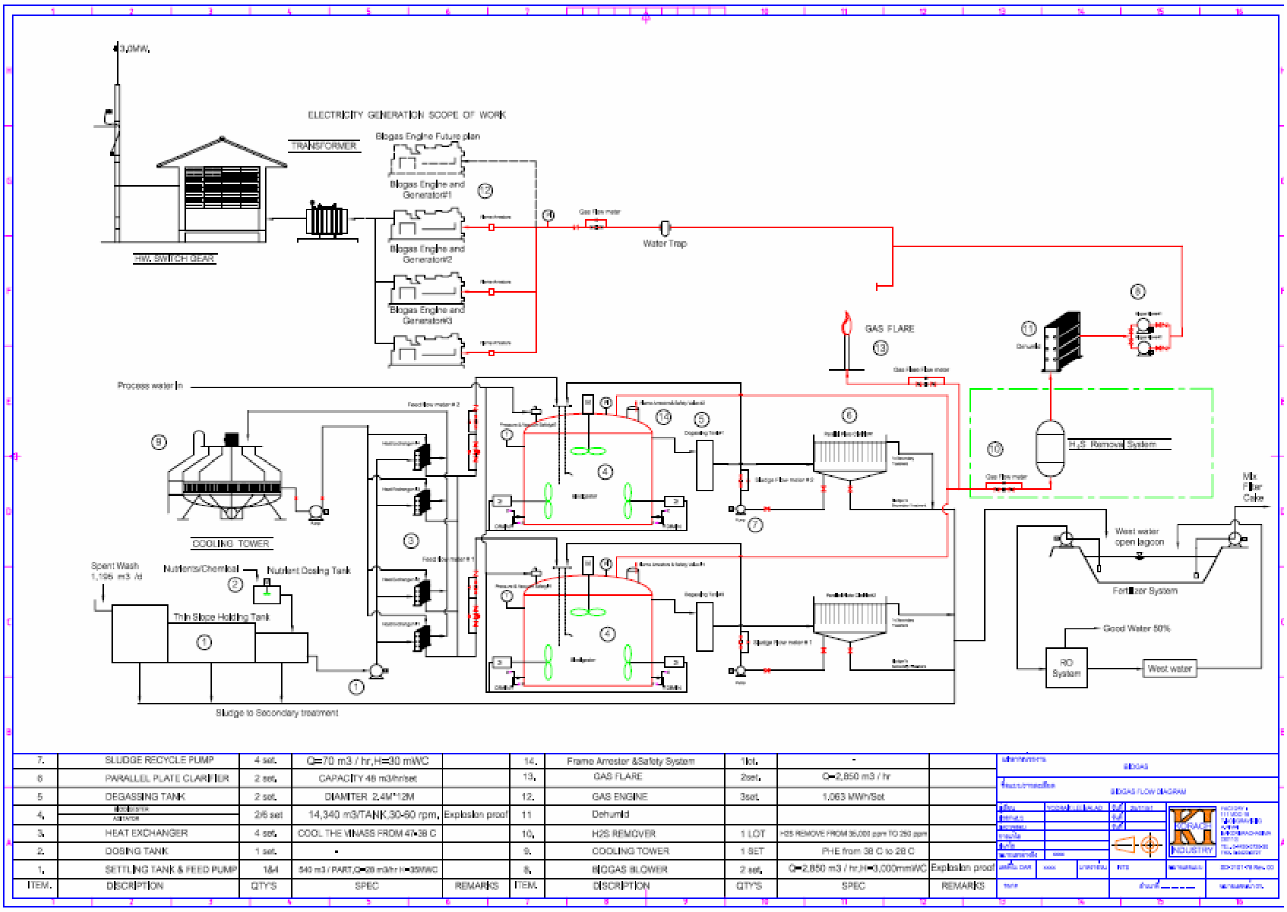

Figure 2 Biogas Flow diagram

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

The estimated amount of emission reductions over the chosen crediting period is summarized in the Table 4 below.

Table 4: Estimated amount of emission reductions over the chosen crediting period

Year	Annual estimation of emission reductions in tonnes of CO_2e
2009	78,682
2010	83,022
2011	83,022
2012	83,022
2013	83,022
2014	83,022
2015	83,022
2016	83,022
2017	83,022
2018	83,022
Total estimated reductions (tonnes of CO_2e)	825,880
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	82,588

A.4.5. Public funding of the project activity:

Neither public funding nor official development assistance (ODA) are used in the project activity. No loans from international financial institutions (IFIs) are included. The financing will be realized by KI Biogas with own capital, and the sale of generated CERs to private investors.

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:

Approved Consolidated Methodology ACM0014 “Mitigation of greenhouse gas emissions from treatment of industrial wastewater”, Version 3, valid from 13 February 09 onwards.
The methodology also refers to

- the “Tool for the demonstration and assessment of additionality” (version 5.2)
- the “Tool to determine project emissions from flaring gases containing methane” (version 01),
- the “Tool to calculate the emission factor for an electricity system” (version 01.1)
- the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (version 02)” and
- the “Tool to estimate the baseline, project and/or leakage emissions from electricity consumption (version 01)”. This tool is referring to the “Tool to calculate the emission factor for an electricity system (version 01)”.

As a result of the design of the project activity, the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” is not relevant. All other tools will be applied.

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

The methodology ACM0014 is applicable because the underlying project activity fulfils all of the defined applicability criteria and the project activity including its baseline is described by a scenario of ACM0014:
The scenarios offered by ACM0014 are summarized in the Table 5.

Table 5: Scenarios applicable to the methodology

Scenario	Description of the baseline situation	Description of the project activity
1	The wastewater is not treated, but directed to open lagoons that have clearly anaerobic conditions.	The wastewater is treated in a new anaerobic digester. The biogas extracted from the anaerobic digester is flared and / or used to generate electricity and / or heat. The residual from the anaerobic digester after treatment is directed to open lagoons or is treated under clearly aerobic conditions (e.g. dewatering and land application).

Scenario	Description of the baseline situation	Description of the project activity
2	The wastewater is treated in a wastewater treatment plant. Sludge is generated from primary and / or secondary settlers. The sludge is directed to sludge pit(s) that have clearly anaerobic conditions.	The wastewater is treated in the same wastewater treatment plant as in the baseline situation. The sludge from primary and / or secondary settler is treated in one or both of the following ways: (a) The sludge is treated in a new anaerobic digester. The biogas extracted from the anaerobic digester is flared and / or used to generate electricity and / or heat. The residual from the anaerobic digester after treatment is directed to open lagoons or is treated under clearly aerobic conditions (e.g. dewatering and land application). (b) The sludge is treated under clearly aerobic conditions (e.g. dewatering and land application).

Scenario 1 is applicable to the project activity. The baseline scenario is that the ethanol plant's effluents are directed to an existing open lagoon system under anaerobic condition. As part of the project activity new anaerobic digesters are being installed. The biogas extracted from the anaerobic digester is mainly used for producing steam for the ethanol plant. Flaring will only occur in times when the some or all of the biogas generators are not in operation. The residuals from the digester are directed to the existing open lagoons.

As shown in Table 6 the project activity fulfils the applicability criteria of ACM0014.

Table 6: Applicability criteria

Applicability criterion as defined in ACM0014	Criterion met by project activity
The average depth of the open lagoons in the baseline scenario is at least 1 m.	YES
Heat and electricity requirements per unit input of the water treatment facility remain largely unchanged in the baseline scenario and the project activity.	YES
Data requirements as laid out in this methodology are fulfilled.	YES
The residence time of the organic matter in the open lagoon system should be at least 30 days.	YES
Local regulations do not prevent discharge of wastewater in open lagoons.	YES

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

The spatial extent of the project boundary includes:
- The area of the KI Biogas Plant where the wastewater is treated;
- The sites where the surplus water of the evaporation pond is used on lands;
- The anaerobic digester, the electricity generation equipment and the flare installed under the project activity.

In line with ACM0014, the sources and gases are included in the project boundary as shown in Table 7:

Table 7: Sources and gases included in the project boundary

	Source	Gas		Justification / Explanation
Baseline	Wastewater treatment processes or sludge disposal	CH_4	Included	The major source of emissions in the baseline of the wastewater. Sludge disposal is not applied.
		N_2O	Excluded	Excluded for simplification. This is conservative.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted.
	Emissions from electricity consumption	CO_2	Included	There is no consumption of electricity of the wastewater or sludge treatment system in the baseline scenario.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	Thermal energy generation	CO_2	Excluded	There is no thermal energy generation with biogas from an anaerobic digester under the project activity.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
Project Activity	Wastewater treatment processes or sludge treatment process	CH_4	Included	The treatment of wastewater and residuals from the digester under the project activity causes different emissions: (i) Methane emission from lagoons (ii) Physical leakage of methane from the digester system (iii) Methane emissions from flaring as a part of the biogas flaring during maintenance time.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted for.
		N_2O	Included	Not applicable as there is no sludge disposal.
	On-site fossil fuel consumption	CO_2	Excluded	Not applicable as there is no fossil fuel consumption by the project.
		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.
	On-site electricity use	CO_2	Included	Additional electricity will be consumed from the grid due to the project activity.
		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.

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

The baseline scenario is determined according to the four steps following in ACM0014.

Step 1: Identification of alternative scenarios
The following are the identified realistic and credible alternatives for the treatment of the wastewater:
W1. The use of open lagoons for the treatment of the wastewater;
W2. Direct release of wastewaters to a nearby water body;
W3. Aerobic wastewater treatment facilities (e.g., activated sludge or filter bed type treatment);
W4. Anaerobic digester with methane recovery and flaring;
W5. Anaerobic digester with methane recovery and utilization for electricity or heat generation

There are 4 existing open lagoons that obtain wastewater from KI ethanol plant during the starting period in year 2007 while the other 2 open lagoons are newly constructed in mid-year 2008 to support more wastewater treatment of KI ethanol Co., Ltd. Size and capacity of each lagoon are already shown in A.4.3 with the total capacity of 512,585 m^3. The annual average wastewater of ethanol plant is about 394,350 m^3 while the natural evaporation based on water temperature, air temperature and the surface of the considered ponds accounts for a water loss of 220,724 m^3/year, based on the 30 years average evaporation in Nakhon Ratchasima, Thailand of 1,817.2 mm/m^2/year[5] and a total surface of the 6 related ponds of 121,464 m^2. The remaining effluent of 173,626 m^3/year estimated to be left in the ponds until the water is used for irrigation purposes on fields. Thus the retention time of 6 ponds would be approx. 3 years. Regardless of the large surface area, the depth of the lagoons is high enough to ensure an anaerobic decomposition. This would support the anaerobic decay as this is one of the key parameters for the rate. To ease the CDM project and future project management, the company KI Biogas Co., Ltd. has been set up, located in the facilities of KI Ethanol Co., Ltd., responsible on managing the treatment of wastewater from KI Ethanol Co., Ltd. including utilization of the collected biogas to generate electricity for project use and grid-feeding. Therefore, alternative W1 will be further considered.
As the project activity includes electricity generation with biogas from a new anaerobic digester, plausible alternative scenarios for the generation of electricity should be determined. These may include, but are not limited to, the following:
E1. Power generation using fossil fuels in a captive power plant;
E2. Electricity generation in the grid;
E3. Electricity generation using renewable sources.

Step 2: Eliminate alternatives that are not complying with applicable laws and regulations
In this step alternatives that are not in compliance with all applicable legal and regulatory requirements are eliminated.

Regulations in Thailand prohibit the direct discharge of untreated wastewater into water bodies such as rivers and lakes, primarily through the Enhancement and Conservation of National Environmental Quality Act of 1992. Therefore, alternative W2 is not in compliance with local laws and regulations and is not further considered.
Open lagoons, aerobic treatment and anaerobic digesters are in compliance with host country regulations and remain as possible alternatives.

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[5] The weather statistics (during years 1971- 2000) of Nakhon Ratchasima, Meteorological Department of Thailand, as quoted from "Environmental Evaluation Assessment Report" of KI Ethanol Co., Ltd., pages 3-8.

Step 3: Eliminate alternatives that face prohibitive barriers

As required by ACM0014, step 3 from the "Tool for the demonstration and assessment of additionality" (version 05 EB39) is applied to eliminate alternatives that face prohibitive barriers.

The following barriers are considered in the following analysis:

a) Investment barriers
b) Technological barriers
c) Barriers due to prevailing practice
d) Other barriers

The remaining options after Step 1 and 2 are:

W1. The use of open lagoons for the treatment of the wastewater;
W3. Aerobic wastewater treatment facilities (e.g. activated sludge or filter bed type treatment);
W4. Anaerobic digester with methane recovery and flaring;
W5. Anaerobic digester with methane recovery and utilization for heat generation.
E1. Power generation using fossil fuels in a captive power plant;
E2. Electricity generation in the grid;
E3. Electricity generation using renewable sources.

W1: As the open lagoons already exist in site with the major propose of retaining wastewater from ethanol plant and utilization of waste water for natural fertilizer production because Thai regulation prohibits the discharge wastewater directly into natural/public water, there is no investment barrier for land requirement for this project. This alternative would constitutes the ongoing of recent procedure. Anaerobic open lagoons are by far the least costly option. The maintenance and operation costs incurred are also very low. Consequently, the majority of wastewater treatment systems in Thailand are open lagoons (including KI Ethanol). Overall, there is no significant investment barrier and no associated investment risks including the barriers of technology and prevailing practice.

W3: Aerobic systems require investment to purchase machinery such as aerators, sludge handling systems, mixing devices etc. Apart from these investment costs, operation is significantly more expensive than simple anaerobic lagoons, partly due to the vastly larger energy requirements when compared to anaerobic lagoons. In addition, the large amount of sludge produced and its disposal places further burden on the project operators. Since there is neither a legal requirement to implement such a system, nor any economic benefit, these barriers have even more weight.

W4, W5: Closed anaerobic treatment digesters are not common practice in Thailand. Both the initial investment and the operation and maintenance costs are high, especially in comparison with open lagoons. There is little experience with biodigesters in general, and particularly in the Ethanol industry. Because of that, there is still considerable uncertainty about the long-term functioning of these systems and the amount of biogas that can be produced.

Because of the very few examples of utilization of anaerobic digestion technology in Thailand, there is a lack of technical skills. This affects the construction, operation and maintenance of the project. Anaerobic systems require a certain degree of automation in the operation of the reactor which requires a significant skills upgrade. Additional training has to be provided and new staff to be recruited (e.g. biotechnologist/waste treatment specialist for the operation of the digester).

Another risk stems from the uncertain political situation, which, if it deteriorates, may have a strong impact on the economy, policy, and the value of the Thai Baht[6].

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[6] http://www.economist.com/countries/Thailand/profile.cfm?folder=Profile-Economic%20Data and http://www.economist.com/world/asia/displaystory.cfm?story_id=11920648m , both accessed on Aug 16th 2008

Furthermore, since anaerobic open lagoons are the prevailing practice as well as by far the cheapest one, there is little incentive to change to another system. The tendency to stick to the prevailing practice also means that finding investors who are willing to invest in such a novel and unproven technology is difficult.
Conclusion for wastewater treatment: Alternatives W3, W4 and W5 face significant barriers, in terms of investment, technology, and prevailing practice/managerial culture. W1 is the prevailing practice, is existing system thus no investment cost. The operation and maintenances cost are low, therefore, does not face significant barriers.
According to the project activity, electricity will be required in the treatment system. The project proponent will utilize produced biogas to generate this electricity to supply to the grid, thus setting off consumption of electricity from the grid.

E1: The alternative on power generation using fossil fuels in a captive power plant is not an adequate and not economic solution in comparison to the project activity. Installing a power plant system would result in a more complex, costly and difficult to maintain installation. In addition, the fuel price is unstable due to global demand and supply. While there is a dramatic increase in energy demand, the supply of fossil fuel has limitation and would be run out in the near future; therefore using fossil fuel in a captive power plant might face the instability of fossil fuel prize and risks lack of sufficient fossil fuel supply. Considering prevailing practices on electricity generation, this is not a common practice in Thailand even that there are some firms generating electricity by themselves, but this is mainly based already on biomass waste or by diesel generator due to instability of grid elecetricity in some areas in Thailand. \

The electricity required for the treatment system in the project activity is small and not economic enough to install an economically operating power plant. Consequently, the investment into captive power plant is economically and environmentally not justified.

E2: Using electricity from grid is the most convenient way for the project. The project does not need any investment in electricity generation equipment and the installation therefore. This alternative would not face investment and technology barriers. However, using electricity from grid might create an impact on electricity use of local community which consume electricity from Electricity Generating Authority of Thailand (EGAT). Moreover, in comparison to the project activity, using grid electricity does not generate additional income as the sales of electricity in the project activity. Electricity stability is not guaranteed and grid electricity still contributes to GHG emission. Economic and environmental disadvantages are making this alternative not attractive enough. This alternative will not solve the problem with high Methane emission from the open lagoons.

E3: Renewable technologies such as solar power require especially high upfront costs and therefore face significant investment barriers. Average payback period for solar Energy with special feed-in-tariff is still more than 10 years. The energy demand of this project is less than 4 MW, a Biomass Power Plant would not operate economically on such a capacity. Moreover, biomass availability in the project's region has decreased markedly in recent years. At the same time, biomass prices have hiked dramatically and several biomass power plants have been forced to shut down[7]. Rice husk prices have risen from about 400 THB/ton in 2002 to about 1200 THB/ton in mid-2008, and a further increase seems likely[8]. With the high

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[7] As relayed by Natee Sithiprasasana, CEO of A.T. Biopower Co Ltd in Thailand, the CDM project in Thailand to be issued CERs, plant operation would not be economically feasible anymore without revenue from CDM.

[8] Matichon (Daily Newspaper), 10. March 2008, last accessed 1. September 2008 at http://www.matichon.co.th/prachachat/prachachat_detail.php?s_tag=02p0105100451&day=2008-04-10&sectionid=0201

uncertainty due to supply problems and high prices, investment in such a system carries too much risk and faces significant technical barriers. Moreover, this alternative as well is not solving the problems with high Methane emission from the open lagoons.

Conclusion for electricity generation: Alternatives E1 and E3 face high and increasing costs of electricity generation while E2 does not have investment and technology barriers, but moderate to severe economic barriers through future increase of electricity costs. Considering the result of the analysis, E2 is the still an alternative to the project activity

Overall conclusion: Alternatives W3, W4 and W5 as well as alternatives E1 and E3 face significant barriers, technologically, economically and environmentally. The only remaining alternatives are W1 (the use of open lagoons for the treatment of the wastewater) and E2 (electricity generation in the grid). Therefore, W1 and E2 are considered to be the baseline scenario.

Step 4: Compare economic attractiveness of remaining alternatives
As only one set of alternatives (W1 & E2) remains after step 3, no comparison of economic attractiveness is performed.

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):

The "Tool for the demonstration and assessment of additionality" (version 05 EB39 Annex 10) is applied and updates Version 05.1 and 05.2 are considered to demonstrate and assess additionality of the project through the following steps:
Step 1: Identification of alternatives to the project activity consistent with current laws and regulations
Step 2: Investment analysis
Step 3: Barrier analysis
Step 4: Common practice analysis

<u>Step 1: Identification of alternatives to the project activity consistent with current laws and regulations</u>
Sub-step 1a: Define alternatives to the project activity:
As in detail described in section B.4, the alternatives for wastewater treatment are as follows:
W1. The use of open lagoons for the treatment of the wastewater;
W2. Direct release of wastewaters to a nearby water body;
W3. Aerobic wastewater treatment facilities (e.g., activated sludge or filter bed type treatment);
W4. Anaerobic digester with methane recovery and flaring;
W5. Anaerobic digester with methane recovery and utilization for electricity or heat generation (the proposed project activity without registration as a CDM project).

The alternatives for electricity generation are as follows:
E1. Power generation using fossil fuels in a captive power plant;
E2. Electricity generation in the grid;
E3. Electricity generation using renewable sources.

Sub-step 1b.: Consistency with mandatory laws and regulations:
As detailed in section B.4, alternative W2 does not comply with local regulations and is therefore not further considered.

Step 2: Investment analysis

No investment analysis is performed, as per the tool, only a barrier analysis is used to demonstrate additionality.

Step 3: Barrier analysis

Sub-step 3a: Identify barriers that would prevent the implementation of the proposed CDM project activity:

The following are realistic and credible barriers that would prevent the implementation of the proposed project activity from being carried out if the project activity was not registered as a CDM activity:

a. Investment barriers, other than the economic/financial barriers in Step 2 above
b. Technological barriers
c. Barriers due to prevailing practice
d. Other barriers

a. Investment barriers

- **Cost-effective current practice:** To continue the existing open pond system is considered as the most economic attractive alternative for KI Biogas as it complies with all regulations and requires the least investment, operation and maintenance costs. In addition, open ponds provide the highest flexibility in case of future expansions and therefore minimize potential future investments. Very little investment is needed, and O&M costs are low.
- **Size and transaction costs:** Most biogas projects within the industrial sectors of Ethanol, Starch and Palm Oil Industry in Thailand, but not limited to these sectors are relatively small in terms of investment requirements (especially when compared to other power generation projects). Their transaction costs on the other hand are relatively high. Moreover, these projects are considered to be high-risk investments by the financiers due to uncertainties of continued performance of the bio-technology and thus revenues and financial advantages in comparison to conventional and long-term approved technologies have a higher risk. Nevertheless, most biogas energy projects require high capital investment per kW installed compared with other mature conventional energy technologies in terms of generated fuel and output security. Hence, biogas project developers face more difficulties in getting their projects financed.
- **Fuel price uncertainty:** The standard investment plan is based on constantly increasing fuel prices for heavy oil on recent high level. In case fuel prices decrease in the future from historically high values, competitive disadvantages could result for KI Biogas compared to competitors utilizing traditional fuels.

b. Technological barriers

- **First of its kind:** The Biodigester Systems received increasing attention in Thailand since the last 5 years. A wide variety of different technologies for anaerobic digestion are applied to a variety of different industries (mainly agro-industries) with a huge variety of wastewater composition. In the Ethanol Industry so far only one system, called covered lagoon system has been implemented and is operating since not longer than one year. KI biogas which is now operating the open lagoon, aims to install an anaerobic digester system. The type of anaerobic biodigester which will be applied to the project is Continuous Mixed Tank Reactor (CMTR). The basic anaerobic digester design, however, to gain more efficiency in methane producing and capturing, a unique design is developed. The completely mixed system including temperature & acidity control, designed by Praj Industries Ltd. (Indian technology provider), is applied to the biodigester and the digesters will be the firstly installed in Thailand; therefore the project is a first-of-its-kind project in the region and referring technology type in this industrial sector.

- **Lack of trained staff and know-how:** There is a lack of locally available know-how and a lack of skilled laborers for operation and maintenance. The technology provider and contractor has qualified personnel but they are not available for full support services. Therefore, additional training has to be provided and new staff to be recruited (e.g. biotechnologist/waste treatment specialist for the operation of the digester). For KI biogas, the technology provider is from India and there is no installation of this technology in Thailand before thus; the design, installation and the first-stage operation will be managed by the technology provider and the local staff must have additional training for further operation stages.
- **Lack of experience with ethanol wastewater in anaerobic digesters:** The performance of the digester is influenced by numerous variables, such as the COD content and yeast, fibers and other solids contained in the wastewater as well as the biodegradability of organics in the waste water depending on the used feedstock for Ethanol production. Because no prior experience exists in applying the CMTR with ethanol wastewater in Thailand, these variables pose a significant risk and thus a barrier. The digester performance is dependant on a biological system (bacteria) which is sensitive to the chemical composition and temperature of the wastewater. If any mismanagement or suboptimal operation of the system were to occur, the efficiency of treatment and the amount of generated gas could be lowered significantly. This poses the additional problem of a higher-than-anticipated COD count of the post-treatment wastewater and possible problems with its re-use or disposal. Altogether, the long-term stability of operation can therefore not be guaranteed, which poses a significant barrier. In comparison to the open ponds alternative, a sophisticated monitoring and control system is necessary, which must be skillfully operated to ensure the optimal operation of the treatment system.

c. Barriers due to prevailing practice

As mentioned in (b), the proposed project implements the first CMTR system in an Ethanol plant in Thailand. At present, there are 11 ethanol factories operating in Thailand[9]. Eight out of these 11 factories are using open storage lagoon while the others installed different kind of system i.e. UASB.[10]

d. Other barriers

There is a significant risk that the amount of available wastewater will be lower than anticipated due to:

- **Market competition:** Market competition as a result of an increased number of suppliers in the ethanol industry may result in lower prices of ethanol. This may in turn lead to lower ethanol production and therefore less wastewater at the project.
- **Material costs:** Raw material cost is hiking, which may lead to an uneconomic production and a decrease of production or temporary halt of operation.[11]
- **Policy uncertainties:** The uncertainty regarding the host country's government policy and economy could effect to the amount of ethanol produced. Since year 2004,

[9] List of Ethanol Plants in Operation updated January, 2009, Department of Alternative Energy and Development, Ministry of Energy. http://www.dede.go.th/dede/index.php?id=172 cited on February 23, 2008

[10] Questionnaire from Thai Ethanol Manufacturing Association, September 2008

[11] Personal Interview with the Manager of Thai Ethanol Manufacturing Association. Thai Ethanol Manufacturing Association office. August 14, 2008

the government policy aims to introduce gasohol (gasoline mixed with ethanol) to the transportation sector in Thailand. The second phase, started in 2006, was to encourage an increase in gasohol consumption. Due to these policies there have been a total of 47 factories approved to produce ethanol with a total capacity of 12,295,000 liters/day. The first one is operating since 2003 and until now there are 11 factories operating with a capacity of 1,575,000 liters/day. A further 11 factories are under construction, with combined capacity of 2,400,000 liters/day[12]. The demand of gasohol however reached only 0.8 million liters/day (June, 2008)[13]. In addition, overall gasoline consumption decreased due to high oil prices and the promotion of Natural Gas Vehicles (NGV). This means that the growth of NGV and LPG consumption (up 20.5% during the first six months of 2008[14]) was partly invading the market share originally planned for gasohol vehicles. If this trend continues, there may soon be an overcapacity of ethanol production and therefore, significant uncertainties regarding production volumes and amount of wastewater at the project site.

Sub-step 3b: Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity):

As shown in section B.4 and B.5, the identified barriers do not affect alternatives W1 and E2. The use of open ponds for wastewater treatment and the use of electricity from the grid are well-established practice in the host country, which clearly demonstrates that their implementation would not be prevented by the identified barriers. The proposed activity, E3 (Electricity generation using renewable sources) and W5 (Anaerobic digester with methane recovery and utilization for heat generation), faces investment, technical, and other barriers. The project is considered as being on high risk which cannot be realized without CDM support.

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[12] Ethanol factory licenses list and production capacities. http://www.dede.go.th/dede/index.php?id=172, accessed 13/08/08

[13] Amount of gasohol consumption per month for the years 2004-2008. http://www.dede.go.th/dede/fileadmin/usr/bers/gasohol_2008/2-510722_Monthly_selling_gasohol_47_51.xls, accessed 13/08/08

[14] Energy Policy & Planning Office, Ministry of Energy, Thailand, Nation Channel. http://breakingnews.nationchannel.com/read.php?newsid=333839&lang=&cat=business, accessed 13/08/08

Step 4: Common practice analysis

Sub-step 4a. Analyze other activities similar to the proposed project activity

According to the information of types of wastewater treatment system from Department of Industrial Works, most of existing ethanol plants apply open ponds to storage their wastewater.
The applied technology CMTR in the proposed project is “first of its kind” in Thailand and in the industrial sector. Even as it is based on the well known continuous mixing principle (Continuous Stired Tank Reactor, Continuous Mixed Tank Reactor), the technology received crucial modifications and adaptations for the application in the ethanol manufacturing in Thailand. Similar technologies have been applied in India, the country of the technology provider for this project , as well as in few ethanol plants in Viet Nam.

Sub-step 4b. Discuss any similar options that are occurring:

There are no similar options occurring in Thailand at all.

Conclusion

Based on the analysis above, the project activity is “first-of-its-kind” technology application and thus being additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

As per the methodology ACM0014, version 02.1, emission reductions of the project activity are equal to baseline emissions minus project emissions. No leakage is estimated.

Baseline emissions

Baseline emissions are calculated as follows:

$BE_y = BE_{CH4,y} + BE_{EL,y} + BE_{HG,y}$ **(1)**

Where:

BE_y	Baseline emissions in year *y* (tCO_2e/yr)
BE_{CH4}	Methane emissions from anaerobic treatment of the wastewater in open lagoons (scenario 1) in the absence of the project activity in year *y* (tCO_2e/yr)
$BE_{EL,y}$	CO_2 emissions associated with electricity generation that is displaced by the project activity and / or electricity consumption in the absence of the project activity in year *y* (tCO_2e/yr)
$BE_{HG,y}$	CO_2 emissions associated with fossil fuel combustion for heating equipment that is displaced by the project in year *y* (tCO2 / yr)

According to ACM0014, baseline emissions are calculated in three steps, as follows:

Step 1: Calculation of baseline emissions from anaerobic treatment of the wastewater or sludge;

Step 2: Calculation of baseline emissions from generation and consumption of electricity (if applicable);

Step 3: Calculation of baseline emissions from heat generation (if applicable);

Steps 1 and 2 are applicable in the proposed project and are included. Again, as there is no heat generation in the project activity, Step 3 is not relevant for the underlying project.

Step 1: Calculation of baseline emissions from anaerobic treatment of the wastewater or sludge

From the current activity, just emissions from the wastewater treatment will be calculated as no sludge is treated and thus is not relevant.

The methodology proposes two alternative methods for the estimation of methane emissions from open lagoons and the option (a) **The Methane Conversation Factor Method** is applied to the project.

Step 1a: Methane conversation factor method (MCFM)

The baseline methane emissions from anaerobic treatment of the wastewater in open lagoons (scenario 1) are estimated based on the chemical oxygen demand (COD) of the wastewater that would enter the lagoon in the absence of the project activity ($COD_{PJ,y}$), the maximum methane producing capacity (B_o) and a methane conversion factor ($MCF_{BL,y}$) which expresses the proportion of the wastewater that would decay to methane, as follows:

$BE_{CH4,y} = GWP_{CH4} \times MCF_{BL,y} \times B_o \times COD_{BL,y}$ **(2)**

Where:

$BE_{CH4,y}$	Methane emissions from anaerobic treatment of the wastewater in open lagoons in the absence of the project activity in year y (t CO_2e / yr)
GWP_{CH4}	Global Warming Potential of methane valid for the commitment period (t CO_2e / t CH_4)
B_o	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand (t CH_4 / t COD)
$MCF_{BL,y}$	Average baseline methane conversion factor (fraction) in year y, representing the fraction of ($COD_{PJ,y}$ x B_o) that would be degraded to CH_4 in the absence of the project activity
$COD_{BL,y}$	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in year y (t COD/yr)

Determination of $COD_{BL,y}$

The baseline chemical oxygen demand ($COD_{BL,y}$) corresponds to the chemical oxygen demand that is treated under the project activity ($COD_{PJ,y}$), because in the absence of the project activity the wastewater that is treated by the project activity would be directed to the open lagoons. Hence, $COD_{BL,y}$ equals $COD_{PJ,y}$.

If there would be an effluent from the lagoons in the baseline, COD_{BL} should be adjusted by an effluent adjustment factor which relates the COD supplied to the lagoon or sludge pit with the COD in the effluent, as follows:

$COD_{BL,y} = AD_{BL} \times COD_{PJ,y}$ **(3)**

Where:

$COD_{BL,y}$	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in year y (t COD / yr)
$COD_{PJ,y}$	Quantity of chemical oxygen demand that is treated in the anaerobic digester in the project activity in year y (t COD / yr)
AD_{BL}	Effluent adjustment factor expression the percentage of COD that is degraded in open lagoons in the absence of the project activity

AD_{BL} is determined as follows:

For project activities implemented in existing facilities with one year historical data of the COD inflow and COD effluent are available, AD_{BL} should be determined as follows:

$$AD_{BL} = 1 - \frac{COD_{out,x}}{COD_{in,x}} \quad \textbf{(4)}$$

Where:

AD_{BL}	Effluent adjustment factor expression the percentage of COD that is degraded in open lagoons in the absence of the project activity
COD_{out}	COD of the effluent (t COD)
COD_{in}	COD directed to the open lagoons (t COD)

$COD_{PJ,y}$ is determined as follows:

$$COD_{PJ,y} = \sum_{m=1}^{12} F_{PJ,dig,m} \times W_{COD,dig,m} \qquad \textbf{(5)}$$

Where:

$COD_{PJ,y}$	Quantity of chemical oxygen demand that is treated in the anaerobic digester in the project activity in year y (t COD / yr)
$F_{PJ,dig,m}$	Quantity of wastewater that is treated in the anaerobic digester in the project activity in month m (m^3 / month)
$w_{COD,dig,m}$	Average chemical oxygen demand in the wastewater that is treated in the anaerobic digester in the project activity in month m (t COD / m^3)
m	Months of year y of the crediting period

Determination of $MCF_{BL,y}$

In line with ACM0014, the methane conversion factor is calculated based on a factor f_d, expressing the influence of the depth of the lagoon on methane generation, and a factor $f_{T,y}$ expressing the influence of the temperature on the methane generation. In addition, a conservativeness factor of 0.89 is applied to account for the considerable uncertainty associated with this approach. $MCF_{BL,y}$ is calculated as follows:

$$MCF_{BL,y} = f_d \times f_{T,y} \times 0.89 \qquad \textbf{(6)}$$

Where:

$MCF_{BL,y}$	Average baseline methane conversion factor (fraction) in year y, representing the fraction of ($COD_{PJ,y}$ x B_o) that would be degraded to CH_4 in the absence of the project activity
f_d	Factor expressing the influence of the depth of the lagoon on methane generation
$f_{T,y}$	Factor expressing the influence of the temperature on the methane generation in year y
0.89	Conservativeness factor

Determination of $f_{T,y}$

$$COD_{available,m} = COD_{BL,m} + (1 - f_{T,m}) \times COD_{available,m-1} \qquad \textbf{(7)}$$

The factor $f_{T,y}$ is calculated with the help of a monthly stock change model which aims at assessing how much COD degrades in each month. For each month m, the quantity of wastewater directed to the lagoon, the quantity of organic compounds that decay and the quantity of any effluent water from the lagoon is balanced, giving the quantity of COD that is available for degradation in the next month: The amount of organic matter available for degradation to methane ($COD_{available,m}$) is assumed to be equal to the amount of organic matter directed to the open lagoon, less any effluent, plus the COD that may have remained in the lagoon from previous months, as follows:

$$COD_{BL,m} = AD_{BL} \times COD_{PJ,m} \qquad \textbf{(8)}$$

$$COD_{PJ,m} = F_{PJ,dig,m} \times W_{COD,dig,m} \qquad \textbf{(9)}$$

Where:

$COD_{available,m}$	Quantity of chemical oxygen demand available for degradation in the open lagoon in month m (t COD / month)
$COD_{BL,m}$	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in month m (t COD / month)
$COD_{PJ,m}$	Quantity of chemical oxygen demand that is treated in the anaerobic digester in the project activity in month m (t COD / month)
AD_{BL}	Effluent adjustment factor expressing the percentage of COD that is degraded in open lagoons in the absence of the project activity
$F_{PJ,dig,m}$	Quantity of wastewater that is treated in the anaerobic digester in the project activity in month m (m^3 / month)
$w_{COD,dig,m}$	Average chemical oxygen demand in the wastewater that is treated in the anaerobic digester in the project activity in month m (t COD / m^3)
$f_{T,m}$	Factor expressing the influence of the temperature on the methane generation in month m
m	Months of year y of the crediting period

The monthly factor to account for the influence of the temperature on methane generation is calculated based on the following "van't Hoff – Arrhenius" approach:

$$f_{T,m} = \begin{cases} 0 & if\ : T_{2,m} < 283K \\ \exp\left(\frac{E \times \left(T_{2,m} - T_1\right)}{R \times T_1 \times T_{2,m}}\right) & if\ : 283K < T_{2.,m} < 303K \\ 1 & if\ : T_{2,m} < 303K \end{cases} \qquad \textbf{(10)}$$

Where:

$f_{T,m}$	Factor expressing the influence of the temperature on the methane generation in month m
E	Activation energy constant (15,175 cal / mol)
$T_{2,m}$	Average temperature at the project site in month m (K)
T_1	303.16 K (273.16 K + 30 K)
R	Ideal gas constant (1.987 cal / K mol)
m	Months of year y of the crediting period

Based on the monthly values $f_{T,m}$ the annual value $f_{T,y}$ is calculated as follows:

$$f_{T,y} = \frac{\sum_{m=1}^{12} f_{T,m} \times COD_{available,m}}{\sum_{m=1}^{12} COD_{BL,m}} \qquad \textbf{(11)}$$

Where:

$f_{T,y}$	Factor expressing the influence of the temperature on the methane generation in year y
$f_{T,m}$	Factor expressing the influence of the temperature on the methane generation in month m
$COD_{available,m}$	Quantity of chemical oxygen demand available for degradation in the open lagoon or sludge pit in month m (t COD / month)

$COD_{BL,m}$	Quantity of chemical oxygen demand that would be treated in open lagoons in the absence of the project activity in month m (t COD / month)
m	Months of year y of the crediting period

Step 2: Baseline emissions from generation and/or consumption of electricity

As part of the project activity, electricity is generated with biogas from a new anaerobic digester and transferred to grid and displaces the electricity consumption of new anaerobic digester. In the first year 3 MWe will be produced to feed into the grid. From the second year on 4 MWe is planned to generate. The project proponent will monitor biogas production in the first year and thus prepare with only 3 generator sets at 1 MW each. Possible overproduced biogas will be flared. If enough biogas is produced a forth set of generator will be installed. As scenario E2 is applied, the baseline emissions are calculated as follows:

Baseline emissions from the generation and / or consumption of electricity are calculated as follows:

$$BE_{EL,y} = (EC_{BL,y} + EG_{PJ,y}) \times EF_{BL,EL,y} \quad \textbf{(15)}$$

Where:

$BE_{EL,y}$ = CO_2 emissions associated with electricity generation that is displaced by the project activity and / or electricity consumption in the absence of the project activity in year *y* (t CO_2 / yr)

EC_{BL} = Annual quantity of electricity that would be consumed in the absence of the project activity for the treatment of the wastewater (scenario 1) or the treatment of the sludge (scenario 2) (MWh / yr)

$EG_{PJ,y}$= Net quantity of electricity generated in year *y* with biogas from the new anaerobic biodigester (MWh / yr)

$EF_{BL,EL,y}$ = Baseline emission factor for electricity generated and / or consumed in the absence of the project activity in year *y* (tCO_2 / MWh)

The determination of $EF_{BL,EL,y}$ depends on the baseline scenario and the configuration at the project site. Since the baseline scenario for displacement of electricity generated with biogas from anaerobic digester is E2 then, the grid emission factor will be used ($EF_{BL,EL,y} = EF_{grid,y}$) in calculation. The Annual quantity of electricity that would be consumed in the absence of the project activity for the treatment of the wastewater (EC_{BL}) will be neglected because there is no electricity consumed before digester installation. Given limited data availability, the Thai grid emissions factor has been calculated as a Simple OM (operating margin) according to "Tool to calculate the emission factor for an electricity system". The analysis determines the Thai grid emissions factor as 0.548 kg CO_2/kWh. Underlying data and details of calculation can be found in Annex 3.

Step 3: Baseline emissions from the generation of heat

This step is applicable if the biogas captured from the new anaerobic digester is utilized in the project scenario for heat generation. Since it is not relevant for the project activity and following ACM0014, these step is skpped

.

Project Emissions

In line with ACM0014, the following emission sources are attributed to the project activity:

i) Methane emissions from the lagoons (applicable if effluent from the treatment under the project activity is directed to a lagoon system):
ii) Physical leakage of methane from the digester system:
iii) Methane emissions from flaring (applicable because a small part of the biogas from the digester is flared):
iv) Methane and nitrous oxide emissions from land application of sludge (if applicable);
v) CO_2 emissions from consumption of electricity and or fossil fuels in the project activity.

Methane and nitrous oxide emissions from land application of sludge (iv) are not relevant for this project, because no sludge application takes place.

Project emissions are calculated as follows:

$PE_y = PE_{CH4,effluent,y} + PE_{CH4,digest,y} + PE_{flare,y} + PE_{sludge,LA,y} + PE_{EC,y} + PE_{FC,y}$ **(19)**

Where:

PE_y	Project emissions in year y ($t\ CO_2e/yr$)
$PE_{CH4,effluent,y}$	Project emissions from treatment of wastewater effluent from the anaerobic digester in year y ($t\ CO_2e/yr$)
$PE_{CH4,digest,y}$	Project emissions from physical leakage of methane from the anaerobic digester in year y ($t\ CO_2e/yr$)
$PE_{flare,y}$	Project emissions from flaring of biogas generated in the anaerobic digester in year y ($t\ CO_2e/yr$)
$PE_{sludge,LA,y}$	Project emissions from land application of sludge in year y (tCO2e / yr)
$PE_{EC,y}$	Project emissions from electricity consumption in year y (tCO2e / yr)
$PE_{FC,y}$	Project emissions from fossil fuel consumption in year y (tCO2e / yr)

(i) Project methane emissions from effluent from the digester

This step is applicable if a new digester is installed under the project activity and if the effluent from this digester is directed to open lagoons, which is the case with the proposed project. To comply with baseline emission calculation, the methane conversion factor method is applied to calculate project methane emissions.

Methane conversion factor method

Project methane emissions from treatment of the effluent from the digester are estimated as follows:

$PE_{CH4,effluent,y} = GWP_{CH4} \times MCF_{PJ,y} \times Bo \times (COD_{PJ,effl,dig,y} - COD_{PJ,effl,lag,y})$ with (20)

$$COD_{PJ,eff,dig,y} = \sum_{m=1}^{12} F_{PJ,Effl,dig,m} x W_{COD,effl,dig,m} \quad (21)$$

$$COD_{PJ,eff,lag,y} = \sum_{m=1}^{12} F_{PJ,Effl,lag,m} x W_{COD,effl,lag,m} \quad (22)$$

Where:

$PE_{CH4,effluent,y}$	Project emissions from treatment of wastewater effluent from the anaerobic digester in year y ($t\ CO_2e$ / yr)
GWP_{CH4}	Global Warming Potential of methane valid for the commitment period ($t\ CO_2e$ / $t\ CH_4$)
$MCF_{PJ,y}$	Project methane conversion factor (fraction) in year y, representing the fraction of ($COD_{PJ,effluent,y}$ x B_o) that degrades to CH_4
B_o	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand ($t\ CH_4$ / t COD)
$COD_{PJ,effl,dig,y}$	Quantity of chemical oxygen demand in the effluent from the digester in year y (t COD / yr)
$COD_{PJ,effl,lag,y}$	Quantity of chemical oxygen demand in the effluent of the open lagoon in which the effluent from the digester is treated in year y (t COD / yr)
$F_{PJ,effl,dig,m}$	Quantity of effluent from the digester in month m (m^3 / month)

$w_{COD,effl,dig,m}$	Average chemical oxygen demand in the effluent from the digester in month m (t COD / m³)
$F_{PJ,effl,lag,m}$	Quantity of effluent from the open lagoon in which the effluent from the digester is treated in month m (m³ / month)
$w_{COD,effl,lag,m}$	Average chemical oxygen demand in the effluent from the open lagoon in which the effluent from the digester is treated in month m (t COD / m³)

The quantity of methane generated from COD disposed to the open lagoon is calculated as follows:

$$MCF_{PJ,y} = f_d \times \mathbf{f}_{PJ,T,y} \quad \textbf{(23)}$$

Where:

$MCF_{PJ,y}$	Project methane conversion factor (fraction) in year y, representing the fraction of ($COD_{PJ,effluent,y}$ x B_o) that degrades to CH_4
f_d	Factor expressing the influence of the depth of the lagoon or dewatering facility on methane generation
$f_{PJ,T,y}$	Factor expression the influence of the temperature on the methane generation under the project activity in year y

The factor $f_{T,PJ,y}$ is calculated, as under baseline emissions, with the help of a monthly stock change model which aims at assessing how much COD degrades in each month, as follows:

$$\mathbf{COD_{PJ,available,m} = (COD_{PJ,effl,dig,m} - COD_{PJ,effl,lag,m}) + (1\text{-}f_{T,m}) \times COD_{PJ,available,m-1}} \text{ with} \quad \textbf{(24)}$$

$$\mathbf{COD_{PJ,effl.dig,m} = F_{PJ,effl,dig,m} \times w_{COD,effl,dig,m}} \text{ and} \quad \textbf{(25)}$$

$$\mathbf{COD_{PJ,effl.lag,m} = F_{PJ,effl,lag,m} \times w_{COD,effl,lag,m}} \quad \textbf{(26)}$$

Where:

$COD_{PJ,available,m}$	Quantity of chemical oxygen demand available for degradation in the open lagoon under the project activity in month m (t COD / month)
$COD_{PJ,effl,dig,m}$	Quantity of chemical oxygen demand in the effluent from the digester in month m (tCOD / month)
$COD_{PJ,effl,lag,m}$	Quantity of chemical oxygen demand in the effluent of the open lagoon in which the effluent from the digester is treated in month m (t COD / month)
$F_{PJ,effl,dig,m}$	Quantity of effluent from the digester in month m (m³ / month)
$w_{COD,effl,dig,m}$	Average chemical oxygen demand in the effluent from the digester in month m (t COD / m³)
$F_{PJ,effl,lag,m}$	Quantity of effluent from the open lagoon in which the effluent from the digester is treated in month m (m³ / month)
$w_{COD,effl,lag,m}$	Average chemical oxygen demand in the effluent from the open lagoon in which the effluent from the digester is treated in month m (t COD / m³)
$f_{T,m}$	Factor expressing the influence of the temperature on the methane generation in month m
m	Months of year y of the crediting period

As for the baseline emissions, the carry-over calculations are limited to a maximum of one year.

The monthly factor to account for the influence of the temperature on methane generation is calculated as per equation (10) above.

Based on the monthly values $f_{T,m}$ the annual value $f_{T,PJ,y}$ is calculated as follows:

$$f_{PJ,T,y} = \frac{\sum_{m=1}^{12} f_{T,m} \times COD_{PJ,available,m}}{\sum_{m=1}^{12} (COD_{PJ,effl,dig,m} - COD_{PJ,effl,lag,m})} \quad \textbf{(27)}$$

Where:

$f_{PJ,T,y}$	Factor expressing the influence of the temperature on the methane generation under the project activity in year y
$f_{T,m}$	Factor expressing the influence of the temperature on the methane generation in month m
$COD_{PJ,available,m}$	Quantity of chemical oxygen demand available for degradation in the open lagoon under the project activity in month m (t COD / month)
$COD_{PJ,effl,dig,m}$	Quantity of chemical oxygen demand in the effluent from the digester in month m (t COD / month)
$COD_{PJ,effl,lag,m}$	Quantity of chemical oxygen demand in the effluent of the open lagoon in which the effluent from the digester is treated in month m (t COD / month)
m	Months of year y of the crediting period

(ii) Project emissions related to physical leakage from the digester

This step is applicable because the project activity includes the construction of a new anaerobic digester. The emissions directly associated with the operation of digesters involve the physical leakage of methane from the digester system. Methane emissions from the new digester are calculated as follows:

$$PE_{CH4,digest,y} = F_{biogas,y} \times FL_{biogas,digest} \times w_{CH4,biogas,y} \times GWP_{CH4} \times 0.001 \quad \textbf{(30)}$$

Where:

$PE_{CH4,digest,y}$	Project emissions from physical leakage of methane from the anaerobic digester ($t\ CO_2e$ / yr)
$F_{biogas,y}$	Amount of biogas collected in the outlet of the new digester in year y (m^3 / yr)
$FL_{biogas,digest}$	Fraction of biogas that leaks from the digester (m^3 biogas leaked / m^3 biogas produced)
$w_{CH4,biogas,y}$	Concentration of methane in the biogas in the outlet of the new digester ($kg\ CH_4 / m^3$)
GWP_{CH4}	Global Warming Potential of methane valid for the commitment period ($t\ CO_2e / t\ CH_4$)

(iii) Methane emissions from flaring

This step is applicable because under the project activity biogas is generated in a new anaerobic digester and a part of the biogas might be flared. Methane may be released as a result of incomplete combustion in the flare. To calculate project emissions from flaring of the biogas (PE_{flare}) the latest approved version of the “Tool to determine project emissions from flaring gases containing methane” is applied.

In the project activity, biogas will be flared only during equipment maintenance periods at the project site or when biogas production exceeds the capacity of the gas engine. Such occasions will be rare, however, and flare use will in fact be sporadic. The runtime of the plant is assumed to be 7,920 (8,460) hours per year and 300 hours is estimated for maintenance which the flare will be operating. The exact quantity will be metered during the project activity. An open flare will be used and though no continuous monitoring is possible. Hence, the default flare efficiency of an open flare as prescribed by the "Tool to determine project emissions from flaring gases containing methane" of 50% is applied. The calculation steps for project emissions are as follows.
The tool involves the following seven steps:
STEP 1: Determination of the mass flow rate of the residual gas that is flared
STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas
STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis
STEP 4: Determination of methane mass flow rate of the exhaust gas on a dry basis
STEP 5: Determination of methane mass flow rate of the residual gas on a dry basis
STEP 6: Determination of the hourly flare efficiency
STEP 7: Calculation of annual project emissions from flaring based on measured hourly values or based on default flare efficiencies.

Step 1. Determination of the mass flow rate of the residual gas that is flared
This step calculates the residual gas mass flow rate in each hour (h), based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$$\mathbf{FM_{RG,h} = \rho_{RGn,h} \times FV_{RG,h}} \qquad \textbf{(Flare: 1)}$$

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/Nm³)
$FV_{RG,h}$	Volumetric flow rate of the residual gas on dry basis at normal conditions in the hour h (Nm³/h)

As stated in the "Tool to determine project emissions from flaring gases containing Methane", a simplified approach is taken, in which only the volumetric fraction of methane is measured and the difference to 100% is considered as nitrogen (N_2).

Step 2. Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas
As the simplified approach is chosen, only the mass fraction of the elements C, H and N will be calculated.

$$\mathbf{fm_{j,h} = \frac{\sum_i f_{i,hh} \times AMj \times NAj,i}{MM_{RG,h}}}$$

(Flare: 4)

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 CH4, CO, CO2, O2,H2, N2

Steps 3 and 4 are excluded as they do not apply to cases where a default value for the flare efficiency is used.

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 ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane ($CH_{4,n,h}$) in the same reference conditions.

$$\mathbf{TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times p_{CH4,n}}$$ **(Flare: 13)**

Where:

$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (Nm^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 conditions (kg/m)

Step 6: Determination of the hourly flare efficiency

In case of open flares and use of the default value for the flare efficiency, the flare efficiency in the hour h ($\eta_{flare,h}$) is 50%, if the flare is detected for more than 20 minutes during the hour h.

If there is no record of the temperature of the exhaust gas of the flare or if the recorded temperature is less than 500 °C for any particular hour, it shall be assumed that during that hour the flare efficiency is zero.

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:

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

(Flare: 15)

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

(v) Project emissions from electricity consumption in the project

No fossil fuels are combusted under the project.

Because the project activity will consume electricity, the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (version 1) is applied to calculate project emissions from electricity consumption ($PE_{EC,y}$).

Scenario A (electricity consumption from the grid) from the tool applies and emissions are calculated as follows:

$$PE_{EC,y} = \sum_{j} EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y})$$

(Electricity: 1)

Where:

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

Since grid electricity will be used, $EF_{EL,j,y} = EF_{grid,CM,y}$. Refer to Annex 3 for calculation of the combined margin grid emission factor for Thailand.

Total Emissions Reductions

$$ER_y = BE_y - PE_y \quad (32)$$

Where:

ER_y Emissions reductions of the project activity in year y (t CO_{2e} / year)
BE_y Baseline emissions in year y (tCO_{2e} / year)
PE_y Project emissions in year y (tCO_{2e} / year)

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

Data / Parameter:	- $COD_{in,x}$ - $COD_{out,x}$
Data unit:	Ton COD / unit of time (year, month)
Description:	- COD directed to the open lagoons (scenario 1) or in sludge pits (scenario 2) in the period x - COD of the effluent in the period x
Source of data used:	Monitored data during year 2008
Value applied:	See details in Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	The measurement is undertaken during a period that is representative for the typical operation conditions of the plant and ambient conditions of the site. The average and COD_{in} and COD_{out} values from the measurement campaign is used in equation (4) and the result is multiplied by 0.89 to account for the uncertainty range (of 30% to 50%) associated with this approach as compared to one-year historical data. Details of measurement method is shown in Annex 3
Any comment:	-

Data / Parameter:	Bo
Data unit:	tCH4 / tCOD
Description:	Maximum methane producing capacity, expressing the maximum amount of CH4 that can be produced from a given quantity of chemical oxygen demand (COD)
Source of data used:	2006 IPCC Guidelines
Value applied:	0.21
Justification of the choice of data or description of measurement methods	No measurement procedures. The default IPCC value for Bo is 0.25 kg CH4 / kg COD. If the methodology is used for wastewater containing materials not akin to simple sugars, a CH4 emissions factor different from 0.21 tCH4 / tCOD has to be estimated and applied.

and procedures actually applied :	
Any comment:	Taking into account the uncertainty of this estimate, a value of 0.21 kg CH4 / kg COD is applied as a conservative assumption for Bo.

Data / Parameter:	fd
Data unit:	-
Description:	Factor expressing the influence of the depth of the lagoon on methane generation
Source of data used:	Apply the following values for the corresponding average depth of the open lagoon: Depth > 5 m: 70% Depth 1 – 5 m: 50% Depth < 1 m: 0%
Value applied:	Depth 1-5 m: 50%
Justification of the choice of data or description of measurement methods and procedures actually applied :	To define depth of lagoon, the measurements were conducted under normal operating conditions and the average depths were determined for the whole lagoons. Since the project lagoons have 5 meters in depth, so the value 0.5 is applied.
Any comment:	Applicable to the methane conversion factor method.

Data / Parameter:	- $EF_{grid,y}$ - $EF_{BL,y, EL,y}$
Data unit:	tCO2 / MWh
Description:	- Grid emission factor in year *y* - Baseline emission factor for electricity generated and / or consumed in the absence of the project activity in year *y* (tCO2 / MWh)
Source of data used:	Electricity Generation Authority of Thailand (EGAT), own calculations based on the Tool to calculate the emission factor for an electricity system (simple operating margin)
Value applied:	0.548
Justification of the choice of data or description of measurement methods and procedures actually applied :	Since the baseline scenario for displacement of electricity generated with biogas from anaerobic digester is E2 then, the grid emission factor is used ($EF_{BL,EL,y}$ = $EF_{grid,y}$) in calculation.
Any comment:	-

Data / Parameter:	$\eta_{flare,h}$
Data unit:	%
Description:	Efficiency of flare
Source of data used:	Tool to determine project emissions from flaring gases containing methane
Value applied:	50
Justification of the choice of data or	Default value of 50% for open flares used according to the “Tool to determine project emissions from flaring gases containing methane”

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

Data / Parameter:	$FL_{biogas,y}$
Data unit:	m³ biogas leaked / m³ biogas produced
Description:	Fraction of biogas that leaks from the digester
Source of data used:	Use a default value of 0.05
Value applied:	0.05
Justification of the choice of data or description of measurement methods and procedures actually applied :	The project cannot prove the amount of biogas leakage from the digester, but can control the leakages in the piping system after digester. Thus the default valve of 0.05 are applied to the project.
Any comment:	Applicable since a new digester is installed under the project activity

Data / Parameter:	**A**
Data unit:	Unit of area (sq.m.)
Description:	Surface of the lagoon
Source of data used:	Base on wastewater plant layout
Value applied:	121,464 m^2
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Data / Parameter:	GWP_{CH4}
Data unit:	tCO_2e / tCH_4
Description:	Global warming potential for CH_4
Source of data used:	IPCC
Value applied:	Default to be applied: 21 for the first commitment period.
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Data / Parameter:	**TDL**
Data unit:	%
Description:	Average technical transmission and distribution losses for providing electricity

	to source
Source of data to be used:	Use recent, accurate and reliable data available within the host country
Value of data applied for the purpose of calculating expected emission reductions in section B.5	8%
Description of measurement methods and procedures to be applied:	-
Any comment:	-

B.6.3. Ex-ante calculation of emission reductions:

Emission reductions are calculated as the difference between baseline emissions and project emissions in line with the provisions in ACM0014. In order to determine baseline emissions, the following data, variables, and parameters will be used for ex-ante calculations:

Calculation of baseline emissions

The baseline methodology as elaborated in ACM0014 is applied to the underlying project activity without changes. Baseline emissions are the CH_4 emissions from open lagoon wastewater treatment systems, and the CO_2 emissions associated with electricity generation that is displaced due to the project activity (The electricity generation of the first year is 3 MW and since the second year 4 MW until the end of crediting period). Since the project activity does not include the heat consumption, no emission reductions are generated by such.

1. Lagoon baseline emissions have been calculated as 81,572 tCO_2e/yr Details are provided in Annex 3.
2. Electricity generation has been calculated as emission of 13,020 tCO_2e/yr and 17,360 tCO_2e/yr for the first year and the year 2-10 accordingly. Details are provided in Annex 3.
3. Total baseline emissions, baseline emissions amount to 94,592 tCO2e/yr and 98,932 tCO2e/yr for the first year and the year 2-10 accordingly.

Calculation of project emissions

In accordance with ACM0014, project emissions consist of methane emissions from the lagoons, physical leakage from the digester system, emissions related with the consumption of electricity in the digester auxiliary equipment and stack emissions from the flare.

1. Methane emissions from post-treatment lagoons have been calculated as 5,727 tCO_{2-eq}/yr. Details are provided in Annex 3.
2. Methane emissions from the digester system
Applying the default value of ACM0014 (5%) leakage, the annual leakage is calculated as 6,368 tCO2eq/yr. Details are provided in Annex 3.
3. Stack emissions from the flare have been calculated as 2,409 tCO2-eq/yr. Details provided in Annex 3.
4. Emissions from land application of sludge are not applicable.
5. Emissions from the consumption of electricity have been calculated as 1,406 tCO2-eq/yr. The operation of the total digester system will lead to an additional electricity consumption of approx. 2,376 MWh/yr. Given limited data availability, the Thai grid emissions factor has been calculated as a Simple OM (operating margin) according to the "Tool to calculate the emission factor for an electricity system ". The analysis determines the Thai grid emissions factor as 0.548 kg CO2/kWh. Underlying data and details of calculation can be found in Annex 3.
6. Emissions from heat consumption are not applicable.
7. Total project emissions
In total, project emissions amount to 15,910 tCO2-eq/year.

Calculation of leakage

According to ACM0014, leakage is not applicable.

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

Emission reductions are calculated as the difference between baseline emissions and project emissions in line with ACM0014.

Year	Emission Reduction t CO2e	Baseline emissions t CO2e	Project emissions t CO2e	Leakage emissions t CO2e
0	78,682	94,592	15,910	0
1	83,022	98,932	15,910	0
2	83,022	98,932	15,910	0
3	83,022	98,932	15,910	0
4	83,022	98,932	15,910	0
5	83,022	98,932	15,910	0
6	83,022	98,932	15,910	0
7	83,022	98,932	15,910	0
8	83,022	98,932	15,910	0
9	83,022	98,932	15,910	0
total (tCO2e)	**830,220**	**989,320**	**159,100**	**0**

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

B.7.1. Data and parameters monitored:

Data/Parameter:	$F_{PJ,dig,m}$ (1,2,3: See diagram)
Data unit:	m^3/month
Description:	Quantity of wastewater that is treated in the anaerobic digester in project activity in month
Source of data to be used:	Measurement (Continuously)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Wastewater 35,850 m^3/month
Description of measurement methods and procedures to be applied:	Flow rates will be continuously recorded with flow meter or similar, installed at least 5 diameters of discharge pipe up-and downstream away from any flow disturbance (e.g. sample points, valve, etc.). An isolating valve will be installed upstream of maintenance purpose. Accuracy <± 1% of actual flow at the lowest typical flow. Hourly value will be transferred online and recorded on computer.
QA/QC procedure to be application	Regular Calibration: The flow meter will be calibrated by manufacturer or approved company at the time of installation. A frequency of subsequent calibration according to recommendations of the manufacturer of the equipment will be appropriate to the application. Each time the meter is calibrated, an On-site – Calibration-report will be submitted to KIB. Inspection and Maintenance: Meters will be installed such to enable easy inspection. Installation will also facilitate separation valves for meter removal and repair and recalibration. A spare meter will be held on stock, to avoid long time loss of data record. O&M staff of the digester will be trained to maintain the meters in accordance with the manufacturer's requirements. Meters will be inspected on daily frequence by the staff. Laboratory and QA/QC staff will train O&M staff for data reading in parallel to online data transfer. Data storage: Online transfer to computer. Weekly data backup on CD of CDM specific data will be carried out by data management staff. Data will be stored for 10 years of CDM project duration and 2 years afterwards. Data backup procedure valid for the overall monitoring. Aggregation to 24 hrs average, weekly, monthly and quarterly rates by automated calculation routines. Monthly aggregated reports will be printed – two copies will be filed at factory and headquarters respectively.
Any comment:	-
Data/Parameter:	$W_{COD,dig,m}$(1,2: See diagram)
Data unit:	$tCOD/m^3$

Description:	Average chemical oxygen demand in the wastewater that is treated in the anaerobic digester in the project activity in month m
Source of data to be used:	Laboratory tests (at least monthly)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.12 $tCOD/m^3$
Description of measurement methods and procedures to be applied:	Wastewater of the influent of settling pond and the influent of each biodigester will be sampled and analyzed for COD (as shown in monitoring plan) according to standard method. **Laboratory tests contracted by KIB;** Method US EPA 410.4. "Potassium Dichromate Digestion" – analysis. Accuracy according US EPA Standard Range Method
QA/QC procedure to be application	Sampling will be carried out adhering to internationally recognized procedures, which could be manual sample and laboratory analysis or automatic continuous measurement. Calibration regularly by manufacturer or approved company as per recommendation of manufacturer Data capture/storage: Data capture at the laboratory/IT-center resp. online transfer, if continuous monitoring system will be used. Regular data backup on CD of CDM specific data will be carried out by data management staff. Data will be stored for 10 years of CDM project duration and 2 years afterwards. Data backup procedure valid for the overall monitoring.
Any comment:	-

Data/Parameter:	$T_{2,m}$
Data unit:	K
Description:	Average temperature at the project site in month *m*
Source of data to be used:	Meteorological Department of Nakhon Ratchasima Province
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Average Temperatures for KI Biogas Co.,Ltd. is obtained from 30-year temperature statistics (1971-2000) of Nakhon Ratchasima Province from Meteorological Department

Month	Temp.(ºC)
Jan	23.9
Feb	26.5
Mar	28.7
Apr	29.7
May	28.9
Jun	28.8
Jul	28.3
Aug	27.9
Sep	27.2
Oct	26.4
Nov	24.9

	Dec 23.1
Description of measurement methods and procedures to be applied:	Measurement continuously by weather service, aggregated in monthly average values
QA/QC procedure to be application	Double check of using the correct value a).internally, and b).through verification process (DOE)
Any comment:	-

Data/Parameter:	$F_{PJ. eff, dig, m}$(4,5: See diagram)
Data unit:	m^3/month
Description:	Quantity of effluent from the digester in month *m*
Source of data to be used:	Measurement (Continuously)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	35,850 m^3/month
Description of measurement methods and procedures to be applied:	See description at $F_{PJ, dig, m}$
QA/QC procedure to be application	See description at $F_{PJ, dig, m}$
Any comment:	

Data/Parameter:	$W_{COD, eff, dig, m}$ (3,4,5: See diagram)
Data unit:	$tCOD/m^3$
Description:	Average chemical oxygen demand in the effluent from the digester in month m
Source of data to be used:	Laboratory tests (at least monthly)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	65% degradation is assumed according to the technical specification of the digester (details in Annex 3). Therefore; 0.042 $tCOD/m^3$ is used in calculation.
Description of measurement methods and procedures to be applied:	The effluent discharged from both digesters into aerobic treatment and the combined wastewater from those digesters will be sampled and analyzed for COD according to standard method. See description at $W_{COD, dig, m}$
QA/QC procedure to be application	See description at $W_{COD, dig, m}$
Any comment:	-

Data/Parameter:	$F_{PJ. eff, lag, m}$ (8,9: See diagram)

Data unit:	m^3/month
Description:	Quantity of effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month *m*
Source of data to be used:	Measurement (Continuously)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	5,241 m^3/month See details in Annex 3
Description of measurement methods and procedures to be applied:	See description at $F_{PJ, dig, m}$
QA/QC procedure to be application	See description at $F_{PJ, dig, m}$
Any comment:	-

Data/Parameter:	$W_{COD, eff, lag, m}$(6: See diagram)
Data unit:	tCOD/m^3
Description:	Average chemical oxygen demand in the open lagoon or dewatering facility in which the effluent from the digester is treated in month *m*
Source of data to be used:	Laboratory tests (at least monthly)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.040
Description of measurement methods and procedures to be applied:	See description at $W_{COD, dig, m}$
QA/QC procedure to be application	See description at $W_{COD, dig, m}$
Any comment:	Assume 5% of COD could be reduced after the digester.

Data/Parameter:	$F_{biogas,y}$ (13: See diagram)
Data unit:	m^3/yr
Description:	Amount of biogas collected in the outlet of the new digester in year y
Source of data to be used:	Measurement (Continuously)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	15,379,650 m^3/yr (based on the technical specification of digester)
Description of measurement methods and procedures to be applied:	Since produced gas contains H_2S that can cause a technical problem on device corrosion thus, a flow meter will be installed to measure amount of biogas after the produced gas is already treated by H_2S scrubber. Mass Flow Meter with appropriate range of measurement. Measure points at each H_2S scrubber line outlet. Accuracy <± 1 %. Hourly values will be transferred online and recorded.
QA/QC procedure to be application	Regular Calibration of flow meter by manufacturer or approved company (frequency of calibration as recommended by manufacturer) – calibration report to KIB. QC staff of KIB will be trained on calibration control and on malfunction recognition. QC of meter function: Data of the meter will be sent to a computer. A spare flow meter will be held on stock for immediate change if needed at any place of gas pipes. Separation valves and bypasses will allow deviation of gas flow through second line during exchange of meter. Range of meter will allow to measure full flow. Data capture/storage: Data capture at IT-center of KIB through online transfer, if continuous monitoring system will be used. Weekly data backup on CD of CDM specific data will be carried out by data management staff. Data will be stored for 10 years of CDM project duration and 2 years afterwards. Data backup procedure valid for the overall monitoring. Monthly aggregated reports will be printed – two copies will be filed at factory and headquarters office.
Any comment:	-

Data/Parameter:	$W_{CH4, Biogas, y}$ (9,10: See diagram)
Data unit:	Kg CH_4/ m^3 biogas
Description:	Concentration of methane in the biogas in the outlet of the new digester
Source of data to be used:	Measurement(at least quarterly)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.39 kg CH_4/ m^3
Description of measurement methods and procedures to be applied:	CH_4 content will be determined through electronic probe and analysis, e.g. Non-Dispersion Infrared method (NDIR). Application of portable analyzer could be possible
QA/QC procedure to be application	Control measurements for use of portable analyzer required. Accuracy of equipment < ± 1 % at full scale. Accuracy of Method (portable analyzer): < ± 2 % due to relatively stable production process and low variation of CH_4 production. Calibration: Regular calibration by manufacturer or approved company (frequency of calibration as recommended by manufacturer) – calibration report to KIB. Data capture/storage: Data capture at IT-center of KIB through online transfer, if continuous monitoring system will be used. Weekly data backup on CD of CDM specific data will be carried out by data management staff. Data will be stored for 10 years of CDM project duration and 2 years afterwards. Data backup procedure valid for the overall monitoring. Monthly aggregated reports will be printed – two copies will be filed at factory and headquarters respectively.
Any comment:	-

Data/Parameter:	$FV_{RG,h}$ (12: See diagram)
Data unit:	m^3/h
Description:	Volumetric Flow Rate of the residual gas to flare in dry basis at normal conditions in the hour *h*
Source of data to be used:	Measurement (Continuously)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1,941.88 (1,756 = 15,379,650/(365*24)) m^3/hr (based on the technical specification of digester) the flare operate 300 hours/year = 582,564 (526,700) m^3/yr
Description of measurement methods and procedures to be applied:	Application of Flow Meter or similar hourly values will be transferred online and recorded. Values to be averaged hourly by using a flow meter. The same basis (dry or wet) is considered for this measurement and the measurement of the volumetric fraction of methane component in the residual gas ($fv_{i,h}$) when the residual gas temperature exceeds 60ºC.
QA/QC procedure to be application	Regular Calibration of flow meter by manufacturer or approved company (frequency of calibration as recommended by manufacturer) – calibration report to KIB. QC staff of KIB will be trained on calibration control and on malfunction recognition. QC of meter function: One flow meter at inlet will be installed, a bypass with separation valves will be prepared to enable exchange of flow meter without data losses. Daily flow meter function inspection. Data capture/storage: Data capture at IT-center of KIB through online transfer, if continuous monitoring system will be used. Regular data backup on CD of CDM specific data will be carried out by data management staff. Data will be stored for 10 years of CDM project duration and 2 years afterwards. Data backup procedure valid for the overall monitoring. Monthly aggregated reports will be printed – two copies will be filed at factory and headquarters respectively
Any comment:	-

Data/Parameter:	$fv_{i,h}$ (7: See diagram)
Data unit:	-
Description:	Volumetric fraction of component *i* in the residual gas in the hour h where *i*=CH4, CO, CO_2, O_2, H_2,N_2 of the residual gas in dry basis at normal conditions in the hour *h*
Source of data to be used:	Measurement (Continuously)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	55% (based on the technical specification of digester which mention that expected CH_4 in biogas is 50-55%)
Description of	Continuously. Values to be averaged hourly or at a shorter time

measurement methods and procedures to be applied:	interval by using continuous gas analyzer. The same basis (dry or wet) is considered for this measurement and the measurement of the volumetric flow rate of the residual gas ($FV_{RG,h}$) when the residual gas temperature exceeds 60ºC
QA/QC procedure to be application	QC of gas analyzer: Analyzer will be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard certified gas. Data recording and storage: Online transfer to computer. Weekly data backup on CD of CDM specific data will be carried out by data management staff. Data will storage for 10 year of CDM project duration and 2 year afterwards. Data backup procedure valid for overall monitoring. Data preparation and reporting: Aggregation to 24 hours average, weekly, monthly and quarterly rate by routines. Monthly aggregated reports will be print – two copies will be field at factory and headquarters respectively.
Any comment:	As a simplified approach, project participants may only measure the methane content of the residual gas and consider the remaining part as N_2

Data/Parameter:	T_{flare} (Flame detector: See diagram)
Data unit:	ºC
Description:	Temperature in the exhaust gas of the flare
Source of data to be used:	Measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.5	N/A
Description of measurement methods and procedures to be applied:	Continuously measurement temperature of exhaust gas stream in the flare by (type N thermocouple). A temperature above 500 ºC indicated that a significant amount of gases are still being burnt and that the flare is operating.
QA/QC procedure to be application	Regulation of calibration: yearly calibration by official organization or authorized company. No further step is applicable due to external quality control (electricity provider). Data recording and storage: Online transfer to computer. Weekly data backup on CD of CDM specific data will be carried out by data management staff. Data will storage for 10 year of CDM project duration and 2 year afterwards. Data backup procedure valid for overall monitoring. Data preparation and reporting: Aggregation to 24 hours average, weekly, monthly and quarterly rate by routines. Monthly aggregated reports will be print – two copies will be field at factory and headquarters respectively.
Any comment:	An excessively high temperature at the sampling point (above 700ºC) is an indication that the flare is not being adequately

	operated or that its capacity is not adequate to the actual flow.

Data/Parameter:	$FV_{gen,,h}$ (13, 14, 15,16,F: See diagram)
Data unit:	m^3/yr
Description:	Flow rate of biogas entering the Gas Engines
Source of data to be used:	Measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.5	N/A
Description of measurement methods and procedures to be applied:	Application of Mass Flow Meter at inlet of generator equipment. Accuracy <± 1 %. Hourly values will be transferred online and recorded
QA/QC procedure to be application	Regular Calibration of flow meter by manufacturer or approved company (frequency of calibration as recommended by manufacturer) – calibration report to KIB. QC staff of KIB will be trained on calibration control and on malfunction recognition. QC of meter function: One flow meter at inlet will be installed, a bypass with separation valves will be prepared to enable exchange of flow meter without data losses. Daily flow meter function inspection. Data capture/storage: Data capture at IT-centre of KIB through online transfer, if continuous monitoring system will be used. Regular data backup on CD of CDM specific data will be carried out by data management staff. Data will be stored for 10 years of CDM project duration and 2 years afterwards. Data backup procedure valid for the overall monitoring. Monthly aggregated reports will be printed – two copies will be filed at factory and headquarters respectively.
Any comment:	-

Data/Parameter:	$EC_{PJ, y}$ (22,23: See diagram)
Data unit:	MWh / yr
Description:	Amount of electricity in the year that is consumed at the project site for the project activity.
Source of data to be used:	Measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.5	2,376 MWh/year
Description of measurement methods and procedures to be applied:	Standard electricity meter (separate meter for waste water plant): continuously measurement. A separate and officially calibrated electric meter will be connected to the main electricity supply of the overall biogas plant.

	Data recording and storage: Online transfer to computer. Weekly data backup on CD of CDM specific data will be carried out by data management staff. Data will storage for 10 year of CDM project duration and 2 year afterwards. Data backup procedure valid for overall monitoring. Data preparation and reporting: Aggregation to 24 hours average, weekly, monthly and quarterly rate by routines. Monthly aggregated reports will be print – two copies will be field at factory and headquarters respectively.
QA/QC procedure to be application	Regulation of calibration: yearly calibration by official organization or authorized company. No further step is applicable due to external quality control (electricity provider).
Any comment:	-

Data/Parameter:	$EG_{PJ,y}$ (20: See diagram)
Data unit:	MWh / yr
Description:	Net Quantity of electricity generated in year *y* with biogas from the new anaerobic digester.
Source of data to be used:	Measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.5	During 1st year : Project aims to produces electricity about 3 MWh or 3 * 24 * 330 (365) = 23,760 (26,280)MWh/yr After 1st year : Project aims to produces electricity about 4 MWh or 4 * 24 * 330 (365)= 31, 680 (35,040)MWh/yr
Description of measurement methods and procedures to be applied:	Standard electricity meter (separate meter for waste water plant): continuously measurement A separate and officially calibrated electric meter will be connected to the main electricity supply of the overall biogas plant. Data recording and storage: Online transfer to computer. Weekly data backup on CD of CDM specific data will be carried out by data management staff. Data will storage for 10 year of CDM project duration and 2 year afterwards. Data backup procedure valid for overall monitoring. Data preparation and reporting: Aggregation to 24 hours average, weekly, monthly and quarterly rate by routines. Monthly aggregated reports will be print – two copies will be field at factory and headquarters respectively.
QA/QC procedure to be application	Regulation of calibration: yearly calibration by official organization or authorized company. No further step is applicable due to external quality control (electricity provider).
Any comment:	-

All data will be kept for at least two years following the end of the crediting period or the last issuance of CERs (whatever is the later). For all monitoring supervision, maintenance, data storage, data handling and plausibility check measures will be elaborated by KI Biogas Co., Ltd. for their monitoring and management staff.

Reconstruction/calculation of data in case of instrument failure

Missing monitoring data derived from instrument failure and during replacement of broken instruments will be reconstructed from former and subsequent series of measurement. Within the first month of monitoring, missing data will not be reconstructed and losses accepted accordingly.

After one month of monitoring and one month data record respectively, missing data will be reconstructed from the average of the lowest measured values of the previous and the following month, if the monitoring interruption is longer than one week (5 working days).

This method is appropriate and conservative, since the flow rates of waste water and biogas as well as the COD content in the waste water and CH_4 content in the biogas is not subject to huge variations in such production processes. To avoid suspicion referring bridging of complete production interruptions, corresponding data from parallel instruments and proved production data from the same period of the instrument failure will be recorded and documented in order to prove the continuity of the production process. Reconstructed values will be marked in the record and monitoring reports accordingly.

Data Storage

The gathered monitoring data will be digitally stored in a SCADA system. At regular intervals, data will be printed out and archived.

B.7.2. Description of the monitoring plan:

The monitoring methodology ACM0014 will be applied. Figure 3 summarizes the major monitoring points and data ID-numbers. Details for each ID-number as well as information on quality control (QC) and quality assurance (QA) procedures are provided.

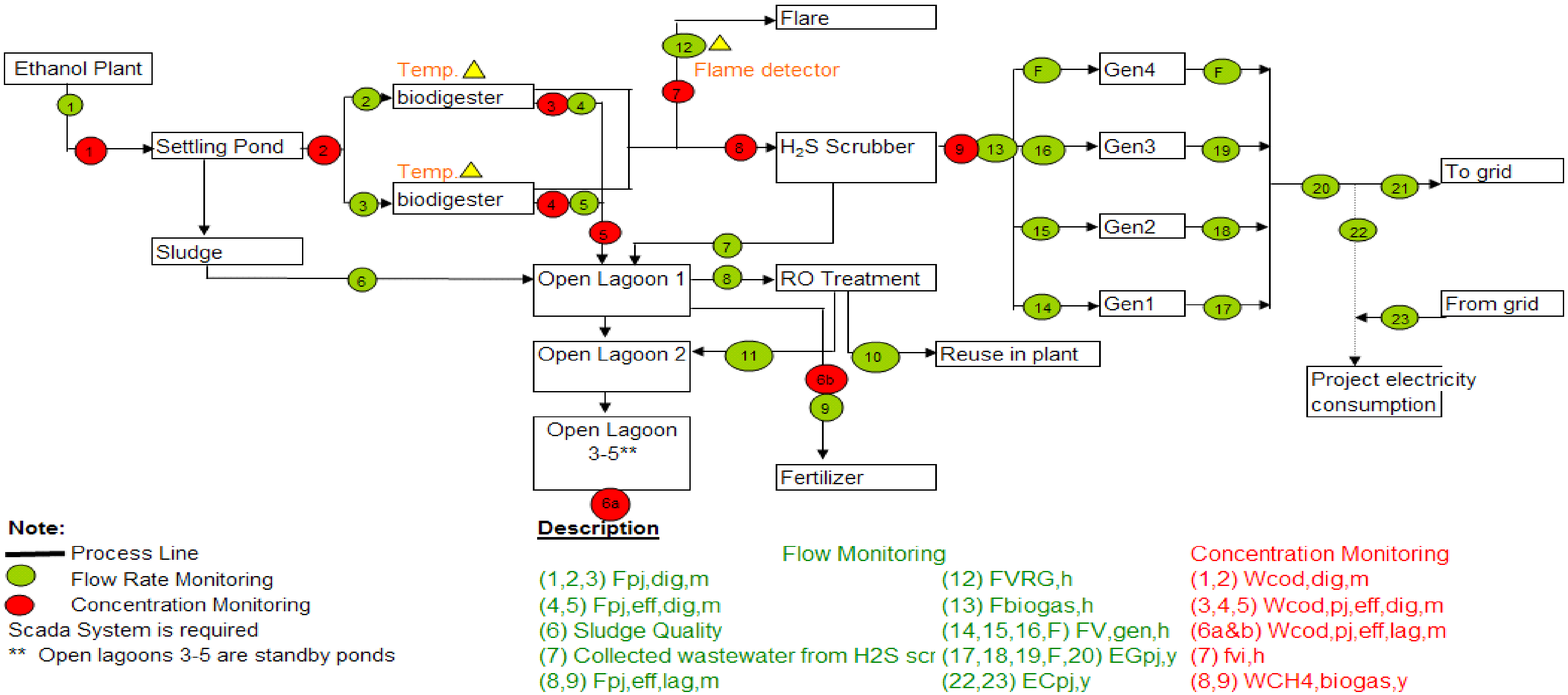

Figure 3: Monitoring plan – overview of measurement points

Organizational and management structures

All monitored data will be safely kept in an electronic data base and submitted to the DOE for verification purposes. The key manager of the waste water plant will be the responsible person for monitoring all of the above mentioned parameters and for recording all data appropriately.

KI Biogas Co. Ltd. QA/QC staff will be in charge and responsible for the accuracy of the data collection and processing. Data will be recorded as part of the daily responsibilities of QA/QC staff and based on requirements of the ISO 9001:2000 scheme. The ISO 9001:2000 schemes defines organizational and management structures in detail, as well as responsibilities of staff and procedures in cases of technical irregularities in details. The scheme will be updated to incorporate the new biogas system before operation of the plant. The management structure as well as implementation and operation management of the efficient monitoring system will be as follows:

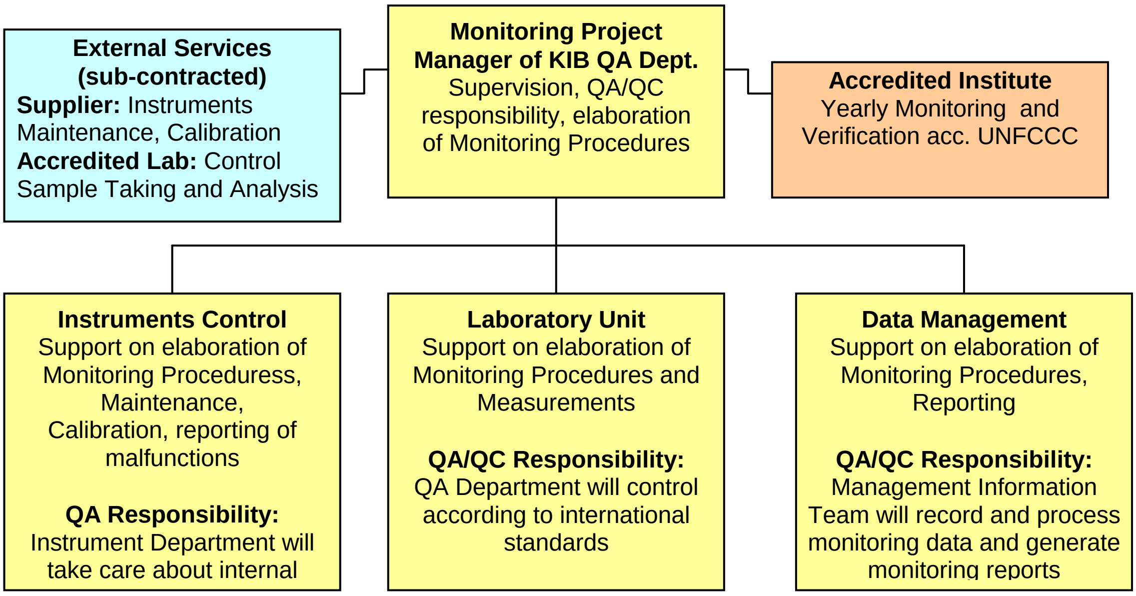

Figure 4: Management Structure of Monitoring System

Monitoring implementation and operation management and procedure

In order to implement, operate, maintain and control the monitoring system appropriately, the following operation procedure will be implemented:

Responsibility of Installation and Operation	Monitoring Implementation and Operation	Training	Responsibly of Training
Supplier	Installation of monitoring equipment	- Instruction on equipment (equipment, maintenance, emergency/failure response) - Determination of responsibilities	Supplier/KIB KIB
Supplier/KIB	Design and implementation of data system, e.g. transfer, storage, processing, reporting and backup	- Instruction on data handling system - Determination of responsibilities	Supplier KIB
KIB	Implementation of control measurement procedures	- Instruction on data sample taking, handling and analysis - Determination of responsibilities	Official laboratory/ Institute KIB
KIB	Elaboration of Monitoring Procedures for sample taking, analysis, instrument control, maintenance, emergency/failure response, data processing, report generation		
Supplier/KIB	Start up operation	Instruction on monitoring reporting	KIB

Operation

Sample taking and laboratory analysis		- Quarterly internal review and operation adjustment and improvement - Review and task Report
Daily/monthly reporting	Daily supervision of instrument function	
Filing & registration backup	Data storage & registration	

Figure 5: Monitoring Operation Procedure

Training

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

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

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

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

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

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

Monitoring of sustainable development benefits

Please see Annex 4 to this document.

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):

The baseline and the monitoring methodology have been prepared by Envima Co. Ltd., Thailand

Company name:	ENVIMA (Thailand) Co., Ltd.
Adress:	1023 TPS Building, 4th Floor Pattanakarn Road, Suan Luang Bangkok 10250, Thailand
Contact person:	Mr. Magnus A. Staudte
Telephone number:	+66 2 717 8114
Fax number:	+66 2 717 8115
Email:	staudtem@envima.de

Completion date of baseline: 19/02/2009

Envima is not project participants in the sense of Annex 1.

SECTION C. Duration of the project activity / crediting period

C.1. Duration of the project activity:

C.1.1. Starting date of the project activity:

February 1, 2009 (planned start of construction)

February 2010 (planned start commissioning)

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

Technical lifetime: 15 years, 0 months

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

10 years crediting period

C.2.1. Renewable crediting period:

A renewable crediting period does not apply.

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

C.2.1.2. Length of the first crediting period:

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

01/04/2010, or upon registration as a CDM project activity at the UNFCCC (whichever is the earlier)

C.2.2.2. Length:

10 years, 0 months.

SECTION D. Environmental impacts

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

According to the regulations of the Kingdom of Thailand, a comprehensive environmental impact assessment (EIA) is not required for the underlying project activity[15]. However, KI ethanol which generates wastewater for KI biogas, has to submit the Environmental Evaluation Assessment (EEA) Report to Department of Industrial Work to get license for factory registration according to the Notification of Department of Industrial Work on the Principle of Factory Registration for Ethanol Production to be used as fuel dated on 24 December B.E 2547. The EEA report includes all the environmental issues such as physical resources, biological resources, human value uses and quality of human life. The impacts, including mitigation & protection measures and monitoring measures are considered appropriately in the report including consideration of wastewater treatment.

Based on a comprehensive environmental impact assessment (EIA) screen the summarizewd results below are indicating that an EIA is not required for the underlying project activity.

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

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

However, an Initial Environmental Evaluation (IEE) has been conducted, following the requirement of Thai DNA and the standards and requirements on sustainable development and environmental impact screening from the Gold Standard Scheme.

Environmental Effect- As mentioned in the project activity description on the project benefits in several levels include:

1. Green House Gas and odor emission reduction

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

2. Reduce electricity generation; the planned project will contribute to energy conservation during the entire life span of the system. By utilizing more than 15 Million m^3/yr of methane to generate electricity and feed to local grid.
3. Reduce water consumption in the production process by reuse the wastewater.
4. Increase employment opportunity.
5. Encourage sustainable development of project area and nearby.

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:

This project will create no significant negative environmental impacts. There will be no water discharge from any of project activities.

SECTION E. Stakeholders' comments

The stakeholder consultation has been taken place twice. First is Initial stakeholder consultation to inform about project activity and the second is Stakeholder feedback round to let people have opportunity to comment or clarify about project activity after approximate 2 month according to Gold Standard criteria of project document publication. The invitation of the stakeholder and documents publication was done by invitation letters and public announcement in both national (Thai and English version) and local newspapers. All processes, questions and comments were responded as describe in the following session.

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

The stakeholder and public consultations have been carried out in three steps: the initial stakeholder consultations, the publications of a non-technical PDD, IEE and draft-PDD, and a final stakeholder meeting. Although there is formally no legal requirement for public participation under Thai law, it is common practice of the governmental agencies responsible for licensing factories or large projects to call for such. With the initial stakeholder consultation, these requirements are met. The additional steps of local stakeholder consultation have been conducted to meet the requirements of the Gold Standard.
A more detailed description of the individual steps is provided below.

Step 1: Initial stakeholder consultations

- The initial local stakeholder consultation was conducted in **January 28, 2009** at the meeting room of Korach Industry Co., Ltd., the same Factory area where the Ethanol Plant is built. Invitation has been made by (a) direct invitation of selected groups of stakeholders, considering public sector, NGOs and population as well as representatives of different groups of the population (e.g. teacher, monks, representatives of health centers) and (b) through public announcement through newspaper, mail and poster at public areas in order to keep the stakeholder consultation open for everybody
- The consultations covered the information of and consultation with people living within 2 kilometers radius from the production site.
- Involved stakeholders include different groups of people. A total of 81 people - governmental officers, Thai DNA officers, school teachers, monks, officers of the Tambon Authority Office (TAO), community's leaders, factory's workers, general villagers, farmers – were included.
- Stakeholders have been briefed on the project purpose, CDM, and biogas technology by KI Co., Ltd., Envima (Thailand) Co., Ltd., and Praj Co., Ltd. and interviewed concerning their perception of the impacts of the waste water treatment plant of the Ethanol factory on the environment, social

systems and general economics. Their opinions on future impacts through the planned project activity and operation of the plant have been gathered and evaluated.

- Question and comments session

1. Can project solve bad odor from ethanol plant's wastewater?

Ans. Yes, 70-80% of the offensive smell will be reduced.

2. Regarding to the description, the project will generate electricity. Is there any effect to the location community?

Ans. The grid system will have more capacity to provide electricity with more stable current.

3. How the wastewater treatment system reduce odor?

Ans. Usually, the complete treatment system is not creating odor. With the larger tanks of the wastewater treatment system applied for KI Biogas, there will be a longer retention time. Means the wastewater will stay and degrade in the system longer. This results to the more complete of the wastewater treatment process. Therefore, odor problem will be reduced.
In India, Praj construct more than 20 ethanol factories which none of them cause odor problem. Together with the more stringent regulation of India than Thailand, the system is meeting all of the Thai pollution standard.

4. Although molasses is useful for farmer, there should be a system control for distributing and applying as fertilizer on land such as zoning of applied area to prevent contamination to nearby natural water.

Ans. Company has consultancy team to research on benefit and effect from applying the wastewater as fertilizer and educating farmer and local people about the fertilizer. All farmers who receive the fertilizer must be registered to the company for monitoring the result of applying in each land. KI has 20 consultancy centers for close cooperation with the farmers.

5. The company experienced the overflow of molasses from ponds during flooding last year. From that time, the company has prevention plan to avoid repeating of the situation. Sand bags have been placed around the ponds edge to prevent an overflow of the wastewater. Moreover, the company asked for near by community to monitor molasses or wastewater transportation as the company service farmer by deliver wastewater to their land but there were some corruption driver discharge the wastewater in other empty land which could lead to water contamination and odor problem. The project activity will help as well on this issue.
6. Are there any negative effects on soil quality by applying molasses on land?

Ans. Land in Pimai area has low nutrient, from the research experiences, applying 20-30 m^3 per rai could help enrich soil quality.

7. Are their any effects to human body from offensive smell from wastewater?

Ans. No harm to the body but sometime can cause dizzy feeling.

- **Summarized Outcome:** Many questions which are mainly about present wastewater utilization as fertilizer and odor problem have been raised up during the meeting. The participants have received clarifying answers. Also, cooperation between the project owner and local people fertilizer utilization management for a sustainable environment has been discussed. The participants agree with CDM project as this is going to improve the local and global environment on long-term.

Step 2: **Publication of non-technical PDD, IEE, draft PDD and stakeholder consultation report at office and factory of KI Biogas Co., Ltd. and at ENVIMA (Thailand) Co., Ltd. office.**

- Public accessible to all documents at KI Factory, KI Offices in Bangkok, and ENVIMA Office in Bangkok from January 28 for at least 2 months.
- Announcement of the project and information on the accessibility of all documents of the project before the first stakeholder consultation meeting through press publications on January 15, 2009 in one English newspaper and one local newspaper and January 28 - February 8, 2009 in one local newspaper as a reminder and including invitations for comments to the project and to the stakeholder consultation report.

Step 3: **The second Stakeholder Meeting (Feed back round) of KI Biogas**

- Summarized Outcome:

Xxxxxxx

E.2. Summary of the comments received:

>>

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

>> As pointed out above, no concerns of severe environmental impacts through the project have been expressed which would have technical or other mitigation measures as a consequence. There was a broad understanding of the applied technology and its improvements compared to the environmental impacts to be expected if fossil fuel would be used.

ANNEX 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	KI Biogas Co., Ltd.
Street/P.O.Box:	222/1 M.18, Nongravieng subdistrict, Pimai District
Building:	
City:	Nakhon Ratchasima
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Postcode/ZIP:	30110
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URL:	
Represented by:	
Title:	
Salutation:	Mr
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Middle name:	-
First name:	Mongkol
Department:	
Mobile:	
Direct FAX:	
Direct tel:	
Personal e-mail:	

ANNEX 2

INFORMATION REGARDING PUBLIC FUNDING

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

Notification of the Energy Policy and Planning Office

Affirmation of the Financial Assistance Provided under

the Project on Biogas Technology Promotion for Industrial Facilities

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

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

Announced on January 2009

(Viraphol Jirapraditkul)

Director-General Energy Policy and Planning Office

ANNEX 3
BASELINE INFORMATION

Calculation of baseline emissions

The baseline methodology as elaborated in ACM0014 has been applied to the underlying project activity without changes. The following Excel spread-sheets summarize the results of calculations for the relevant categories of baseline emission, project emissions and emission reductions. For verbal explanations please see section B.6.

1. Total Baseline Emissions

Year	Baseline emissions t CO_2e	$BE_{CH4,y}$ t CO_2e	$BE_{EL,y}$ t CO_2e	$BE_{HG,y}$ t CO_2e
0	94,592.00	81,571.52	13,020.48	0
1	98,932.16	81,571.52	17,360.64	0
2	98,932.16	81,571.52	17,360.64	0
3	98,932.16	81,571.52	17,360.64	0
4	98,932.16	81,571.52	17,360.64	0
5	98,932.16	81,571.52	17,360.64	0
6	98,932.16	81,571.52	17,360.64	0
7	98,932.16	81,571.52	17,360.64	0
8	98,932.16	81,571.52	17,360.64	0
9	98,932.16	81,571.52	17,360.64	0
Total (tCO_2e)	**984,981.49**	**815,715.25**	**169,266.24**	**0.00**

1.1) Baseline Emission from Open Lagoons ($BE_{CH4,y}$)

$BE_{CH4,y}$ t CO_2e	GWP_{CH4} t CO_2e / t CH_4	$MCF_{BL,y}$ fraction	B o t CH_4 / t COD	$COD_{BL,y}$ t COD / yr
81,571.52	21.00	0.44	0.21	41,568.01

$COD_{BL,y}$ t COD / yr	AD_{BL} fraction	$COD_{PJ,y}$ t COD / yr	COD in, campaign* t COD / yr	COD out,campaing* t COD / yr
41,568.01	0.81	51,624.00	22,316.00	4,347.00

Note: * 1 year-monitoring data see Table 3-A

***Table 3-A Amount and Concentration of Influent and Effluent of Existing Open Lagoons Year 2008**

Month	Amount Wastewater (m^3/year)		Concentration ($tCOD/m^3$)	
Year 2008	Influent (Pond 1)	Effluent (Pond 5,6)*	Influent (Pond 1)	Effluent (Pond 5,6)*
January	31,073.39	12,679.69	0.005	0.003
February	28,867.26	10,473.56	0.006	0.002
March	32,406.99	14,013.29	0.008	0.001
April	30,613.55	12,219.85	0.008	0.001
May	32,116.69	13,722.99	0.044	0.030
June	31,465.15	13,071.45	0.095	0.084
July	29,508.53	11,114.83	0.100	0.041
August	31,904.59	13,510.89	0.105	0.050

September	31,558.77	13,165.07	0.108	0.055
October	14,621.35	-3,772.36	0.101	0.050
November	30,071.06	11,677.36	0.097	0.051
December	22,228.75	3,835.05	0.096	0.046
Total	**346,436.07**	**125,711.67**	**0.064**	**0.035**

Source: KI Ethanol Co., Ltd., 2009

Note: * Pond no.6 is operated since July 2008 thus, data of Pond no.5 is used in calcualation for Jan-June 2008

$COD_{PJ,m}$ t COD / year	$F_{PJ,dig,m}$ m³ / year	$w_{COD,dig,m}$ t COD / m³	$MCF_{BL,y}$ fraction	f_d factor	$f_{T,y}$ factor	Consertivness factor
51,624	430,200	0.12	0.44	0.5	0.99996	0.89

$COD_{available,m}$ t COD / year	$COD_{BL,m}$ t COD / year	AD_{BL} fraction	$COD_{PJ,m}$ t COD / year	$F_{PJ,dig,m}$ m³ / year	$w_{COD,dig,m}$ t COD / m³	$f_{T,m}$
41,577	41,568	0.81	51,624	430,200	0.12	0.99947

Month	$f_{T,m}$ factor	$T_{2,m}$ K	E cal / mol	T1 K	R cal / K mol
1	0.999468984	296.9	15.175	303.16	1.987
2	0.999692195	299.5	15.175	303.16	1.987
3	0.999878098	301.7	15.175	303.16	1.987
4	0.999961718	302.7	15.175	303.16	1.987
5	0.999894866	301.9	15.175	303.16	1.987
6	0.999886485	301.8	15.175	303.16	1.987
7	0.999844497	301.3	15.175	303.16	1.987
8	0.999810807	300.9	15.175	303.16	1.987
9	0.999751638	300.2	15.175	303.16	1.987
10	0.99968368	299.4	15.175	303.16	1.987
11	0.999555289	297.9	15.175	303.16	1.987
12	0.999399525	296.1	15.175	303.16	1.987

1.2) Baseline Emission from Electricity Consumption ($BE_{EL,y}$)

Year	$BE_{EL,y}$ t CO2e / yr	$EC_{BE,y}$ MWh / yr	EG MWh/yr	$EF_{BL,y}$** tCO2 / MWh
0	13,020.48	0	23,760	0.548
1	17,360.64	0	31,680	0.548
2	17,360.64	0	31,680	0.548
3	17,360.64	0	31,680	0.548
4	17,360.64	0	31,680	0.548
5	17,360.64	0	31,680	0.548
6	17,360.64	0	31,680	0.548
7	17,360.64	0	31,680	0.548
8	17,360.64	0	31,680	0.548
9	17,360.64	0	31,680	0.548
10	17,360.64	0	31,680	0.548
Total (tCO2e)	**186,626.88**	**-**	**340,560**	**-**

Note: **To define $EF_{BL,y}$, see details of calculation of Thai grid emission factor

CALCULATION OF THAI GRID EMISSIONS FACTOR

The Thai grid emissions factor needs to be determined to calculate project-related CO_2-emissions (electricity consumption by digester parasitic).

Several institutions, EGAT (Electricity Generation Authority of Thailand), EPPA/O (Emissions Prediction and Policy Analysis, MIT) and DEDE (Department of Alternative Energy Development and Efficiency, Thailand) can be safely assumed to hold the required data for calculation of electricity emission factor using the combined margin (CM) approach according to "Tool to calculate the emission factor for an electricity system" version 1. However, those institutions do currently not supply the plant-specific data required for build margin (BM) calculation. They also do not supply data that would enable calculation of operating margin (OM) using the simple adjusted OM approach or Dispatch Data Analysis OM approach.

However, EGAT has published data on the public electricity generation in 2003 by power source and data on the fuel consumed for electricity generation in 2003 by fuel type. The data can be found in the EGAT 2004 Power Development Plan and is displayed in the table below. More updated data was not publicly available in December 2006.

With the available data the Simple OM according to "Tool to calculate the emission factor for an electricity system" can be calculated. It has been assumed that all renewable power sources are either low-operating cost (e.g. hydro-power) or must-run power plants and are consequently excluded from the calculation. Consequently, grid emissions factor represents the fossil fuel-based generation-weighted average emission factor of the Thai grid.

The result is the Thai grid emissions factor = 0.548 kg CO_2/kWh.

Tool to calculate the emisson factor for an electricity system Vs. 01

Baseline Emission Factor THAILAND	
Year 2004 (y1)	
EF_{OM} (tCO_2/MWh)	0.5930
Annual generation[1] (MWh)	117,127,444
Year 2005 (y2)	
EF_{OM} (tCO_2/MWh)	0.5877
Annual generation[1] (MWh)	128,784,794
Year 2006 (y3)	
EF_{OM} (tCO_2/MWh)	0.6135
EF_{BM} (tCO_2/MWh)	0.4979
Annual generation[1] (MWh)	132,812,942
Generation weighted $EF_{OM,y1\text{-}y3}$	0.598 (tCO_2/MWh)
$EF_{CM} = 0.5{*}EF_{OM,y1\text{-}y3} + 0.5{*}EF_{BM,y3}$ =	0.548 (tCO_2/MWh)

Method used to calculate OM: Simple OM (ex ante)

1. For ex-ante calculation of simple OM generation weighted average considering total generation **excluding** LC/MR and **including** approved CDM projects if applicable and **including**

2. Calculations based on:
New methodological tool to calculate the EF for an electricity system (based on EB35, Annex 12);
Sources: EGAT, DEDE, EPPO (see data sheet for sources)
own calculations,
IPCC (2006)

Low Cost / Must Run Technologies	2002	2003	2004	2005	2006	average
Total Generation (GWh)	111,254	118,408	125,339	136,887	143,403	
Total LC / MR Technologies (GWh)	7,369	7,210	8,212	8,102	10,590	
% LC/MR Technologies	**6.62%**	**6.09%**	**6.55%**	**5.92%**	**7.38%**	**6.51%**

(Low cost / must run constitute less than 50% of total grid generation in average 2002-2006, therefore Simple OM method is applicable)

2. Total Project Emissions

Year	PE_{y} t CO2e / yr	$PE_{CH4,effluent,y}$ t CO2e / yr	$PE_{CH4,digest,y}$ t CO2e / yr	$PE_{flare,y}$ t CO2e / yr	$PE_{sludge,LA,y}$ t CO2e / yr	$PE_{EC,y}$ t CO2e / yr	$PE_{FC,y}$ t CO2e / yr
0	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
1	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
2	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
3	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
4	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
5	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
6	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
7	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
8	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
9	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
10	15,910.04	5,726.78	6,368.21	2,408.84	0	1,406.21	0
Total (tCO2e)	**175,010.45**	**62,994.56**	**70,050.35**	**26,497.21**	**0**	**15,468.33**	**0**

$PE_{CH4,effluent,y}$ t CO2e / yr	GWP_{CH4} t CO2e / t CH4	$MCF_{PJ,y}$ fraction	B o t CH4 / t COD	$COD_{PJ,effl,dig,y}$ t COD / yr	$COD_{PJ,effl,lag,y}$ t COD / yr
5,727	21	0.5	0.21	5,107	2,509

$PE_{CH4,digest,y}$ t CO2e / yr	$F_{biogas,y}$ m³ / yr	$FL_{biogas,digest}$ m³ bg leaked / m³ biogas produced	$w_{CH4,biogas,y}$ kg CH4 / m³	GWP CH4	$w_{CH4,biogas}$ fraction	ρ_{CO2} kg / Nm³	ρ_{CH4} kg / Nm³
6,368.21	15,379,650	0.05	0.39435	21	0.55	1.977	0.717

PE flare,y t CO2e / yr	TMRG,h ton/year	FVrg m3/yr	FVch4	rCH4	hflare	GWP
2,408.84	229.41	582,562.50	0.55	0.716	0.50	21

$PE_{EC,y}$	$EC_{PJ,y}$	$EF_{EL,y}$	$TD_{L,y}$
t CO2e / yr	MWh / yr	tCO2 / MWh	fraction
1,406.21	2,376	0.548	0.08

ANNEX 4
MONITORING INFORMATION

Sustainability Monitoring Plan

No		1
Indicator		Water quality
Mitigation measure		None
Repeat for each parameter		-
Chosen parameter		Level of COD at the digester outlet
Current situation of parameter		NA
Future target for parameter		Meet environmental quality standard
Way of monitoring	How	Method US EPA 410.4. 50
	When	Monthly basis
	By who	KI Biogas (Project owner)

No		2
Indicator		Air quality
Mitigation measure		None
Repeat for each parameter		-
Chosen parameter		Odour
Current situation of parameter		NA
Future target for parameter		Meet environmental quality standard
Way of monitoring	How	Record of complaints
	When	Up to complaints
	By who	KI Biogas (Project owner)

No		3
Indicator		Quantitative employment and income generation
Mitigation measure		None
Repeat for each parameter		-
Chosen parameter		Average salary
Current situation of parameter		NA
Future target for parameter		Fulfilment of labour standards comply with average salary at project .
Way of monitoring	How	Record of salary data
	When	Yearly basis
	By who	KI Biogas (Project owner)

No	4

Indicator		Employment
Mitigation measure		None
Repeat for each parameter		-
Chosen parameter		Monthly number of staff
Current situation of parameter		NA
Future target for parameter		Number of employee
Way of monitoring	How	Record of data
	When	Monthly basis
	By who	KI Biogas (Project owner)

No		5
Indicator		Balance of payment
Mitigation measure		None
Repeat for each parameter		-
Chosen parameter		Monthly electricity sales income
Current situation of parameter		NA
Future target for parameter		Meet balance payment
Way of monitoring	How	Record of data
	When	Monthly basis
	By who	KI Biogas (Project owner)

No		6
Indicator		Project replicability/ Technology Transfer
Mitigation measure		None
Repeat for each parameter		-
Chosen parameter		Applications of similar projects
Current situation of parameter		NA
Future target for parameter		Meet the goal of the project
Way of monitoring	How	Collect data from Ministry of Industry and Ministry of Energy
	When	Yearly basis
	By who	KI Biogas (Project owner)

Additional remarks monitoring

Monitoring of sustainable development benefits

In addition to monitoring baseline and project emissions, the actual project performance in terms of sustainable development benefits will be assessed on an annual basis. Based on the results of the first stakeholder consultation and the resulting evaluation on social, environmental and technical sustainability in the beginning of 2009, the most sensitive sustainable development indicators have been determined. As summarized in the table above, they will be monitored on a yearly basis. People from surrounding communities will be informed periodically by KI Biogas on the monitoring results.

Data to be collected in order to monitor the project's performance on the most sensitive sustainable development indicators

Referring to the items in the table, the following monitoring system will be introduced:

1. Monitoring of the COD of the effluent at the digester outlet

2. Based on the existing complaints-system of the Ministry of Natural Resources and

	Environment, complaints with regard to offensive smells will be recorded. KI Biogas will regularly collect the information and will add them to the overall monitoring report.
# 3. + 4.	KI Biogas will keep record of project-related employment and will add respective information to the overall monitoring report.
# 5.	Based on production statistics and records on fuel consumption, KI Biogas monitors the reduction of fossil fuel and related savings.
# 6.	KI Biogas will request for information from the Ministry of Industry and Ministry of Energy on applications of similar projects on a yearly basis.