



**CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
VERSION 03 - IN EFFECT AS OF: 28 JULY 2006**

ADOPTED FOR COMPLIANCE WITH THE VOLUNTARY CARBON STANDARD (VCS)

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Revision history of the document

Version Number	Date	Description and reason for revision
01	June 19 th 2007	Initial version

**SECTION A. General description of project activity****A.1 Title of the project activity:**

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“Wastewater Treatment with Biogas production (UASB) and heat utilization at General Starch Co Ltd.”

Version no. and Date: Version 1, dated 19 June 2007

A.2. Description of the project activity:

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The project activity involves installation of an anaerobic wastewater treatment facility, based on Upflow Anaerobic Sludge Blanket (UASB) technology, at a starch manufacturing plant that has been in operation since 1995. Prior to project implementation, the wastewater treatment facility has been an open lagoon-based ponding system with gravitational flow (cascading flow through 34 individual lagoons). The quality of the treated water has been in compliance with the effluent standards regulated by the authority.

The first phase of the project (UASB 1) was implemented at General Starch Co., Ltd. in 2003 with start up of operations in January 2004 and the second phase of the project (UASB 2) in 2005 with start up of operations in January of 2006.

The starch plant has a total production capacity of 600 tonnes of native starch per day, generating an average of 5,000 m³ of wastewater every production day. As a normal practice, the wastewater in the plant is treated through cascading lagoons with a retention time of more than a year. The minimum depth of these ponds is about 10 meters for the first two lagoons and more than 3 m from the water surface for the remaining lagoons. The average atmospheric temperature in the region is 28 degree Celsius and the waste water has a temperature of between 25 and 35 degree Celsius at all times.

These conditions result in anaerobic environment within the ponds, resulting in methane generation from the organic content (characterized by chemical oxygen demand or COD) of the wastewater which is released into the atmosphere.

The use of UASB to treat the wastewater generated in the plant will enable the capture of methane produced in the process as well as to meet the effluent standards. This will help reduce the emission of GHG.

The project utilizes the captured methane as fuel in existing heat generating devices in the plant replacing heavy fuel oil, and the surplus methane, if any, is flared in an open flare.

Sustainable Development Benefits of the Project**1. Economic dimension**

The construction, operation and maintenance of the biogas plant generate local employment. Eight permanent positions will be created (2 qualified positions and 6 support staff). The displacement of fuel oil with biogas means (a) less dependence on imported fossil energy, resulting in energy security and



foreign exchange savings. The local manpower and other resources are used more efficiently in this project.

2. Environmental dimension

The proposed project activity captures the methane which otherwise would have been let into the atmosphere, and uses it for energy purpose, thereby achieving better local air quality. The risk of groundwater contamination is overcome by reducing the COD of wastewater in a concrete digester before it is released to the tail-end ponds. Also, the treated water is recycled for use in the plant, and is not released into any surface water body, thus promoting a better local environment. The implementation of the project does not divert land under agriculture or natural growth, as well as that linked to cultural heritage. Therefore, it is not expected to affect any biodiversity sensitive areas, or other ecologically or culturally important sites in the region. The sludge from the wastewater treatment system has a potential to be applied as a fertilizer for agriculture.

3. Social dimension

The involvement of local employees in the project activity will help to enhance the skills of the labor in the region by training them in different technical areas. In addition, the close collaboration between external experts and local counterparts is expected to promote long-term sustainable partnerships, benefiting the local stakeholders. The substitution of fuel oil with biogas due to the project activity will result in increased availability of these fuels in the local market. The noise, arising from pumps and blowers operating in the biogas plant, is insignificantly low. There are no other occupational health issues identified. The safety aspects of operating the biogas plant will be sufficiently addressed. Stainless steel piping is used for transporting the generated gas, which avoids all possibilities of corrosion, leakage and fire hazard.

4. Technology dimension

The project involves the use of some imported components and hence the transfer of technology from outside the country. The UASB technology is already available in a few local industries and hence the local technology transfer is enhanced. The use of this technology in wastewater treatment by the project owner will popularise the technology know how in the nearby areas and in the plants looking for similar technologies in the country. Also, the locally produced equipment may be put to use in other parts of Thailand for similar purposes.

A.3. Project participants:

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Name of Party involved (*) ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)
Thailand (host)	General Starch Ltd. Prayut Vitthayanukorn Executive Director New Rama IX Road, Soi 53 Suanluang, Bangkok 10250



Switzerland	South Pole Carbon Asset Management AG as the CDM / VCU developer and certificate buyer.
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A.4. Technical description of the project activity:**A.4.1. Location of the project activity:**

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A.4.1.1. Host Party(ies):

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Thailand

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

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Nakhorn Ratchasima Province

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

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No. 99, Chok Chai – Kornburi Road, Amphur Kornburi, Nakhorn Ratchasima

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

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The proposed project site is located on Ratchasima-Chokchai Road in Amphur Kornburi in Nakorn Ratchasima Province in the northeast of Thailand. Nakorn Ratchasima, about 250 km away from Bangkok, is one of the five biggest cities in Thailand. Most of the tapioca starch plants in Thailand are located in this province. The closest Railway station is Jira Station, and the closest airport is Nakorn Ratchasima Airport.

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

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

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

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The project activity deals with the recovery of methane from the wastewater generated in the tapioca processing plant. The recovered methane is used to replace heavy fuel oil in the starch drying boiler. The excess methane may also be flared for safety purpose, in case it is not used for heating.

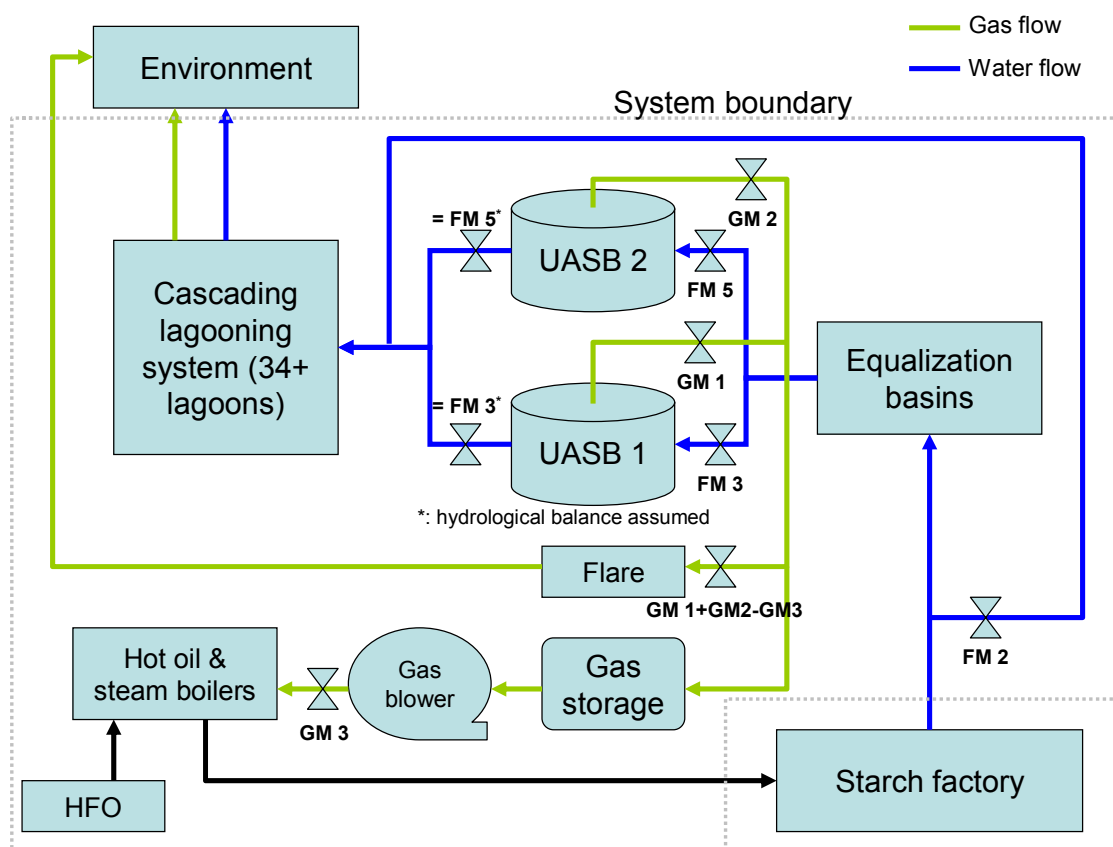
UASB technology is used in the project for methane generation from wastewater high in organic content by anaerobic digestion. This is a two-stage technology, involving an Acidification System and a UASB Reactor. The organic matter is the wastewater, which is represented by its COD and BOD.

In the first stage, starch in wastewater is converted into Volatile Fatty Acids through the Acidification System that uses acidogenic bacteria. The pH of wastewater drops significantly due to the acidification process. In the second stage, effluent from the Acidification System is processed through the UASB

reactor after neutralizing it with lime. The UASB reactor can briefly be described as a system in which wastewater passes first through an expanded sludge bed containing a high concentration of biomass. The sludge in the reactor may exist in granular or flocculent form. Most of the organic matter removal takes place in the sludge bed. The remaining portion of the substrate passes through a less dense biomass, called the sludge blanket. Above the sludge blanket, the reactor has a three-phase Gas-Liquid-Solid (GLS) separator, which separates the solid particles from the liquid and gas, allowing liquid and gas to leave the system. The system is diagrammatically represented in the figure.

The organic matter in the wastewater is digested by methanogenic bacteria in the UASB reactor. This results in the production of methane, which is separated in GLS separator and collected for further use, or for flaring.

Figure: Project system



The present wastewater treatment facility, the open lagoon system, is able to treat the wastewater and meet the current environmental standards, with 120 mg or less COD per liter of wastewater released into the water bodies. However, the treated wastewater is not discharged into a water body but evaporates.

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

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Year	Estimation of emission reductions (tonnes of CO ₂ eq)	Conservative estimation of emission reductions (tonnes of CO ₂ eq)
2004	23,888	15,653
2005	25,368	20,229
2006	91,885	91,885
2007	90,514	86,833
2008	103,636	99,955
2009	103,636	99,955
2010	103,636	99,955
Total estimated reductions (tonnes of CO ₂ eq) of first period	542,564	514,466
Total estimated reductions (tonnes of CO ₂ eq) of second period	725,454	699,688.21
Total estimated reductions (tonnes of CO ₂ eq) of third period	725,454	699,688.21

Table 1: Estimated amount of emissions reductions

A.4.5. Public funding of the project activity:

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No public funding from Annex I parties is involved in the project.

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

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Avoided wastewater and on-site energy use emissions in the industrial sector – version04 (AM0022 version 04). It is hereafter referred to as the baseline methodology.

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

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

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

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

Requirement 2: The organic wastewater contains simple organic compounds (mono-saccharides). If the methodology is used for wastewater containing materials not akin to simple sugars a CH₄ emissions factor different from 0.21 kgCH₄/kgCOD has to be estimated and applied;

- The primary organic compound contained in the cassava processing wastewater is starch, which is a poly-saccharide, a more complex organic compound compared to mono-saccharides. As the baseline methodology stipulates, an alternative CH₄ emission factor is estimated and applied for the project activity. Using the maximum CH₄ producing capacity ($B_0 = 0.25 \text{ kgCH}_4/\text{kgCOD}$) for this project as a starting point, the emission factor is calculated using long-term (multi-year), average measured parameters for COD in, COD out and CH₄ production. Considering the fact that this value has been established using continuous measurements over a long time, it is deemed a conservative and transparent approach for the project participant to determine this value for the methane emission factor.

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

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

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



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

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

- The depth of the first anaerobic lagoon within the existing lagoon system is approximately 10 meters and always greater 3 meters.

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

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

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

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

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

- Before and after the Project implementation, heat and electricity needs per unit input of the water treatment facility remain largely unchanged. Water flows in the lagoon systems are operating on gravitational flow basis, the installed electric capacity of the UASB reactors is below 100 kW.

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

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

The baseline methodology will be used in conjunction with the approved monitoring methodology AM0022 version04.

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

	Source	Gas	Included?	Justification / Explanation
Baseline	Direct emissions from the waste water treatment process	CH ₄	Included	The major source of emissions in the baseline.
		CO ₂	Excluded	CO ₂ emissions from the decomposition of organic waste are not accounted.
		N ₂ O	Excluded	Negligible and excluded.
	Emissions from electricity consumption / generation	CO ₂	Included	Electricity is consumed from the grid in the baseline scenario.
		CH ₄	Excluded	Excluded for simplification. This is conservative.
		N ₂ O	Excluded	Excluded for simplification. This is conservative.
	Emissions from thermal energy consumption	CO ₂	Included	Thermal energy is generated in the project activity.
		CH ₄	Excluded	Excluded for simplification. This is conservative.
		N ₂ O	Excluded	Excluded for simplification. This is conservative.
Project Activity	Direct emissions from the waste water treatment process	CH ₄	Included	Emissions from non-combusted methane and leakage from anaerobic digesters is included. Emissions from dewatering and land application are insignificant.
		CO ₂	Excluded	CO ₂ emissions from the decomposition of organic waste are not accounted.
		N ₂ O	Excluded	Excluded for simplification. Not and important emission source.
	Emissions from electricity consumption / generation	CO ₂	Excluded	Electricity consumption from the grid is negligible and not included.
		CH ₄	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N ₂ O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from thermal energy consumption	CO ₂	Included	Emissions from continued use of heavy fuel oil are included for cross-checking.
		CH ₄	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N ₂ O	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 identified using the barrier analysis method described in the UNFCCC CDM EB additionality tool.

Step 1: List a range of potential baseline options

1. Status-quo: sludge is brought to sludge pits (open lagoons)
2. Methane recovery and utilization for heat generation and flaring of remaining methane (proposed project).
3. Aerobic waste water treatment
4. Direct discharge
5. Methane recovery and flaring

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

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

1. Legal barriers
2. Technical barriers
3. Financial barriers
4. Social barriers
5. Business culture barriers

Step 3: Score the barriers

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

1. Legal barriers

Scoring Criteria:

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

Performance of alternatives:

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

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

2. Technical barrier



Scoring Criteria:

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

Performance of alternatives:

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

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

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

Alternative 4 is already excluded.

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

3. Financial barriers

Scoring Criteria:

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



- Is the proposed project exposed to commercial risk?

Performance of alternatives:

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

Alternative 2 entails high investment and O&M costs and uncertain commercial returns (from the production and use of biogas). The project operator does not intend to invest using his own equity due to the financial risks. Instead, a third party affiliated to the supplier of key technology components, with a primary interest to implement his own technology and a therefore more aggressive attitude towards the commercial risk, was asked to carry out the investment and operate the plant. Significant financial barriers exist.

Alternative 3 entails high investment and O&M costs (i.e. electricity for air blowing) and no commercial returns (as no biogas is produced). The financial barriers are not surmountable and the alternative is excluded from further analysis.

Alternative 4 is already excluded.

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

4. Social barrier

Scoring Criteria:

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

Performance of alternatives:

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

Alternative 2 faces certain social barriers associated with the low understanding of the technology. While there is a lot of talk about the technology, technical understanding of the involved processes (biological, chemical and physical) are poorly understood and therefore decision-making is uninformed, slowing the uptake of this technology. With the increased availability of operational experience, this barrier is likely to become less relevant over time.

Alternatives 3 to 5 have been excluded already.

5. Business Culture barriers

Scoring Criteria:



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

Performance of alternatives:

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

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

Step 4: Compare which is the most plausible baseline option

As discussed above, Alternative 1, continuation of the current situation, does not have any significant barriers while Alternative 2, anaerobic digestion system, and Alternative 3, aerobic treatment system, face a number of technical, financial and business culture barriers, which prevent the implementation of these alternatives under baseline conditions.

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

**Summary of Barrier Scoring Performance**

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

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

According to the Thai Tapioca Development Institute, lagoon based treatment of sludge is still by far the most commonly used method in Thailand.

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): >>



Any comment:	The project developer did not carry out biochemical tests prior to project implementation. For this reason, comparable test results were used.
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Data / Parameter:	R_{deposition}
Data unit:	%
Description:	Organic material deposition ratio
Source of data used:	Estimated by project developer on basis of experience
Value applied:	0 (project scenario), 0 (baseline scenario)
Justification of the choice of data or description of measurement methods and procedures actually applied :	Estimated by project developer as follows: a) Project scenario Value from registered project no 1040 “Korat waste to energy” is applied here which has been determined using Appendix 3 of AM0022. According to this analysis, all solid material that could sediment is assumed to be removed by the UASB system implemented by the project activity. This is a conservative assumption. b) Baseline scenario Value from registered project no 1040 “Korat waste to energy” is applied: the analysis determined that there is little or no sedimentation occurring in the anaerobic pond as the anaerobic activity effectively keeps all solid COD material in suspension.
Any comment:	This corresponds to the assumptions made for the Korat Waste to Energy project, a registered AM0022 project in Thailand.

Data / Parameter:	ECH4_NAWTF
Data unit:	tCO _{2e}
Description:	Methane emitted from UASB digesters
Source of data used:	IPCC default value
Value applied:	0
Justification of the choice of data or description of measurement methods and procedures actually applied :	Value from registered project No 1040 (<i>Korat Waste to Energy</i>) is applied here due to lack of documentary evidence from the technology supplier.
Any comment:	

Data/Parameter	R_{NAWTF}
Data unit:	Fraction
Description:	Total organic material removal efficiency of the new project wastewater facility.
Source of data used:	Calculated using COD concentration entering the project treatment facility and COD concentration leaving the treatment facility.
Value applied:	95.92%
Justification of the choice of data or description of measurement methods	Based on actual measurement of COD removal over a 16 months period. Monitored COD in for UASB1 and UASB 2 in 2006, plus Jan to April of 2007.



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

Project additionality is confirmed using criteria A. in the VCS Version 1 verification protocol and standard.

There is clear evidence that each of the following three requirements of the Additionality Test have been met by the project:

Additionality Criteria	Evidence	Documentation
The project is not common practice. - Provision of underlying service or product with the project technology does not exceed 51% in the defined market area. - Business-as-usual technology options are clearly defined and their position on the market proven by official Statistics.	The treatment of wastewater from tapioca starch production in Thailand is mandated to ensure that the effluent that is discharged into the environment meets national effluent standards for COD. Historically, all 50 starch producers used open lagoon systems (the only business as usual technology option) to comply with this standard. The project was one of the first in Thailand introducing UASB technology. An increasing number of starch producers invest in either UASB reactors or covered lagoons. All of the projects that have been implemented previously or are currently underway that are similar to the proposed project activity in Thailand have submitted CDM applications, intend to do so or plan to produce VER and are therefore not to be considered in the current practice scenario (according to CDM EB Additionality Tool Step 4a).	Market overview: waste water treatment in Thai tapioca starch factories.
2. The project is not required by regulation - Local or National Legislation does not require the production of the underlying service or product with the chosen technology. - Additionally, the Project should not have been undertaken to meet a formal or voluntary target imposed by government regulation or under agreement with a government agency (e.g. the auto manufacturers and the EU, where companies agree to meet reduction targets voluntarily through their industry association). - Carbon credits should not be the by-product from the creation of an ancillary environmental asset and/or financial instrument (e.g. renewable energy credits). - The emission reductions from the Project must not have been used against any voluntary corporate emission reduction targets. - Project is not a downstream energy efficiency	Regulation mandates the concentration of a number of pollutants in the effluent that is discharged into the environment and does not mandate the technology. Also, the project was not undertaken to meet any agreed target but on the initiative of the plant owner. No other environmental asset or financial instrument is created by the project. The project operator does not have a voluntary corporate emission reduction target. Project is not a downstream energy efficiency project in a jurisdiction with a mandatory GHG emissions cap.	



project in a jurisdiction with a mandatory GHG emissions cap on upstream electricity generators.		
3. The project is not the least cost option for providing the underlying product or service. ▪ Companies shall provide calculations that illustrate that the project is not the Least Cost Option.	The use of the existing open lagoon system is the least cost option to comply with effluent standard regulation when compared to the project investment and its cost of operation.	Financial analysis comparison

B.6. Emission reductions:**B.6.1. Explanation of methodological choices:**

Baseline and project emissions as well as emission reductions are calculated using AM 0022, version 4.

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

(Copy this table for each data and parameter)

Data / Parameter:	EF _{CH4}
Data unit:	kg CH ₄ / kg COD
Description:	Methane emission factor
Source of data used:	Expert selection based on AM0013 v4 guidance
Value applied:	0.241
Justification of the choice of data or description of measurement methods and procedures actually applied :	The CH₄ emissions factor for the tapioca starch wastewater is determined from the proportion of COD that has been degraded and has formed methane in the new wastewater treatment system. It is calculated using measured data over a 12 months period using the following formula: $EF_{CH4} = (\text{produced biogas (Nm}^3/\text{a)} * \text{average CH}_4 \text{ concentration} * \text{density of methane at normal conditions (kg/ Nm}^3)) / ((\text{COD}_{in} \text{ (kg/a)} - \text{COD}_{out} \text{ (kg/a)}))$ For conservativeness reasons, this figure must be smaller than the maximum theoretical methane producing capacity of 0.25 kg CH₄/ kg COD.
Any comment:	Details of the calculation and data used are provided in Annex 3.

Data / Parameter:	R _{lagoon}
Data unit:	%
Description:	Organic material removal ratio
Source of data used:	Applied from registered project no 1040 “Korat Waste to Energy”
Value applied:	87.88
Justification of the choice of data or description of measurement methods and procedures actually applied :	Estimated by registered project No 1040 “Korat Waste to Energy” project using historical COD data of wastewater from tapioca starch from lagoon system located 50 km from project site.



and procedures actually applied :	
Any comment	

Data / Parameter:	CEF
Data unit:	tCO ₂ /MWh
Description:	NA
Source of data used:	NA
Value applied:	NA
Justification of the choice of data or description of measurement methods and procedures actually applied :	NA
Any comment:	NA

Data / Parameter:	EF
Data unit:	tCO ₂ /TJ
Description:	Carbon emission factor of fuel oil
Source of data used:	IPCC 2006
Value applied:	77.367
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value
Any comment:	

Data / Parameter:	NCV
Data unit:	TJ/t
Description:	Net calorific value of fuel oil
Source of data used:	IPCC 2006 p. 1.18
Value applied:	0.0404
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value
Any comment:	

Data / Parameter:	Density of CH₄
Data unit:	kgCH ₄ / Nm ³ CH ₄



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

Data / Parameter:	Lagoon surface area
Data unit:	Hectare
Description:	Total lagoon area
Source of data used:	Project developer
Value applied:	16
Justification of the choice of data or description of measurement methods and procedures actually applied :	Facility operates approx. 34 lagoons. Surface area data from the project operator.
Any comment:	

Data / Parameter:	Flare efficiency
Data unit:	%
Description:	Flare efficiency for open flare
Source of data used:	Tool to determine project emissions from flaring gases containing methane
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value determined in accordance with the tool to determine project emissions from flaring gases containing methane. This figure corresponds also with the figure used by registered project activity No 1040 and the observation of other flare parameters leading to the selection of a 50% default efficiency as flare is detected for more than 20 minutes during every hour at a temperature of 850 degree Celsius during the hour.
Any comment:	When the flare is active, a flame can be visibly observed.

B.6.3 Ex-ante calculation of emission reductions:

As per the equations set out in AM0022, the following equations are used to estimate project emissions.

Total project emissions (t CO₂eq)



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

Formula (1) AM 22 v4

$$E_{project} = E_{CH_4_lagoons} + E_{CH_4_NAWTF} + E_{CH_4_IC+Leaks}$$

Where:

$E_{project}$ are the Total Project Emissions (tCO₂e)

$E_{CH_4_lagoons}$ are the fugitive methane emissions from lagoons from equations 2 (tCO₂e)

$E_{CH_4_NAWTF}$ are the fugitive methane emissions from the new anaerobic waste water treatment facility (tCO₂e)

$E_{CH_4_IC+leaks}$ are the methane emissions from inefficient combustion and leaks (tCO₂e)

Formula 1	2004	2005	2006	2007	2008	2009	2010	2011	2012
$E_{project}$	40,521	45,394	13,770	11,575	6,360	6,360	6,360	6,360	6,360
$E_{CH_4_lagoons}$	33,739	41,287	-	-	-	-	-	-	-
$E_{CH_4_NAWTF}$	-	-	-	-	-	-	-	-	-
$E_{CH_4_IC+Leaks}$	6,783	4,107	13,770	11,575	6,360	6,360	6,360	6,360	6,360

Fugitive Methane Emissions from Lagoons in the project scenario

Formula (2 (project)) AM 22 v4

$$E_{CH_4_lagoons} = M_{lagoon_anaerobic} \cdot EF_{CH_4} \cdot GWP_{CH_4} / 1000$$

Where:

$E_{CH_4_lagoons}$ is the methane emissions from the lagoons (tCO₂e)

$M_{lagoon_anaerobic}$ is the amount of organic material removed by anaerobic processes in the lagoon system (kg COD³)

EF_{CH_4} is the methane emission factor (kg CH₄ / kg COD). A default COD to Methane conversion factor of 0.21kg CH₄/kgCOD is used⁴. If the methodology is used for waste water containing materials not akin to simple sugars a CH₄, a different emissions factor different has to be estimated and applied. Where a metric for organic wastewater flows other than COD is to be applied, the developer should set out the case for a relevant carbon emission factor.

GWP_{CH_4} is the Global Warming Potential of methane ($GWP_{CH_4} = 21$)

Whereby the mass balance in the considered lagoon system provides the amount of organic material removed by anaerobic processes.

Formula 2 (project)	2004	2005	2006	2007	2008	2009	2010	2011	2012
$E_{CH_4_lagoons}$	33,739	41,287	0	0	0	0	0	0	0
$M_{lagoon_anaerobic}$	6,666	8,158	0	0	0	-	-	-	-
EF_{CH_4}	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241
GWP_{CH_4}	21	21	21	21	21	21	21	21	21

Formula (3 (project)) AM 22 v4

$$M_{lagoon_anaerobic} = M_{lagoon_total} - M_{lagoon_aerobic} - M_{lagoon_chemical_ox} - M_{lagoon_deposition}$$



Where:

M_{lagoon_total} is the total amount of organic material removed in the lagoon system from equation 5 (kg COD)

$M_{lagoon_aerobic}$ is the amount of organic material degraded aerobically in the lagoon system (kg COD).

Surface aerobic losses of organic material in pond based systems equal to 254 kg COD per hectare of pond surface area and per day is assumed to be lost through aerobic processes.

Where other more project specific losses can be determined, these should be applied.

$M_{lagoon_chemical_ox}$ is the amount of organic material lost through chemical oxidation in the lagoon system (kg COD)

$M_{lagoon_deposition}$ is the amount of organic material lost through deposition in the lagoon system from equation 6 (kg COD)

Formula 3 (project)	2004	2005	2006	2007	2008	2009	2010	2011	2012
$M_{lagoon_anaerobic}$	6666	8158	0	0	0	-	-	-	-
M_{lagoon_total}	8,150	9,641	792	803	803	803	803	803	803
$M_{lagoon_aerobic}$	1,483	1,483	1,483	1,483	1,483	1,483	1,483	1,483	1,483
$M_{lagoon_chemical_ox}$	-	-	-	-	-	-	-	-	-
$M_{lagoon_deposition}$	-	-	-	-	-	-	-	-	-

Registered project No 1040 (Korat Waste to Energy) carried out a sensitivity analysis to determine the suitability of the surface oxidation factor utilised in this project analysis. Also, deposition, total removal and chemical oxidation are project specific factors that must be quantified on a project-specific basis. Considering strong similarities between the two projects, the analysis was applied to this project.

To assess the amount of COD entering the lagoon system the amount two waste water flows need to be quantified:

- the amount of COD actually entering the lagoon system from the new wastewater treatment facility which is equivalent to the amount of COD entering the new wastewater treatment facility minus the amount of COD removal as a result of the new wastewater treatment facility, and
- the amount of COD actually entering the lagoon system, bypassing the new wastewater treatment facility.

The first part is determined with:

Formula (4 (project)) AM 22 v4

$$M_{lagoon_input} = M_{input_total} \cdot (1 - R_{NAWTF})$$



Where:

M_{lagoon_input} is the input of organic material from the new project anaerobic waste water treatment facility into the lagoon system (kg COD)

M_{input_total} is the total amount of organic material fed into the new project water treatment facility (kg COD)

R_{NAWTF} is the total organic material removal efficiency of the new project water treatment facility (-). It is a project specific factor used to estimate how much COD will be removed from the system. The most appropriate manner to estimate this factor is to undertake pilot plant trials with a pilot scale digester system prior to project implementation. Where this is not possible, manufacturers estimates as to equipment removal efficiencies may be applied. This factor will be used to determine estimates of COD flows to the project lagoon system, and the related monitoring methodology (AM0022 “Avoided Wastewater and On-site Energy Use Emissions in the Industrial Sector”) sets out how the actual amount of COD can be monitored to allow calculation of actual project emissions.

The second part is determined with

Formula (4(a) (project)) AM 22 v4

$$M_{lagoon_input_bypass} = M_{input_bypass}$$

Where

M_{input_bypass} is the total organic material that is entering the lagoon untreated. It is equivalent to the waste water flow of the bypass and the same COD load (mg/l) as measured for the waste water entering the lagoon.

The second part is not recognized by AM0022 even though AM0022 monitoring method identifies this parameters. It is, however, not included in the calculation for AM0022 projects. For the purposes of this calculation M_{lagoon_input} is defined as

M_{lagoon_input} (as defined in AM0022) plus $M_{lagoon_input_bypass}$.

Formula 4 (project)	2004	2005	2006	2007	2008	2009	2010	2011	2012
M_{lagoon_input}	9,274	10,971	901	914	914	914	914	914	914
M_{input_total}	6,859	6,308	22,067	22,378	22,378	22,378	22,378	22,378	22,378
R_{NAWTF}	95.92%	95.92%	95.92%	95.92%	95.92%	95.92%	95.92%	95.92%	95.92%
$M_{input_lagoon_bypass}$	8,994	10,713	-	-	-	-	-	-	-

Total Material Removed in the Lagoon System is:

Formula (5 (project)) AM 22 v4

$$M_{lagoon_total} = M_{lagoon_input} \cdot R_{lagoon}$$



Where:

M_{lagoon_total} is the total amount of organic material removed in the lagoon system through various routes (kg COD)

R_{lagoon} is the total organic material removal ratio of the lagoon (-). It is a project specific factor, and is equal to the proportion of organic material removed (through all routes) within the boundaries of the lagoon system under consideration. This factor should be determined by carrying out a series of biochemical tests prior to project implementation. These tests will determine the COD flows into the system, and the COD flows out of the system at the system boundary. The relative difference of COD flowing in and out of the system over a period of time will allow determination of the Total Organic Material Removal Ratio.

and where M_{lagoon_input} includes $M_{lagoon_input_bypass}$

Formula 5 (project)	2004	2005	2006	2007	2008	2009	2010	2011	2012
M_{lagoon_total}	8,150	9,641	792	803	803	803	803	803	803
M_{lagoon_input}	9,274	10,971	901	914	914	914	914	914	914
R_{lagoon}	87.88%	87.88%	87.88%	87.88%	87.88%	1	1	1	1

Due to the lack of measurement data for $M_{lagoon_input_bypass}$ (FM 2 has not been in operation in 2004 nor 2005) the flow of wastewater bypassing the new waste water treatment facility is estimated using benchmark data for the use of water in starch production and a water balance approach, defining the quantity of waste water bypassing the new waste water treatment facility as the difference between water usage and water flows into the new waste water treatment facility.

Month	Root cassava(kg)	Wet Starch(kg)	Dryer Starch(ton)	Heavy oil(ltr)	Bio gas(m ³)	Water to reactor m3/a	water/root (l/kg)	Total water use (m3)	Water bypassing reactor (m3)	COD load mg/l	COD entering lagoon bypass (kg)
2004 Total	488,523,305	117,615,174	123,223	4,648,430	791,967	470,437	2.52	1,232,157	761,720	11807	8,993,626
2005 Total	462,510,492	105,518,142	126,967	4,187,578	2,573,465	426,633	2.52	1,166,547	739,914	14479	10,713,217
2006 Total	499,479,381	122,336,917	148,404	2,466,719	9,317,439	1,319,869		1,319,869	-		
2007 January	61,789,690	16,079,257	17,968	326,807	992,781						
2007 February	52,355,220	14,550,586	16,187	205,531	1,084,753						
2007 March	57,873,710	15,011,728	18,511	203,723	1,281,558						
2007 April	53,829,500	12,475,499	15,783	154,275	1,165,882	509,557		509,557	-		
Benchmark	725,327,501					1,829,426	2.52	1,829,426			

Benchmark from 2006 and 2007 data (for which no waste water was bypassing reactors):

General Starch provided data for root processing for 2004 to 2007. A water use per kg root benchmark is defined (2.52 l/kg root) using flow meter data for waste water entering the new waste water treatment facility for 2006 and 2007 (water to reactor), years in which no waste water was bypassing the new waste water treatment facility due to the capacity expansion of the new waste water treatment facility in 2006 (UASB2).

This benchmark is applied to the total root processing in 2004 and 2005 (total water use). The waste water flow bypassing the reactor is defined using a hydrological balance:

$$WW_{bypass} = WW_{total_use} - WW_{input}$$

To determine $M_{lagoon_input_bypass}$ WW_{bypass} is multiplied with the average COD load for 2004 and 2005, using measured data at the reactor inlet.

$M_{lagoon_anaerobic}$ becomes zero when all wastewater is treated in the new waste water treatment facility as all remaining COD entering the lagoon is removed on aerobic basis.

Material Deposition into the Lagoon System is:

Formula (6 (project)) AM 22 v4

$$M_{lagoon\ deposition} = M_{lagoon\ input} \cdot R_{deposition}$$

Where:

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

[illegible]

Methane emissions from new anaerobic waste water treatment facility

In accordance with AM0022, methane emissions from the reactor should be assessed and estimated based on measurements, technology supplier data and expert estimates. They may be disregarded if documented evidence for their insignificance is given. Registered project no 1040 (KWTE) determined that methane emissions from the reactor are not significant and thus disregarded here as well.

Methane emissions from Inefficient Combustion Emissions

Methane emissions from inefficiency combustion are calculated as:

Formula (7) AM 22 v4

$$E_{CH4_IC+Leaks} = (\sum_r V_r \cdot C_{CH4_r} \cdot (1 - f_r) \cdot GWP_{CH4}) + PE_{flare}$$

Where:

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

V_r is the biogas combustion process volume in route r (Nm^3)

C_{CH_4} is the methane concentration in biogas (tCH₄/Nm³) to be measured on wet basis.

f_r is the proportion of biogas destroyed by combustion (-)

PE_{flare} are the project emissions from flaring of the residual gas stream (tCO₂e) calculated following the procedures described in the “*Tool to determine project emissions from flaring gases containing Methane*”. PE_{flare} can be calculated on an annual basis or for the required period of time using this tool.

[illegible]

In the project activity, biogas will be flared when biogas production exceeds the capacity of the dual fuel burners or during maintenance shut down of the starch plant. Project emissions from the flare will be calculated using the “Tool to determine project emissions from flaring gases containing Methane”. Since no continuous monitoring takes place, the default flare efficiency prescribed by the tool is utilized. The calculation steps for project emissions are as follows:

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.

Formula 1 flaring tool:

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

Where:

$FM_{RG,h}$: Mass flow rate of the residual gas in hour h (kg/h)

$p_{RG,n,h}$: Density of the residual gas at normal conditions in hour h (kg/Nm³)

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

Flaring tool: 1	2004	2005	2006	2007	2008	2009	2010	2011	2012
$FM_{RG,h}$	153	89	288	247	112	112	112	112	112
$p_{RG,n,h}$	0.901	0.901	0.901	0.901	0.901	0.901	0.901	0.901	0.901
$FV_{RG,h}$	170	99	319	274	125	125	125	125	125
V_1	1,364,357	797,637	2,566,871	2,200,468	1,001,211	1,001,211	1,001,211	1,001,211	1,001,211

As stated in the “Tool to determine project emissions from flaring gases containing Methane”, a simplified approach may be taken, in which only the volumetric fraction of methane is measured and the difference to 100% is considered as nitrogen (N₂). From this simplified composition of the gas $p_{RG,n,h}$ is calculated as:

Formula 2 flaring tool

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

Where:

Variable	SI Unit	Description
$p_{RG,n,h}$	kg/m ³	Density of the residual gas at normal conditions in hour h
P_n	Pa	Atmospheric pressure at normal conditions (101 325)
R_u	Pa.m ³ /kmol.K	Universal ideal gas constant (8 314)
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour h
T_n	K	Temperature at normal conditions (273.15)

with $MM_{RG,h} = 65\% \times 16 + 35\% \times 28$



STEP 2 though STEP 4 are not applicable for this project

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 ($f_{vCH_4, RG,h}$) and the density of methane ($\rho_{CH_4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis). Considering that the gas is cooler than 60 degree Celsius, the reported density is expressed on dry basis already.

$$TM_{RG,h} = FV_{RG,h} \times f_{vCH_4, RG,h} \times \rho_{CH_4,n}$$

Where:

$FV_{RG,h}$: Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (Nm^3/h)

$f_{vCH_4, RG,h}$: Volumetric fraction of methane in the residual gas on dry basis in hour h

$\rho_{CH_4,n}$: Density of methane at normal conditions (kg/m)

Flaring tool: 13	2004	2005	2006	2007	2008	2009	2010	2011	2012
$TM_{RG,h}$	79	46	149	127	58	58	58	58	58
$FV_{RG,h}$	170	99	319	274	125	125	125	125	125
$f_{vCH_4, RG,h}$	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
$\rho_{CH_4,n}$	0.716	0.716	0.716	0.716	0.716	0.716	0.716	0.716	0.716

STEP 6: Determination of the hourly flare efficiency

The determination of the hourly flare efficiency depends on the operation of flare (e.g. temperature), the type of flare used (open or enclosed) and, in case of enclosed flares, the approach selected by project participants to determine the flare efficiency (default value or continuous monitoring).

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

As the temperature will be 850°C for more than 40 minutes during the hour h, the 50% default was selected.

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:

Formula 15 Flaring tool

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times (1 - \eta_{flare,h}) \times \frac{GWP_{CH_4}}{1000}$$



GWP_{CH₄}: Global Warming Potential of methane valid for the commitment period

[illegible]



To calculate $E_{CH_4_lagoons_BL}$, formulas 2 to 6 are applied using baseline data.

Formula (2 (baseline)) AM 22 v4

$$E_{CH_4_lagoons_BL} = M_{lagoon_anaerobic_BL} * EF_{CH_4} * GWP_{CH_4} / 1000$$

Formula 2 (baseline)	2004	2005	2006	2007	2008	2009	2010	2011	2012
$E_{CH_4_lagoons_BL}$	62,997	68,196	90,638	92,021	92,021	92,021	92,021	92,021	92,021
$M_{lagoon_anaerobic_BL}$	12,448	13,475	17,909	18,182	18,182	18,182	18,182	18,182	18,182
EF_{CH_4}	0.241	0.241	0.241	0.241	0.241	0	0	0	0
GWP_{CH_4}	21	21	21	21	21	21	21	21	21

Formula (3 (baseline)) AM 22 v4

$$M_{lagoon_anaerobic_BL} = M_{lagoon_total_BL} - M_{lagoon_aerobic_BL} - M_{lagoon_chemical_ox_BL} - M_{lagoon_deposition}$$

Formula 3 (baseline)	2004	2005	2006	2007	2008	2009	2010	2011	2012
$M_{lagoon_anaerobic}$	12448	13475	17909	18182	18182	18,182	18,182	18,182	18,182
$M_{lagoon_total_BL}$	13,931	14,958	19,392	19,666	19,666	19,666	19,666	19,666	19,666
$M_{lagoon_aerobic_BL}$	1,483	1,483	1,483	1,483	1,483	1,483	1,483	1,483	1,483
$M_{lagoon_chemical_ox_BL}$	-	-	-	-	-	-	-	-	-
$M_{lagoon_deposition_BL}$	-	-	-	-	-	-	-	-	-

Formula (11) AM 22v4 (corresponding to the logic of formula (4) AM 22 v4 in the project scenario

$$M_{lagoon_input_BL} = M_{input_total}$$

Formula 4 (baseline)	2004	2005	2006	2007	2008	2009	2010	2011	2012
$M_{lagoon_input_BL}$	15,852	17,021	22,067	22,378	22,378	22,378	22,378	22,378	22,378
$M_{input_total_BL}$	6,859	6,308	22,067	22,378	22,378	22,378	22,378	22,378	22,378
R_{NAWTF}	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$M_{input_lagoon_bypass_BL}$	8,994	10,713	-	-	-	-	-	-	-

Formula (5 (baseline)) AM 22 v4

$$M_{lagoon_total_BL} = M_{lagoon_input_BL} * R_{lagoon}$$

Formula 5 (baseline)	2004	2005	2006	2007	2008	2009	2010	2011	2012
$M_{lagoon_total_BL}$	13,931	14,958	19,392	19,666	19,666	19,666	19,666	19,666	19,666
$M_{lagoon_input_BL}$	15,852	17,021	22,067	22,378	22,378	22,378	22,378	22,378	22,378
R_{lagoon}	87.88%	87.88%	87.88%	87.88%	87.88%	87.88%	87.88%	87.88%	87.88%

Formula (6 (baseline)) AM 22 v4

$$M_{lagoon_deposition_BL} = M_{lagoon_input_BL} * R_{deposition}$$



Formula 6 (baseline)	2004	2005	2006	2007	2008	2009	2010	2011	2012
$M_{\text{lagoon_deposition_BL}}$	-	-	-	-	-	-	-	-	-
$M_{\text{lagoon_input_BL}}$	15,852	17,021	22,067	22,378	22,378	22,378	22,378	22,378	22,378
$R_{\text{deposition}}$	-	-	-	-	-	-	-	-	-

Result from formula (9), AM 22 v4:

Whereby on Site Heat Generation Emissions displaced by generation based on biogas collected in the anaerobic treatment facility are calculated as follows (replacement of power from the grid does not apply):

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

Formula (9) AM 22 v4

$$E_{\text{CO}_2_heat} = F \cdot NCV \cdot EF$$

Where:

F is the corresponding amount of fossil fuel displaced by the use of biogas for the generation of on site heat (unit). This is estimated as product of : (1) Average specific fuel consumption for the output of the facility, estimated using 3 years historical data; and (2) the annual production
 NCV is the net calorific value of the fossil fuel considered (TJ/unit). Site specific local NCV values should be applied where available; however, should this information not be available, IPCC data may suffice for that specific country.⁷

EF is the carbon emission factor of the fossil fuel considered (tCO₂/TJ).

Formula 9	2004	2005	2006	2007	2008	2009	2010	2011	2012
$E_{\text{CO}_2_heat}$	1,412	2,567	15,017	10,068	17,975	17,975	17,975	17,975	17,975
F	452	821	4,804	3,221	5,751	5,751	5,751	5,751	5,751
NCV	0.0404	0.0404	0.0404	0.0404	0.0404	0	0	0	0
EF	77.37	77.37	77.37	77.37	77.37	77.37	77.37	77.37	77.37

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

- 1 m³ biogas at 65% concentration of methane = 23.2 MJ
- Combustion efficiency on HFO as well as biogas is considered to be 100 % in absence of the manufactures data.
- 1 ton of heavy fuel oil = 40.400 MJ
- Therefore: 1m³ biogas = 0.0005743 tons of heavy fuel oil

A 65% concentration default value is used in the absence of continuously monitored data.

Emission reductions

Emission reductions are calculated using



Formula (12) AM22v4

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

Formula 12	2004	2005	2006	2007	2008	2009	2010	2011	2012
ER	23,888	25,368	91,885	90,514	103,636	103,636	103,636	103,636	103,636
E _{BL}	64,409	70,763	105,655	102,089	109,997	109,997	109,997	109,997	109,997
E _{project}	40,521	45,394	13,770	11,575	6,360	6,360	6,360	6,360	6,360

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

Formula (13) AM22v4

$$E_{CH_4_lagoon_BL} - (E_{CH_4_lagoon} + E_{CH_4_nawtf} + E_{CH_4_coll})$$

Formula 13	2004	2005	2006	2007	2008	2009	2010	2011	2012
=	8,235	5,140	-16,194	3,681	3,681	3,681	3,681	3,681	3,681
E _{CH₄_lagoon_BL}	62,997	68,196	90,638	92,021	92,021	92,021	92,021	92,021	92,021
E _{CH₄_lagoon}	33,739	41,287	-	-	-	-	-	-	-
E _{CH₄_NAWTF}	-	-	-	-	-	-	-	-	-
E _{CH₄_Coll}	21,023	21,769	106,832	88,340	88,340	88,340	88,340	88,340	88,340

Any positive difference between emissions of CH₄ from the lagoon and emissions from the digester and the lagoons in the project situation are to be deducted from the emission reduction estimate.

Conservative emission reduction estimate:

	2004	2005	2006	2007	2008	2009	2010	2011	2012
ER _{conservative}	15,653	20,229	91,885	86,833	99,955	99,955	99,955	99,955	99,955
ER	23,888	25,368	91,885	90,514	103,636	103,636	103,636	103,636	103,636
Conservativeness estimate (from 13)	8,235	5,140	-16,194	3,681	3,681	3,681	3,681	3,681	3,681

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

Year	Estimation of project activity emissions (tonnes of CO ₂ eq)	Estimation of Baseline emissions (tonnes of CO ₂ eq)	Estimation of emission reductions (tonnes of CO ₂ eq)	Conservative estimation of emission reductions (tonnes of CO ₂ eq)
2004	40,521	64,409	23,888	15,653
2005	45,394	70,763	25,368	20,229
2006	13,770	105,655	91,885	91,885
2007	11,575	102,089	90,514	86,833
2008	6,360	109,997	103,636	99,955
2009	6,360	109,997	103,636	99,955
2010	6,360	109,997	103,636	99,955
2011	6,360	109,997	103,636	99,955
2012	6,360	109,997	103,636	99,955
2013	6,360	109,997	103,636	99,955
Total	149,423	1,002,896	853,473	814,333

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

Project emissions are monitored in accordance with the AM0022 v4 prescribed monitoring method.

**B.7.1 Data and parameters monitored:**

Data/Parameter	AM0022 ID 1 Wastewater flows entering the project treatment facility
Data unit	m3 / year
Description	The volume of wastewater flows entering into the new anaerobic digestion system
Source of data to be used	Measured by project operator
Value of data applied for the purpose of calculating expected emission reductions in section B.5	UASB1: 495,467 UASB2: 824,402
Description of measurement methods and procedures to be applied:	Measured continuously by flow meters.
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards.
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	AM0022 ID 2 Wastewater flows leaving the project treatment facility
Data unit	m3 / year
Description	The volume of wastewater flows leaving the new anaerobic digestion system
Source of data to be used	Established using ID 1 and assuming hydrological balance
Value of data applied for the purpose of calculating expected emission reductions in section B.5	UASB1: 495,467 UASB2: 824,402
Description of measurement methods and procedures to be applied:	Assumed hydrological balance and using metered data from ID 1.
QA/QC procedures to be applied:	
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	AM0022 ID 3 Wastewater organic material concentration entering the project treatment facility
Data unit	kg COD / m3
Description	COD concentration of the wastewater entering the new anaerobic digestion system
Source of data to be used	Measured by project operator
Value of data applied for the purpose of calculating expected emission reductions in section B.5	16.8
Description of measurement	Daily sampling of the untreated process effluent. COD concentration



methods and procedures to be applied:	is analyzed daily at the Project site.
QA/QC procedures to be applied:	Sampling and analysis will be carried out adhering to internationally recognized procedures
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	AM0022 ID 4 Wastewater organic material concentration leaving the project treatment facility
Data unit	kg COD / m ³
Description	COD concentration of the wastewater leaving the new anaerobic digestion system
Source of data to be used	Measured by project operator
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.339
Description of measurement methods and procedures to be applied:	Daily sampling of the UASB reactor effluent. COD concentration is analyzed daily at the Project site.
QA/QC procedures to be applied:	Sampling and analysis will be carried out adhering to internationally recognized procedures
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	AM0022 ID 5 Volume of biogas sent to facility heaters
Data unit	Nm ³ biogas
Description	Volume of biogas sent to facility heaters
Source of data to be used	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	8,364,074
Description of measurement methods and procedures to be applied:	Measured continuously by flow meter GM3
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	AM0022 ID 6 Blank
Data unit	
Description	
Source of data to be used	
Value of data applied for the	



purpose of calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	
QA/QC procedures to be applied:	
Any comment	

Data/Parameter	AM0022 ID 7 Electricity generated from collected biogas
Data unit	MWh
Description	Electricity generated from the biogas collected in the anaerobic treatment facility and consumed on site or sent the grid
Source of data to be used	N/A
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	N/A
QA/QC procedures to be applied:	Electricity meters would undergo maintenance / calibration subject to appropriate industry standards.
Any comment	Project does not include power generation.

Data/Parameter	AM0022 ID 8 F: Fossil fuel volume equivalent to generate the same amount of heat generated from the biogas collected in the anaerobic treatment facility
Data unit	Liters per year
Description	Fossil fuel volume equivalent to generate the same amount of heat generated from the biogas collected in the anaerobic treatment facility
Source of data to be used	Calculated using ID 5, ID 15, ID 19
Value of data applied for the purpose of calculating expected emission reductions in section B.5	4,279,625
Description of measurement methods and procedures to be applied:	Measurements and procedures related to ID 5, 15, 19 and calculation
QA/QC procedures to be applied:	
Any comment	The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.



Data/Parameter	AM0022 ID 9 Biogas sent to flares (V1)
Data unit	Nm3 biogas
Description	Surplus biogas sent to flare system (wet basis)
Source of data to be used	Calculated from gas production meters for UASB 1 and UASB 2 (GM 1 plus GM 2) minus gas meter to boiler (GM 3) and pipe leakage assumption, adjusted for dry gas conditions.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	2,566,871
Description of measurement methods and procedures to be applied:	Estimated using mass balance and piping losses. A wetness factor of 0.75 from the gas meter calibration report is applied to convert this value to dry basis.
QA/QC procedures to be applied:	
Any comment	

Data/Parameter	AM0022 ID 10 Biogas sent to generation
Data unit	Nm3 biogas
Description	Biogas sent to generation facility and used for electricity generation
Source of data to be used	Measured by project developer using GM 3
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:	Would be measured continuously by flow meters
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards
Any comment	Does not apply as project does not include power generation from biogas.

Data/Parameter	AM0022 ID11 Biogas methane concentration
Data unit	%
Description	Methane concentration in biogas
Source of data to be used	From calibration report of gas meter GM3
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.65
Description of measurement methods and procedures to be applied:	For this verification period, a measured value of 65% was applied (determined by independent laboratory). Future measurement will be based on near infrared spectrometry.
QA/QC procedures to be applied:	A to be installed near infrared spectrometry will undergo maintenance / calibration subject to appropriate industry standards



Any comment	
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Data/Parameter	AM0022 ID 12 Project emissions from flaring of the residual gas stream (PEflare)
Data unit	t CO ₂ e
Description	Project emissions from flaring of the residual gas stream
Source of data to be used	Measured/Calculated using biogas production data from reactors measured with meters GM 1 + GM 2 minus biogas use data measured with meter GM 3. Pipe leakage assumed to be zero as piping is shorter than 2 km. a wetness factor of 0.75 is applied.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	9,408
Description of measurement methods and procedures to be applied:	Calculated using mass balance from gas flow meters and CDM calculation tool “Tool to determine project emissions from flaring gases containing methane”.
QA/QC procedures to be applied:	
Any comment	No separate gas flow meter is in front of the flare. No transmission losses are assumed, therefore mass balance from meter readings at reactor and before boiler are adequate. The value applied for the purpose of ex-ante estimation was calculated using operating data from 2006.

Data/Parameter	AM0022 ID 13 Amount of chemical oxidising agents entering system boundary
Data unit	tonnes/m ³
Description	Amount of chemical oxidising agents entering system boundary
Source of data to be used	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	Continuously monitored whether oxidative chemical species are utilized in the process.
QA/QC procedures to be applied:	Regular samples will test for concentration of oxidising agents where they are identified as being likely to be present in wastewater when they are part of the process
Any comment	

Data/Parameter	AM0022 ID 14 Gen set combustion efficiency (f)
Data unit	%
Description	Proportion of biogas combusted by generation facility
Source of data to be used	Measured by project developer
Value of data applied for the purpose of calculating expected	N/A



emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	N/A
QA/QC procedures to be applied:	N/A
Any comment	

Data/Parameter	AM0022 ID 15 Heating system combustion efficiency
Data unit	%
Description	Proportion of biogas combusted by heating system facility (hot oil and steam boilers)
Source of data to be used	Default value as no supplier specification is available
Value of data applied for the purpose of calculating expected emission reductions in section B.5	100%
Description of measurement methods and procedures to be applied:	Heating system efficiency was determined during commissioning.
QA/QC procedures to be applied:	Calculation was conducted on the basis of standard industry practice.
Any comment	

Data/Parameter	AM0022 ID 16 Flow of wastewater directly to the current wastewater treatment system
Data unit	m ³
Description	Volume of flow of wastewater directly to the current wastewater treatment system and bypassing the new wastewater treatment facility
Source of data to be used	Measured by project developer using FM 2 since 2006 and estimated on the basis of hydrological balance analysis and benchmark data for water use in starch production for 2004 and 2005.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	2004: 8994 t COD/a 2005: 10713 tCOD/a 2006 and all following years: 0
Description of measurement methods and procedures to be applied:	Bypass flow is measured by an electromagnetic flow meter. This meter is not in use as all waste water is send to the reactor. Estimate for 2004 and 2005 based on starch production data, WW _{input} data when all WW was treated in reactor (WW _{bypass} was zero) in 2006 and 2007, application of benchmark value for total water use and hydrological balance $WW_{bypass} = WW_{total} - WW_{input}$.
QA/QC procedures to be applied:	
Any comment	



Data/Parameter	AAM0022 ID 17 Loss of biogas from pipeline
Data unit	tCO _{2e}
Description	Loss of biogas from pipeline
Source of data to be used	Estimated, spot checks using mobile leak detector
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	Integrity of biogas pipeline for losses is checked using mobile gas leak detector. If necessary volume of losses are then estimated through pressurizing the system and establishing pressure drops through leakage.
QA/QC procedures to be applied:	Checks to be carried out to international standards if there is indication for leakage.
Any comment	

Data/Parameter	AM0022 ID 18 Organic material removed from wastewater facility
Data unit	t COD
Description	Organic material removed from wastewater facility
Source of data to be used	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	Removal of COD after monitoring and prior to entry to the lagoon system should be recorded to ensure CH ₄ emissions are not overestimated. This may be material screened out after the wastewater concentration is recorded.
QA/QC procedures to be applied:	
Any comment	

Data/Parameter	AM0022 ID 19 Biogas calorific value
Data unit	J/Nm ³
Description	Calorific value of biogas
Source of data to be used	Measured by project developer through laboratory analysis during commissioning and annually
Value of data applied for the purpose of calculating expected emission reductions in section B.5	23205
Description of measurement methods and procedures to be applied:	IPCC default, taken from registered AM0022 project activity in Thailand.
QA/QC procedures to be applied:	



Any comment	
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**B.7.2 Description of the monitoring plan:****1. Monitoring Management**

The required monitoring equipment is installed by the BOT operator. Flow meters are regularly calibrated to recognized procedures by the operator (who is also the turn-key supplier of technology) and sampling is carried out by the onsite Biogas Lab Manager according to appropriate industrial standards.

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

The plant is operated by two trained operators who also collect data under the supervision of the Assistant Plant Manager who is in charge of filing and processing data.

2. Quality Assurance and Quality Control

The Plant Manager monitors overall performance of the plant, ensures proper and timely calibration, data acquisition and storage.

3. On-site Procedures

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

Procedures for Calibration of Equipment

The plant operator carries out calibration according to international standards.

4. Data Storage and Filing – Electric Workbook

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

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

>>

Completion date: 20/06/2007

by

Ingo Puhl

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Switzerland

**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:**

Commissioning of first UASB reactor: 1st Jan 2004

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

21 years

C.2 Choice of the crediting period and related information:**C.2.1. Renewable crediting period****C.2.1.1. Starting date of the first crediting period:**

January 2004

C.2.1.2. Length of the first crediting period:

7 years

SECTION D. Environmental impacts

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

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The project does not lead to any additional emissions. No EIA was required.

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:

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The proposed project is not required to undertake an Environmental Impact Assessment according to the Thailand regulations (<http://www.onep.go.th/eia/>). No negative environmental effects are expected from implementation of the project.

SECTION E. Stakeholder Comments

Not applicable

**Annex 1****CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY**

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Represented by:	Mr. Prayut Vitthayanukorn
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Salutation:	
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funding is involved in the project

Annex 3**BASELINE INFORMATION**Calculation of EF_{CH_4}

The CH_4 emissions factor for tapioca starch wastewater is calculated from 12 months of operating data (2006) from the project on a weight average basis and using the following formula:

$$EF_{CH_4} = \text{produced biogas (Nm}^3/\text{a)} * \text{average } CH_4 \text{ concentration (Nm}^3 \text{ } CH_4/\text{Nm}^3 \text{ biogas)} / (\text{COD in} - \text{COD out})$$

To ensure conservativeness, the methane conversion factor (MCF) must be below 1 whereby MCF is calculated as:

$$MCF = E / B_0$$

Whereby B_0 is the maximum theoretical methane producing capacity (kg CH_4 /kg COD) and MCF is representing the proportion of COD that is likely to degrade to form methane in reality.

	UASB 1			UASB 2			Total			
	COD _{in}	COD _{out}	Gas produced	COD _{in}	COD _{out}	Gas produced	COD _{in}	COD _{out}	Gas produced	%CH ₄
	kg/month	kg/month	Nm ³ /month	kg/month	kg/month	Nm ³ /month	kg/month	kg/month	Nm ³ /month	
Jan-06	463,178	24,827	169,807	891,369	70,123	548,481	1,354,546	94,949	718,288	65%
Feb-06	567,331	20,430	295,784	1,217,538	74,605	593,202	1,784,869	95,035	888,986	65%
Mar-06	946,880	53,564	340,620	1,126,679	95,518	491,593	2,073,559	149,083	832,213	65%
Apr-06	942,100	41,160	441,417	1,363,091	65,552	595,097	2,305,191	106,712	1,036,514	65%
May-06	883,636	24,415	548,355	955,344	40,161	609,576	1,838,980	64,575	1,157,931	65%
Jun-06	884,084	25,222	591,811	709,399	23,970	476,918	1,593,483	49,191	1,068,729	65%
Jul-06	426,760	11,607	233,678	762,257	30,517	532,449	1,189,017	42,123	766,127	65%
Aug-06	671,392	16,993	271,350	1,276,793	50,376	512,178	1,948,185	67,369	783,528	65%
Sep-06	570,797	14,053	265,461	1,165,938	48,757	384,209	1,736,735	62,810	649,670	65%
Oct-06	472,612	7,500	241,814	1,353,829	55,513	644,518	1,826,441	63,013	886,332	65%
Nov-06	690,654	12,589	319,519	1,510,704	63,764	749,445	2,201,358	76,353	1,068,964	65%
Dec-06	805,801	22,454	416,333	1,408,827	83,691	657,330	2,214,629	106,144	1,073,663	65%
						Totals	22,066,994	977,358	10,930,945	65%
									EFCH₄	0.241

The resulting $MCF = 0.241/0.25 = 96\%$ which is smaller than 1 (100%) and represents the proportion of COD that has been degraded in the biogas reactor and formed methane.

The actual performance is above the design performance: design performance is the value guaranteed by the equipment supplier and is therefore conservative. Actual performance is expected to be above design performance.

Table: wastewater characteristics (design)

COD removal Efficiency of UASB system	90	%
COD (before UASB system)	25,000	mg/liter
COD (after UASB system)	2,500	mg/liter
Effluent flow	5,000	m ³ /day
Annual COD load to lagoons before UASB system implementation	17,500,000	Kg COD/a



Annual COD load to lagoons after UASB system implementation	1,750,000	Kg COD/a
Plant operation	350	Days/a

Source: Plant operator

Table: wastewater characteristics (from 2006 operating data)

COD removal Efficiency of UASB system	96%	%
COD (before UASB system)	16,719	mg/liter
COD (after UASB system)	740	mg/liter
Effluent flow	3,939	m3/day
Annual COD load to lagoons before UASB system implementation	22,066,994	Kg COD/a
Annual COD load to lagoons after UASB system implementation	977,358	Kg COD/a
Plant operation	335	Days/a

Source: Plant operator

Table: Lagoon characteristics

Lagoon Depth	5 – 10	M
Area	16	Ha
Minimum Lagoon Temperature (2005)	25	Degree Celsius
Minimum Ambient Temperature (2005)	35	Degree Celsius

Organic material removal ratio for lagoons based on the historical lagoon COD data

Organic material removal ration for lagoons is based on measurements taken from registered project no 1040 Korat Waste to Energy. The applied value is 87.88% which is based on a measurement calculated as the difference between observed COD values behind the static screen and sump at exit of pond 4.

Table: Specifications of displaced fuel

	Density	Net calorific value	Net calorific value	Carbon emission factor	Oxidation factor
Fuel type	Kg/1000 l	TJ/Nm3	TJ/kt	tC/TJ	%
Data source			IPCC	IPCC	IPCC
Heavy fuel oil	880		40.19	21.1	0.99



Annex 4

MONITORING INFORMATION

Attached as separate excel file