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

CONTENTS

Annexes

Abbreviations

CIGAR	Covered In-Ground Anaerobic Reactor
COD	Chemical Oxygen Demand
GHG	Greenhouse gas
IRR	Internal rate of return
SQS	Siam Quality Starch Co., Ltd.

SECTION A. General description of project activity

A.1 Title of the project activity:

Siam Quality Starch Wastewater Treatment and Energy Generation Project in Chaiyaphum, Thailand (the Project)

Version 1.0 31/08/2007

A.2. Description of the project activity:

Siam Quality Starch Co., Ltd. (SQS) manufactures Native and Modified Starch, extracted and refined from tapioca root, at its starch factory in Chaiyaphum Province, in the North Eastern region of Thailand. The production of starch, totalling about 200,000 tonnes annually, produces a large amount of high organic content wastewater, which emits methane when treated in anaerobic open lagoons prior to land application in eucalyptus plantations that surround the lagoons, on-site.

The Project, to be carried out by SQS at its starch factory, is the installation and operation of an anaerobic digestion and methane recovery system for the treatment of wastewater coupled with an energy generation system. In the absence of the Project, the wastewater will be treated in a series of anaerobic open lagoons, emitting methane during the long decomposition process. The captured methane will be destructed in boilers totalling 17.068MW_{th} for the production of hot thermal oil for use in heating air in process dryers.

The Project will therefore be responsible for two types of emission reductions. The first is the avoidance of methane, a potent greenhouse gas (GHG), that would be emitted from the baseline open lagoons, through its capture and destruction. The second is the displacement of bunker oil by the Project's carbon neutral energy, which will result in the reduction of carbon dioxide emissions from the combustion of bunker oil. The project activity is expected to reduce GHGs by an average of about 100,000 tonnes annually.

The Project contributes to sustainable development of Thailand in the following ways:

- Improvement of local air quality. Apart from the reduction in GHGs, the Project will improve the environmental performance of SQS's starch factory by reducing the COD load of effluent entering the open lagoons. Organic effluent treated in open lagoons not only emits a large amount of methane, a flammable gas, but also produces a strong pungent stench. By using the captured methane for energy generation and reducing fossil fuel consumption, the Project will also reduce emissions associated with the burning of fossil fuels.

- Reduction in reliance of fossil fuels. The project activity will displace internal bunker oil consumption. While the Project's fossil fuel consumption is small as compared to power plants, it is nevertheless significant in that the replication of such projects nation-wide will amount to a large reduction in the long term.

A.3. Project participants:

Table 1: Table of project participants

Name of Party involved	Private and/or public entity (ies) project participants	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Thailand (host)	Siam Quality Starch Co., Ltd.	No
Japan	Mitsubishi UFJ Securities Co., Ltd.	No

Siam Quality Starch Co., Ltd. (SQS)

SQS is a Thai-based producer of starch since 1995 and is a major producer of tapioca starches in the Asia Pacific, with its products distributed both locally and internationally to destinations including USA, Japan, Europe, Australia and New Zealand. SQS specializes in producing premium quality, food-grade native and modified tapioca starches.

SQS is implementing the project activity.

Mitsubishi UFJ Securities Co., Ltd. (MUS)

Through its Clean Energy Finance Committee, MUS provides consulting services to promote Clean Development Mechanism (CDM) and Joint Implementation (JI) projects. MUS is the CDM advisor to the Project and the contact for the project activity.

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Thailand

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

Chaiyaphum Province

A.4.1.3. City/Town/Community etc:

Village 10, Tambol Khokrerngrom, Ampher Bumnetnarong

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

Chaiyaphum Province is approximately 340 km kilometres north-east of Bangkok and has an area of 12,778 km^2, sharing borders with the Khon Kaen, Nakhon Ratchasima, Lopburi and Phetchabun Provinces. The major industry is agriculture, with principal crops including rice, tapioca, sugar cane and some maize.

The factory is located on Route 205 in the South Eastern corner of Chaiyaphum Province, about 10 km West of the nearest township of Kham Ping. The area is completely agricultural, with rice grown in low-lying areas and tapioca or sugar cane grown on higher, dryer ground. Kham Ping consists mainly of a cluster of businesses around an intersection existing to serve the agricultural community plus the Ampher Bumnetnarong Hospital.

Figure 1: Map of Thailand with Chaiyaphum Province highlighted (Courtesy of Wikipedia)

Figure 2: Map of Chaiyaphum Province (Courtesy of sawadee.com)

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

The Project fits under the following two categories of project activity:

- Sectoral Scope 1
  Energy industries (renewable / non-renewable sources)

- Sectoral Scope 13
  Waste handling and disposal

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

Wastewater treatment system:

Under the project activity, the wastewater will be treated with a Covered In-Ground Anaerobic Reactor (CIGAR) with a useable volume of 90,000 m^3. In the digester, the organic compounds in the wastewater are broken down with the help of anaerobic bacteria, which thrive in the absence of oxygen. The digester is lined with high density polyethylene (HDPE) to prevent both the biogas and wastewater from leaking.

The wastewater is treated in the anaerobic digester for 10 to 15 days, reducing the Chemical Oxygen Demand (COD) load by approximately 80%, and the biogas recovered, before the wastewater is discharged for further treatment in the existing open lagoons.

After lagoon treatment, the final effluent is pumped via underground piping to the surrounding eucalyptus plantation, which covers approximately half of the 120+ hectares of the SQS premises. The method of final discharge remains the same before and after the project activity.

A relatively small amount of sludge is removed infrequently from the existing open lagoons. When sludge is removed, it is given to local farmers for application on tapioca fields as fertilizer.

Energy generation system:

The boilers in the starch plant were originally four thermal oil heaters with a 2 x 3,300kW and 2 x 5,234kW configuration, designed to burn fuel oil. Under the Project, the 2 x 5,234kW burners are retrofitted with “RAY” dual fuel burners such that the boilers can be co-fired using the biogas collected in the CIGAR system. The 2 x 3,300kW burners are completely replaced by new 2 x 5,234kW burners, both in order to allow dual fuel injection and to cater for biogas, which has a low heat content by volume.

Excess biogas flare:

The biogas flare is designed to ignite on overpressure of the biogas supply to the boilers, although it can be operated with a nominal flow to enable a constant flare and reduce the risk of ignition failure. While it has the capacity to handle up to 50% of the biogas flow, under normal operation the flare is not utilized.

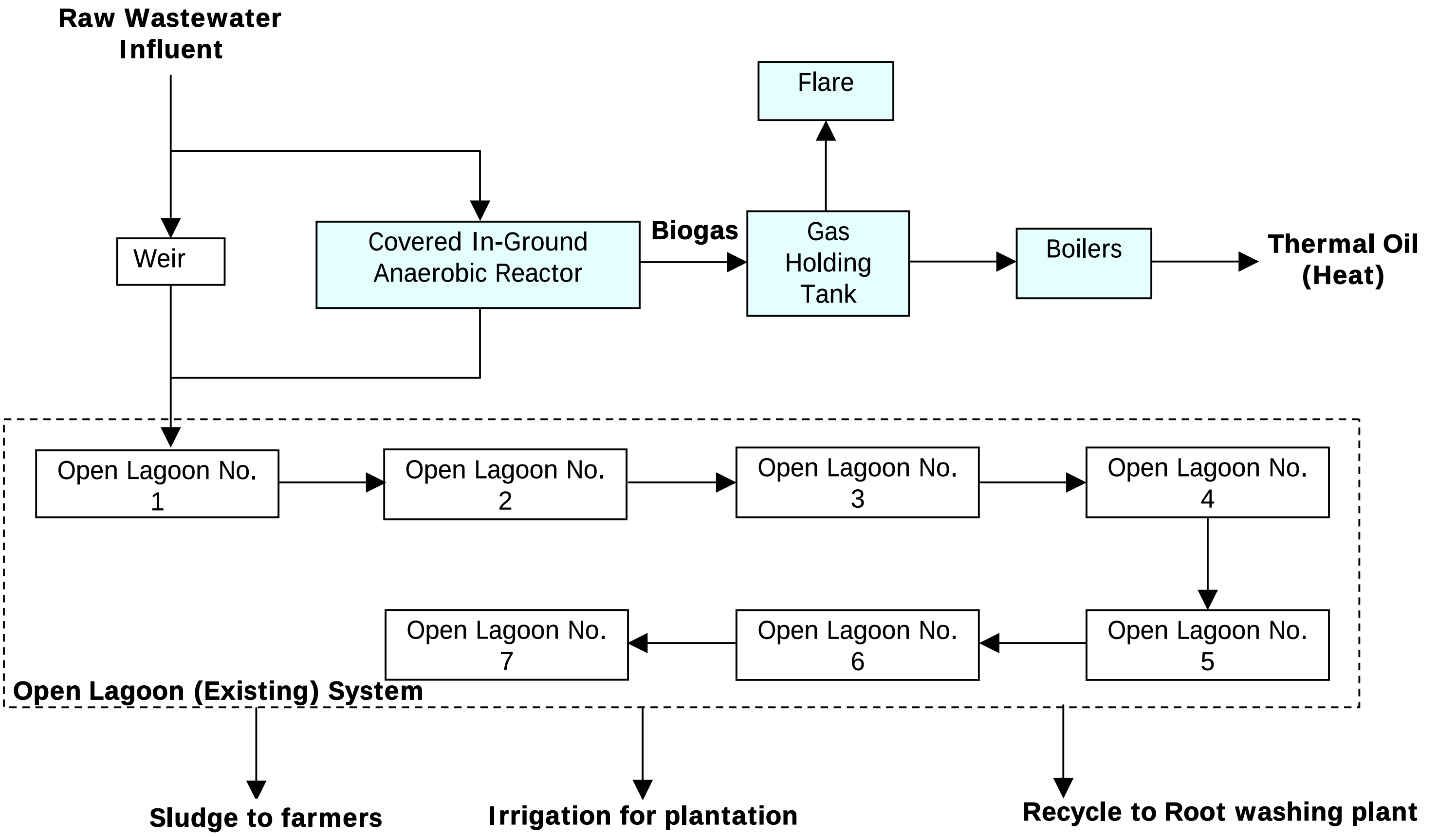

Figure 3: Simple process diagram of Project's wastewater treatment and energy generation systems (additions due to project activity coloured)

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

The estimated amount of emission reductions over the crediting period is shown below.

Table 2: *Ex ante* estimation of emission reductions

Years	Estimation of annual emission reductions in tonnes of CO_2e
2008	99,443
2009	99,443
2010	99,443
2011	99,443
2012	99,443
2013	99,443
2014	99,443
2015	99,443
2016	99,443
2017	99,443

Total estimated reductions (tonnes of CO_2e)	994,430
Total number of crediting years	10
Annual average of the estimated reductions over the crediting period (tCO_2e)	99,443

A.4.5. Public funding of the project activity:

The Project does not involve funding from an Annex I country.

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:

The following two approved baseline and monitoring methodologies are applied.

- AM0013: "Avoided methane emissions from organic waste-water treatment"
  Version 04, valid from 22 December 2006

- AMS-I.C. "Thermal energy for the user"
  Version 12, valid from 10 August 2007

For the purpose of establishing additionality, Version 03 of the *Tool for the demonstration and assessment of additionality* ("Additionality Tool") is also used.

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

The Project meets all the applicability conditions of the methodologies, as described below.

Table 3: Applicability conditions for AM0013

	Applicability condition	Project case
1	The existing waste water treatment system is an open lagoon system with an 'active' anaerobic condition, which is characterized as follows: • The depth of the open lagoon system is at least 1m; • The temperature of the anaerobic lagoons is higher than 10°C. If the average monthly temperature in a particular month is less than 10°C, this month is not included in the estimations, as it is assumed that no anaerobic activity occurs below such temperature. • The residence time of the organic matter should be at least 30 days.	SQS's wastewater treatment system in the absence of the Project is an actively anaerobic open lagoon system where: • The seven open lagoons all have a depth of at least 1m; • The temperature of the anaerobic lagoons is higher than 10°C. The mean temperatures in Chaiyaphum range from 24°C to 30°C[1]. • The residence time of the organic matter in open lagoons is approximately 40 to 45 days.
2	Sludge produced during project activity is not stored onsite before land application to avoid any possible methane emissions from anaerobic degradation.	Sludge, which is removed infrequently, is not stored onsite. They are given away to nearby farmers.

Table 4: Applicability conditions for AMS-I.C.

Applicability condition	Project case

[1]weather.com, accessed March 2007.

1	This category comprises renewable energy technologies that supply individual households or users with thermal energy that displaces fossil fuels. Examples include solar thermal water heaters and dryers, solar cookers, energy derived from renewable biomass for water heating, space heating, or drying, and other technologies that provide thermal energy that displaces fossil fuel. Biomass-based cogenerating systems that produce heat and electricity for use on-site are included in this category.	The project activity involves the supply to users of thermal energy derived from renewable biogas that displaces fossil fuels, namely, fuel oil.
2	Where generation capacity is specified by the manufacturer, it shall be less than 15MW.	See 3. below.
3	For co-generation systems and/or co-fired systems to qualify under this category, the energy output shall not exceed 45 $MW_{thermal}$ e.g. for a biomass based co-generating system the capacity for all the boilers affected by the project activity combined shall not exceed 45 $MW_{thermal}$. In the case of the co-fired system the installed capacity (specified for fossil fuel use) for each boiler affected by the project activity combined shall not exceed 45 $MW_{thermal}$.	The capacity of the boilers total 17.068MW_{th} and will be co-fired with fuel oil.
4	In the case of project activities that involve the addition of renewable energy units at an existing renewable energy facility, the added capacity of the units added by the project should be lower than 45 $MW_{thermal}$ and should be physically distinct from the existing units.	Not applicable. The project activity does not involve the addition of renewable energy units at an existing renewable energy facility.

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

As per the methodology, the project boundary includes the existing waste water treatment plant, where sludge is degraded in open sludge lagoons under mainly anaerobic conditions. The following emission sources are included:

Table 5: Sources and gases in the project boundary

Source		Gas	Included/Excluded	Justification / Explanation
Baseline	Direct emissions from the waste treatment processes	CH_4	Included	The major source of emissions in the baseline
		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 / generation	CO_2	Excluded	Not applicable to the Project.
		CH_4	Excluded	

		N_2O	Excluded	
	Emissions from thermal energy generation	CO_2	Included	Thermal energy generation is included in the project activity
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
Project activity	On-site fossil fuel consumption due to the project activity	CO_2	Included	May be an important emission source
		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.
	Emissions from on-site electricity use in the digester auxiliary equipment	CO_2	Included	May be an important emission source. If electricity is generated from collected biogas, these emissions are not accounted for.
		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.
	Direct emissions from the waste treatment processes	N_2O	Excluded	Excluded for simplification. Not an important emission source.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted.
		CH_4	Included	The emission from uncombusted methane and also leakage in case of anaerobic digesters. In case of dewatering and land application, conservative estimates of methane are included.

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

The most plausible baseline scenario is identified in the following steps:

- Step I. Identification of all plausible alternatives to the Project;
- Step II. Narrowing down of the alternatives through barrier assessment.
- Step III. Confirmation by applying the latest version of the "Tool for demonstration and assessment of additionality"

Step I. Identification of all plausible alternatives to the Project

The alternative scenarios available to SQS and that provide comparable outputs to the Project are summarized in the table below.

Table 6: List of plausible alternatives to the Project

Alternative	Wastewater treatment	Biogas usage	Description of alternative scenario
A	Sequential treatment using CIGAR system and existing open lagoon	Used to produce process heating	The Project undertaken without being registered as a CDM project activity
B	Sequential treatment using CIGAR system and existing open lagoon	Not utilized	The wastewater treatment method is the same as the Project, but does not include biogas utilization and hence smaller capital cost
C	Sequential treatment using anaerobic/aerobic system other than CIGAR and existing open lagoon	Used to produce process heating or not utilized (in the case of aerobic system)	This alternative involves an upgrade to a wastewater treatment system with comparable results to the Project
D	Open lagoons	Uncontrolled release into the atmosphere	This is the continuation of current practice
E	Open lagoons in short- to medium-term, upgrade to sequential treatment using CIGAR system and existing open lagoon in future	Uncontrolled release into the atmosphere in short- to medium-term, used to produce process heating in future	This is the continuation of current practice, with the Project undertaken without being registered as a CDM project activity in the future

Step II. Narrowing down of the alternatives through barrier assessment

Of the five alternatives identified in Step I above, all but Alternative D, the continuation of current practice, can be immediately ruled out as plausible alternatives, as delineated below.

Alternative A: As further discussed in Section B.5 below, this alternative involves high risk and upfront capital cost that is not acceptable to SQS in the absence of the CDM.

Alternative B: This is a less advantageous option as compared to Alternative A. While the upfront cost is lower, not only does this alternative involve the same high risks, but there is no cost recovery in the form of reduced fossil fuel consumption.

Alternative C: This is also a less advantageous option as compared to Alternative B. While this alternative provides a comparable output, the CIGAR system utilized in Alternative A is one of the less cost intensive options available for the treatment of wastewater. A more technologically advanced system may provide greater process stability and potentially higher biogas yield, however, the cost was considered too high by SQS to warrant the risky investment.

Alternative D: This is the continuation of current practice. SQS' original plan prior to the decision to proceed with the CDM project activity was to continue treatment of its wastewater in the existing lagoons, and to increase the capacity of the open lagoons either by increasing the number of ponds or increasing the volume of each pond as necessary to cater for any increase in starch production capacity.

Alternative E: This alternative involves the implementation of the Project without the assistance of the CDM not immediately but in the future. For the same reasons outlined for Alternative A, this alternative was not acceptable to SQS. In addition, as briefly discussed in Alternative D, the project circumstances will remain the same in the future, as the SQS starch factory has an abundance of land such that any increase in production capacity or tightening of discharge limits can be catered for by simply increasing the capacity of the open lagoons.

Therefore, the most plausible baseline scenario is Alternative D, the continuation of current practice. This conclusion will be reinforced in the assessment of additionality in the ensuing section.

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 Project's additionality is demonstrated by applying the latest version of the "Tool for the demonstration and assessment of additionality" (Version 03), which is consistent with Option B of the methodology.

Step 1. Identification of alternatives to the project activity consistent with current laws and regulations

Realistic and credible alternatives to the project activity is identified in this step through the following sub-steps.

Sub-step 1a. Define alternatives to the project activity

See Section B.4. The most plausible baseline scenario is the continuation of current practice.

Sub-step 1b. Consistency with mandatory laws and regulations

All alternatives identified are consistent with mandatory laws and regulations.

Step 2. Investment analysis

The IRR is chosen as the most suitable indicator. As per the Tool, the equity IRR will be used as there is only one possible developer.

Sub-step 2a – Determine the appropriate analysis method

As the CDM project activity generates financial benefits in the form of reduced consumption of fuel oil, the simple cost analysis is not appropriate. Of the remaining investment comparison analysis and benchmark analysis, the benchmark analysis is chosen.

Sub-step 2b – Option III. Apply benchmark analysis

At the time the Project was being considered by SQS in 2003, the internal benchmark IRR used was 20%, taking into account SQS internal policies and factors such as risk to factory operation. If retrospectively, one applies the benchmark analysis, a premium would have been added to the government bond rate of a little above 4% at the time, to reflect risks to private sector investment and the significant risk inherent to using an unfamiliar technology, particularly in view of the potential to adversely affect the core business at SQS. This would have resulted in a benchmark of between 15% and 20%. For conservatism, an IRR of 15% is adopted.

Sub-step 2c – Calculation and comparison of financial indicators

The following table summarizes the Project's IRR calculation, including all assumptions made.

Table 7: Assumptions and results for calculation of the Project's IRR

Input Parameters		Value	Unit	Notes
Total cost for CDM project activity		75,000,000	THB	
Loan	Equity percentage	100	%	
	Interest rate	N/A		
	Loan period	N/A		
Annual costs	Operation and Maintenance	3,750,000	THB/year	5% of total cost
	Cost of chemicals	5.5	THB/m^3 effluent	To maintain optimal digester operation
Fuel savings		7.77	THB/litre	5-year average oil price from 1999 – 2003
Depreciation	Depreciation rate	5,769,231	THB/year	
	Salvage value	5,769,231	THB	
	Salvage year	12		
Tax rate		30	%	Applied to increased profit from fuel savings
Project life		12	years	
Operating parameters	Operating days in year	330	days	
	COD load of raw effluent	15.0	kg/m^3	Based on historic records
	COD treatment efficiency	80	%	From technology provider (mid-range values adopted)
	Biogas generation rate	0.4	m^3/kgCOD	
	Biogas methane content	50	% by volume	
	Biogas leakage from digester	15	%	Assumption
	Methane energy content	36.3	MJ/m^3	
	Flare rate	0		For normal operation
	Fuel oil heat value	41	MJ/l	From SQS
IRR		8.68	%	

As can be seen in the above table, the IRR of the Project if carried out under business-as-usual stands at 8.68%, well below the expected IRR of 15%.

Sub-step 2d – Sensitivity analysis

In order to test the robustness of the assumptions made, sensitivity analyses were carried out as follows:

1. 10% decrease in annual costs (O&M and chemicals). This is a realistic target that SQS is striving to achieve.
2. 20% increase in biogas capture. This is also a target that SQS is striving to achieve, by maximising the quality and stability of the biogas captured.
3. 4% increase in fuel prices. The price rise is based on the average annual price rise over the 5-year period between 1999 and 2003, as calculated in 2003.

The above changes in assumptions increased the IRRs for each of the cases to 10.40%, 14.79% and 14.51% respectively. The sensitivity analyses show that in spite of the range of realistic and optimistic assumptions made, the project returns remain unfavourable.

It is noteworthy that the COD loading of the wastewater is indirectly proportional to the extraction efficiency of the starch in the factory. Thus, maximizing the project activity's returns is at odds with maximizing profits from SQS' core business. Naturally, priority is given to running the core business of starch production, regardless of whether it results a lower COD load and therefore lower biogas yield. The possibility of lower biogas yields exacerbates the problem of a low IRR.

Step 3. Barrier analysis

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

The implementation of the Project requires an upgrading of skills for the proper operation and maintenance of the anaerobic digester, as well as the gas burners. There are numerous variables, such as the COD load of incoming wastewater and the temperature conditions that affect the quantity and quality of the biogas. As the quality of the biogas feed is crucial to the smooth operation of the burners, which in turn is important for the uninterrupted operation of the starch factory, the upgrading of skills is a significant challenge to SQS.

The challenge is even more significant when taking into account the context of the food processing industry, where very few plant owners have ventured into advanced technology for wastewater treatment. Indeed, it is understood that most projects which are now attempting to introduce this technology is doing so with the assistance of the CDM, while others did so with funding sources no longer available. Against this backdrop, the technology barrier faced by SQS is too high to justify the risk of going ahead under business-as-usual.

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)

The continuation of current practice does not require any upgrading of skills.

It is noted that with regards to the wastewater treatment system, SQS has abundant land as well as access to cheap land in the vicinity in order to expand its current

The wastewater treatment for the plant expansion could and would have been treated using the existing open lagoon system, either by increasing the number or volume of lagoons. This was what was envisaged when the budget for the plant expansion was originally established in 2003. SQS has access to over 120 ha of available land, more than enough to accommodate such an expansion.

It would have been much cheaper to implement this option, as SQS still has available land. It is also noted that the land around the SQS factory was and still is relatively cheap and available for purchase.

Thus, at least one option, the continuation of current practice, would not have been prevented by the barriers identified in Sub-step 3a.

Step 4. Common practice analysis

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

According to the Thai Tapioca Starch Association, there are 82 tapioca starch plants in Thailand. Of these, there are approximately 30 plants that have or have just completed the installation of biogas recovery systems.

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

Of all of these Projects, the majority of them have been implemented within the past three years. It is understood that these projects were commenced on the strong expectation, as is the case for SQS, of eventual Thai government approval.
The remaining projects were carried out with the assistance of grants and soft loans, which the other projects including SQS did not have access to.

Starting dates of the project activity and validation

It is required that where the starting date of the project activity falls before the date of validation, evidence is to be provided to show that the incentive from the CDM was seriously considered in the decision to proceed with the project activity. As given in Section C.1.1., the starting date of the project activity, here defined as the commissioning date, was March 2005, which is prior to commencement of the validation.

There is ample evidence to show that SQS seriously considered the CDM from the very early stages of the project development. The Project was considered only after it became known that the Korat wastewater project, the first wastewater-related project in Thailand, had started developing its project as a CDM. Various consultants emphasized the attractiveness of such a project due to the CER revenues, and there was much talk in the industry from all biogas digester suppliers. It is thought that all similar projects were developed with the same goal in mind. It is also worth noting that in 2003, SQS' joint venture partner of the time, AVEBE BA of The Netherlands, strongly recommended to proceed with the Project due to its CDM advantage.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

The emission reductions due to the Project is calculated in the following manner.

Equation 1

$$ER_y = BE_y - PE_y$$

where

Equation 2

$$BE_y = BE_{lagoon,y} + BE_{fuel\_oil,y}$$

and

Equation 3

$$PE_y = PE_{lagoon,y} + PE_{phys\_leak,y} + PE_{sludge,y} + PE_{dewater,y} + PE_{energy\_cons,y} + PE_{stack,y}$$

where

$BE_{lagoon,y}$	=	Baseline CH_4 emissions from the open lagoons in year *y* (tCO_2e/yr)
$BE_{fuel\_oil,y}$	=	Baseline CO_2 emissions from the combustion of fuel oil in year *y* (tCO_2/yr)
$PE_{lagoon,y}$	=	Project CH_4 emissions from the open lagoons in year *y* (tCO_2e/yr)
$PE_{phys\_leak,y}$	=	Project CH_4 emissions due to the physical leakage from the anaerobic digester in year *y* (tCO_2e/yr)
$PE_{sludge,y}$	=	Project CH_4 emissions from the land application of sludge in year *y* (tCO_2e/yr)
$PE_{dewater,y}$	=	Project CH_4 emissions from wastewater removed in the dewatering process in year *y* (tCO_2e/yr)
$PE_{energy\_cons,y}$		Project CO_2 emissions from the consumption of energy on the account of the project activity in year *y* (tCO_2/yr)
$PE_{stack,y}$	=	Project CH_4 emissions from incomplete combustion of biogas in the flare and boilers in year *y* (tCO_2e/yr)

In the Project's case, $PE_{dewater,y}$ is not relevant and so Equation 3 becomes:

$$PE_y = PE_{lagoon,y} + PE_{phys\_leak,y} + PE_{sludge,y} + PE_{energy\_cons,y} + PE_{stack,y}$$

No leakage is associated with the project activity.

The calculation method and input values of the baseline and project emissions are described in the ensuing tables.

Table 8: Formulae, input values and data sources for the calculation of $BE_{lagoon,y}$

Parameter	Description	Value	Source
Equation 4: $BE_{lagoon,y} = \sum_m \left(COD_{available,m} \times MCF_{baseline,m}\right) \times B_o \times GWP\_CH_4$			
$COD_{available,m}$	Monthly COD available for conversion which is equal to sum of the monthly COD entering the digester ($COD_{baseline,m}$) and the COD carried over from the previous month (kgCOD)	Calculated	Refer to Equation 5
$MCF_{baseline,m}$	Monthly methane conversion factor	Calculated	Refer to Equation 8

	for the open lagoons in the baseline case (fraction)		
B_o	Maximum methane producing capacity ($kgCH_4/kgCOD$)	0.21	AM0013
GWP_CH_4	Global warming potential for methane (tCO_2e/tCH_4)	21	AM0013, consistent with IPCC

Equation 5

$$COD_{available,m} = COD_{baseline,m} + COD_{carryover,m-1}$$

$COD_{baseline,m}$	Monthly COD of effluent entering lagoons (kgCOD)	Calculated	Refer to Equation 6
$COD_{carryover,m-1}$	COD that remains in the system from the previous month (kgCOD)	Calculated	Refer to Equation 7

Equation 6

$$COD_{baseline,m} = COD_{conc\_in,baseline,m} \times \left(1 - \frac{COD_{conc\_out,baseline,m}}{COD_{conc\_in,baseline,m}}\right) \times F_{digester} \times OP_m$$

			N/A
$COD_{conc\_in,baseline,m}$	COD concentration of effluent entering the lagoons in the baseline ($kgCOD/m^3$)	15	SQS, to be monitored
$COD_{conc\_out,baseline,m}$	COD concentration of final effluent in the baseline ($kgCOD/m^3$)	0.12	Maximum allowable level under government regulations
$F_{digester}$	Flow rate of wastewater fed in to the digester (m^3/day)	6,000	SQS, to be monitored. Total maximum raw effluent from the factory is 7,200m^3/day.
OP_m	Number of operation days in month (day)	Month – Op. Day Jan – 31 Feb – 28 Mar – 31 Apr – 30 May – 31 Jun – 30 Jul – - Aug – 31 Sep – 30 Oct – 31 Nov – 30 Dec – 31	SQS, to be monitored

Equation 7 $COD_{carryover,m-1} = \left[COD_{available,m-1} \times \left(1 - MCF_{baseline,m-1}\right)\right] - \left(Q_{sludge,m-1} \times COD_{conc\_sludge,m-1}\right)$			
$COD_{available,m-1}$	COD available in previous month (kgCOD)	Calculated	As per calculation of COD available,m
$MCF_{baseline,m-1}$	Monthly methane conversion factor for the open lagoons in the baseline case in previous month (fraction)	Calculated	Refer to Equation 8
$Q_{sludge,m-1}$	Amount of sludge removed in previous month (m^3)	100% of carry over removed annually	SQS, to be monitored. Sludge is currently removed less than once a year
$COD_{conc\_sludge,m-1}$	COD concentration of sludge removed in previous month (kgCOD/m^3)		
Equation 8 $MCF_{baseline,m} = f_d \times f_{t,m} \times 0.89$			
f_d	Fraction of anaerobic degradation as a function of depth (fraction)	0.7 (>5m) 0.5 (1 – 5m) 0 (<1m)	AM0013
$f_{t,m}$	Fraction of anaerobic degradation as a function of temperature, on a monthly basis, where $f_{t,m} \leq 1$ (fraction)	Calculated	Refer to Equation 9
Equation 9 $f_{t,m} = \exp\left(\frac{E \times \left(T_2 - T_1\right)}{R \times T_1 \times T_2}\right)$			
E	Activation energy constant (cal/mol)	15,175	Constant
T_2	Ambient temperature (°K)	Month / Temp: Jan 297.16 Feb 300.16 Mar 302.16 Apr 303.16 May 302.16 Jun 301.16 Jul 301.16 Aug 301.16 Sep 300.16 Oct 300.16 Nov 299.16 Dec 297.16	Based on ambient temperature records, to be monitored
T_1	Reference temperature (°K)	303.16	Constant
R	Ideal gas constant (cal/kmol)	1,987	Constant

Table 9: Formula, input values and data sources for the calculation of $BE_{fuel\_oil,y}$

Parameter	Description	Value	Source

$BE_{fuel\_oil,y} = Q_{fuel\_oil,y} \times CO_2EF_{fuel} \times OX_{fuel}$			Equation 10
$Q_{fuel\_oil,y}$	Quantity of fuel oil consumed in year *y* at the project site in the absence of the project activity (TJ)	146.62	SQS, to be monitored. Based on approximation of biogas energy content. Total fuel oil requirement in the absence of the project activity is 370TJ, which cannot be wholly replaced.
CO_2EF_{fuel}	CO_2 emission factor for thermal energy generation using fuel oil (tCO_2/TJ)	77.4	IPCC 2006 Table 2.2
OX_{fuel}	Oxidation factor for fuel oil (fraction)	1	IPCC 2006 Table 1.4

Table 10: Formula, input values and data sources for the calculation of $PE_{lagoon,y}$

Parameter	Description	Value	Source
$PE_{lagoon,y} = \sum_m \left(F_{dig\_out,m} \times COD_{conc\_dig\_out,m} \times OP_m \times MCF_{project,m}\right) \times B_o \times GWP\_CH_4$			Equation 11
$F_{dig\_out,m}$	Flow rate of wastewater in exiting the digester to enter the open lagoons in the project activity (m^3/day)	6,000	SQS, to be monitored
$COD_{conc\_dig\_out,m}$	Monthly COD of wastewater exiting the digester to enter the open lagoons in the project activity (kgCOD/m^3)	3.0	SQS, to be monitored
OP_m	See above	See above	See above
$MCF_{project,m}$	Monthly methane conversion factor for the open lagoons in the project case (fraction)	Calculated	Calculated as per Equation 8, where $MCF_{project,m}$ is analogous to $MCF_{baseline,m}$
B_o	See above	See above	See above
GWP_CH_4	See above	See above	See above

Table 11: Formula, input values and data sources for the calculation of $PE_{phys\_leak,y}$

Parameter	Description	Value	Source
$PE_{phys\_leak,y} = Q_{biogas\_total,y} \times w_{CH4} \times \rho_{CH4} \times LF \times GWP\_CH_4$			Equation 12
$Q_{biogas\_total,y}$	Quantity of biogas produced and collected in the digester in year *y* (m^3biogas/yr)	8,078,400	SQS, to be monitored

w_{CH4}	Fraction of CH_4 in biogas (m^3CH_4/m^3biogas)	0.5	SQS, to be monitored
ρ_{CH4}	Density of CH_4 (tCH_4/m^3CH_4)	0.00065	Approximate for 30°C based on density of 0.0007168 tCH_4/m^3CH_4 at STP
LF	Rate of physical leakage from digester (fraction)	0.15	Default value provided in AM0013, to be monitored if lower value applied
GWP_CH_4	See above	See above	See above

Table 12: Formula, input values and data sources for the calculation of $PE_{sludge,y}$

Parameter	Description	Value	Source
$PE_{sludge,y} = Q_{sludge,y} \times \left(COD_{sludge,y} \times B_o \times MCF_{la} \times GWP\_CH_4 + NC \times EF_{N_2O} \times GWP\_N_2O\right)$			Equation 13
$Q_{sludge,y}$	Quantity of sludge generated by the wastewater treatment in year *y* (t)	324	SQS, to be monitored
$COD_{sludge,y}$	Chemical Oxygen Demand of the sludge used for land application (kgCOD/kg sludge)	0.10	Assumed in absence of *ex ante* data, to be monitored
B_o	See above	See above	See above
MCF_{la}	Methane correction factor of the sludge in year *y* (fraction)	0.05	AM0013
GWP_CH_4	See above	See above	See above
NC	Nitrogen content of sludge (kgN/kg sludge)	0.10	Assumed in absence of *ex ante* data, to be monitored
EF_{N_2O}	Emission factor of nitrogen from sludge applied to land (kgN_2O/kgN)	0.016	AM0013
GWP_N_2O	Global warming potential for nitrous oxide (tCO_2e/tN_2O)	310	IPCC

Table 13: Formula, input values and data sources for the calculation of $PE_{energy\_cons,y}$

Parameter	Description	Value	Source
$PE_{energy\_cons,y} = Q_{elec\_cons,y} \times CO_2EF_{elec} + Q_{fuel\_cons,y} \times CO_2EF_{fuel} \times OX_{fuel}$			Equation 14
$Q_{elec\_cons,y}$	Quantity of electricity consumed due to the project activity in year *y* (MWh)	0	SQS, to be monitored
CO_2EF_{elec}	CO_2 emissions factor for electricity consumed at the project site (tCO_2/MWh)	N/A	Calculated as per AMS-I.D., in the case electricity is consumed

$Q_{fuel\_cons,y}$	Quantity of fuel oil consumed due to the project activity in year *y* (TJ)	0	SQS, to be monitored
CO_2EF_{fuel}	As above	As above	As above
OX_{fuel}	As above	As above	As above

Table 14: Formula, input values and data sources for the calculation of $PE_{stack,y}$

Parameter	Description	Value	Source
$PE_{stack,y} = \left[Q_{biogas\_burner,y} \times (1 - CE_{burner}) + Q_{flare,y} \times (1 - CE_{flare})\right] \times w_{CH4} \times \rho_{CH4} \times GWP\_CH_4$ Equation 15			
$Q_{biogas\_burner,y}$	Quantity of biogas to be fed to burner in year *y* (m^3biogas/year)	8,078,400	SQS, to be monitored
CE_{burner}	Combustion efficiency of burner (fraction)	0.995	SQS, to be monitored
$Q_{flare,y}$	Quantity of biogas to be fed to flare in year *y* (m^3biogas/year)	0	SQS, to be monitored
CE_{flare}	Combustion efficiency of flare (fraction)	0.5	Default value provided in Flaring Tool, for open flare. To be monitored
w_{CH4}	As above	As above	As above
ρ_{CH4}	As above	As above	As above
GWP_CH_4	As above	As above	As above

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

Data / Parameter:	$COC_{conc\_out,baseline,m}$
Data unit:	kgCOD/m^3
Description:	COD concentration of final effluent in the baseline
Source of data used:	Thai government regulation
Value applied:	0.12
Justification of the choice of data or description of measurement methods and procedures actually applied :	Although the actual discharge load may be lower, the maximum allowable COD load under government regulations, 0.12 kgCOD/m^3, is used for simplicity and conservatism.
Any comment:	N/A

Data / Parameter:	f_d
Data unit:	Fraction
Description:	Fraction of anaerobic degradation as a function of depth
Source of data used:	AM0013
Value applied:	0.5
Justification of the	This is set as a function of lagoon depth, as per AM0013.

choice of data or description of measurement methods and procedures actually applied :	
Any comment:	N/A

B.6.3 Ex-ante calculation of emission reductions:

B.6.3.1 Baseline emissions

Estimation of $BE_{lagoon,y}$

The formulae and input values given in Table 8 were used to calculate $BE_{lagoon,y}$. The results are summarized in Table 15.

Table 15: $BE_{lagoon,y}$ **for year**

Month	Average Ambient Temperature (°C)	$f_{t,m}$	$MCF_{baseline,m}$	$COD_{available,m}$	$BE_{lagoon,y}$
January	24	0.60	0.27	2,767,680	3,266
February	27	0.78	0.35	4,526,941	6,906
March	29	0.92	0.41	5,728,531	10,343
April	30	1.00	0.45	6,061,649	11,896
May	29	0.92	0.41	6,131,895	11,071
June	28	0.85	0.38	6,299,874	10,459
July	28	0.85	0.38	3,928,308	6,521
August	28	0.85	0.38	5,217,190	8,661
September	27	0.78	0.35	5,931,597	9,049
October	27	0.78	0.35	6,647,249	10,141
November	26	0.71	0.32	7,026,041	9,845
December	24	0.60	0.27	7,561,251	8,923
Total for year					**107,081**

Estimation of $BE_{fuel\_oil,y}$

Using the formula and input values given in Table 9, $BE_{fuel\_oil,y}$ was calculated as 11,349 tCO_2/yr.

B.6.3.2 Project emissions

Estimation of $PE_{lagoon,y}$

Based on the formula and input values provided in Table 10, $PE_{lagoon,y}$ was calculated as 8,512tCO_2e/yr.

Estimation of $PE_{phys\_leak,y}$

Using the formula and input values given in Table 11, $PE_{phys\_leak,y}$ was calculated as 9,730tCO_2e/yr.

Estimation of $PE_{sludge,y}$

$PE_{sludge,y}$ was calculated based on the formula and input values provided in Table 12. The emissions from this source was estimated as 469tCO_2e/yr.

Estimation of $PE_{energy\_cons,y}$

The emissions from this source was not estimated ex ante, as the increased consumption of grid electricity or fossil fuel on the account of the CDM project activity was considered minimal. Nevertheless, this will be monitored.

Estimation of $PE_{stack,y}$

Based on the formula and input values provided in Table 14, $PE_{stack,y}$ was calculated as 276tCO_2e/yr.

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

Table 16: Ex-ante estimation of emission reductions

Year	Estimation of project activity emissions (tCO_2e)	Estimation of baseline emissions (tCO_2e)	Estimation of leakage (tCO_2e)	Estimation of overall emission reductions (tCO_2e)
2008	18,987	118,430	0	99,443
2009	18,987	118,430	0	99,443
2010	18,987	118,430	0	99,443
2011	18,987	118,430	0	99,443
2012	18,987	118,430	0	99,443
2013	18,987	118,430	0	99,443
2014	18,987	118,430	0	99,443
2015	18,987	118,430	0	99,443
2016	18,987	118,430	0	99,443
2017	18,987	118,430	0	99,443
Total (tonnes of CO_2e)	189,870	1,184,300	0	994,430

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

B.7.1 Data and parameters monitored:

Data / Parameter:	$F_{digester}$ / $F_{dig\_out,m}$
Data unit:	m^3/hr
Description:	Flow rate of wastewater fed in to / discharge out of the digester

Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	6,000
Description of measurement methods and procedures to be applied:	The flow rate is measured continuously using a flow meter. As the digester is kept in hydraulic balance, only one monitoring point is necessary.
QA/QC procedures to be applied:	The flow meter will be calibrated according to appropriate industry/international standards. The product of the measured flow rate and the measured COD load can be double checked against the factory's starch production records, with which there is a direct correlation.
Any comment:	Used for the calculations of $BE_{lagoon,y}$ and $PE_{lagoon,y}$

Data / Parameter:	OP_m
Data unit:	Day
Description:	Number of operation days in month
Source of data to be used:	SQS
Value of data applied for the purpose of calculating expected emission reductions in section B.5	see table below
Description of measurement methods and procedures to be applied:	Based on biodigester operation
QA/QC procedures to be applied:	N/A
Any comment:	Used for the calculation of $BE_{lagoon,y}$

Month	Operating Days
January	31
February	28
March	31
April	30
May	31
June	30
July	-
August	31
September	30
October	31
November	30
December	31

Data / Parameter:	$COD_{conc\_in,baseline,m}$

Data unit:	$kgCOD/m^3$
Description:	COD concentration of effluent entering the lagoons in the baseline
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	15
Description of measurement methods and procedures to be applied:	This is equivalent to the COD concentration of raw effluent from the starch factory. The COD load will be measured either using standard COD tests either in house or through an outside laboratory, typically once a day.
QA/QC procedures to be applied:	Standard calibration will be carried out.
Any comment:	Used for the calculation of $BE_{lagoon,y}$

Data / Parameter:	T_2
Data unit:	°K
Description:	Ambient temperature
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	(see table below)
Description of measurement methods and procedures to be applied:	Daily average will be monitored, and translated to monthly average.
QA/QC procedures to be applied:	The results will be checked against local weather data from an official source.
Any comment:	Used for the calculation of $BE_{lagoon,y}$

Month	Average Ambient Temperature	
	(°C)	(°K)
January	24	297.16
February	27	300.16
March	29	302.16
April	30	303.16
May	29	302.16
June	28	301.16
July	28	301.16
August	28	301.16
September	27	300.16
October	27	300.16
November	26	299.16
December	24	297.16

Data / Parameter:	$D_{lagoon,project}$
Data unit:	M
Description:	Depth of open lagoons
Source of data to be used:	SQS
Value of data applied for the purpose of calculating expected emission reductions in section B.5	4.5m for all ponds
Description of measurement methods and procedures to be applied:	A marker will be put in place that will indicate the 5m depth, and daily checks will be conducted to show whether the depth is below or above this height.
QA/QC procedures to be applied:	N/A
Any comment:	Used for the calculation of $BE_{lagoon,y}$

Data / Parameter:	$Q_{sludge,m}$ / $Q_{sludge,y}$
Data unit:	m^3 / t
Description:	Amount of sludge generated and removed in month / year
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	For the purpose of estimating $BE_{lagoon,y}$, removal of 100% sludge at year end was assumed. In practice, sludge removal only occurs very infrequently. For estimating $PE_{sludge,y}$, a figure of 324 t/yr was used, based on extrapolation of operating parameters.
Description of measurement methods and procedures to be applied:	The quantity of sludge will be either weighed or measured with a flow meter or V-notch weir and measurement of solids content.
QA/QC procedures to be applied:	Weight scales and flow and density meters will be calibrated according to relevant industry/international standards.
Any comment:	Used for the calculation of $BE_{lagoon,y}$ and $PE_{sludge,y}$

Data / Parameter:	$COD_{conc\_sludge,m}$
Data unit:	kgCOD/m^3
Description:	COD concentration of sludge removed in month
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	N/A. In *ex ante* estimation it is assumed sludge is carried over until year end, when all sludge is removed.

Description of measurement methods and procedures to be applied:	The COD load will be measured either using standard COD tests either in house or through an outside laboratory. As sludge is removed infrequently, less than once a year, the COD test will be carried out not at any set interval, but as sludge removal occurs.
QA/QC procedures to be applied:	Standard calibration will be carried out.
Any comment:	Used for the calculation of $BE_{lagoon,y}$

Data / Parameter:	$Q_{fuel\_oil,y}$
Data unit:	TJ
Description:	Quantity of fuel oil displaced in year *y*
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	146.62
Description of measurement methods and procedures to be applied:	The quantity of thermal energy displaced is equivalent to the energy content of the biogas fed into the burners for production of hot oil.
QA/QC procedures to be applied:	The meter will be calibrated according to appropriate industry/international standards.
Any comment:	Used for the calculation of $BE_{fuel\_oil,y}$

Data / Parameter:	$COD_{conc\_dig\_out,m}$
Data unit:	kgCOD/m^3
Description:	COD <u>out</u> of biodigester to lagoons
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	3
Description of measurement methods and procedures to be applied:	The COD load will be measured either using standard COD tests either in house or through an outside laboratory, typically once a day.
QA/QC procedures to be applied:	Standard calibration will be carried out.
Any comment:	Used for the calculation of $PE_{lagoon,y}$

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

Data unit:	m^3/yr
Description:	Quantity of biogas produced and collected in the digester in year *y*
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	8,078,400
Description of measurement methods and procedures to be applied:	Flow meters are used to measure the quantity of biogas collected on a continuous basis, and data aggregated annually.
QA/QC procedures to be applied:	The flow meters will be calibrated according to appropriate ndustry/international standards.
Any comment:	Used for the calculation of $PE_{phys\_leak,y}$

Data / Parameter:	w_{CH4}
Data unit:	m^3CH_4/m^3biogas (wet basis)
Description:	Fraction of methane in biogas
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.5
Description of measurement methods and procedures to be applied:	The methane content in biogas will be monitored using online measurements.
QA/QC procedures to be applied:	The gas analyzer will be calibrated according to appropriate industry/international standards.
Any comment:	Used for the calculation of $PE_{phys\_leak,y}$ and $PE_{stack,y}$

Data / Parameter:	$COD_{sludge,y}$
Data unit:	kgCOD/kg sludge
Description:	Chemical Oxygen Demand of the sludge used for land application
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.10
Description of	At least monthly, or as sludge removal occurs, if sludge removal occurs less

measurement methods and procedures to be applied:	frequently.
QA/QC procedures to be applied:	Standard calibration will be carried out.
Any comment:	For the calculation of $PE_{sludge,y}$

Data / Parameter:	NC
Data unit:	kgN/kg sludge
Description:	Nitrogen content of sludge
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.10
Description of measurement methods and procedures to be applied:	At least monthly, or as sludge removal occurs, if sludge removal occurs less frequently.
QA/QC procedures to be applied:	Standard calibration will be carried out.
Any comment:	For the calculation of $PE_{sludge,y}$

Data / Parameter:	$Q_{elec\_cons,y}$ / $Q_{elec\_cons,y}$
Data unit:	MWh / TJ
Description:	Quantity of electricity / fuel oil consumed due to the project activity in year *y*
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	The consumption will be measured by a continuous electricity / flow meter, with data aggregated monthly.
QA/QC procedures to be applied:	The flow meter will be calibrated according to appropriate industry/international standards.
Any comment:	Used for the calculation of $PE_{energy\_cons,y}$

Data / Parameter:	CO_2EF_{elec}
Data unit:	tCO_2/MWh
Description:	CO_2 emission factor for electricity consumed at project site

Source of data to be used:	EGAT/EPPO/DEDE
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:	Calculated as per AMS-I.D
QA/QC procedures to be applied:	N/A – data are obtained from official sources
Any comment:	Used for the calculation of $PE_{energy\_cons,y}$

Data / Parameter:	$Q_{biogas\_burner,y}$ / $Q_{biogas\_flare,y}$
Data unit:	m^3biogas/h
Description:	Volumetric flow rate of the biogas in dry basis at normal conditions in the hour *h*
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.6	N/A – for the purpose of *ex ante* estimation, $Q_{biogas\_burner,y}$ and $Q_{biogas\_flare,y}$ were used.
Description of measurement methods and procedures to be applied:	This parameter will be continuously measured by a flow meter. The same basis (dry or wet) is considered for this measurement and the measurement of volumetric fraction of all components in the biogas ($fv_{i,biogas,h}$) when the biogas temperature exceeds 60°C. Value to be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Flow meters are to be periodically calibrated according to the manufacturer's recommendation.
Any comment:	Used for the calculation of $PE_{stack,y}$

Data / Parameter:	T_{flare}
Data unit:	°C
Description:	Temperature of the exhaust gas of the flare
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.6	N/A
Description of	This parameter will be measured in the flare by a Type N thermocouple. A

measurement methods and procedures to be applied:	temperature above 500°C indicates that a significant amount of gases are still being burnt and that the flare is operating. 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.
QA/QC procedures to be applied:	Thermocouples should be replaced or calibrated every year.
Any comment:	Used for the calculation of $PE_{stack,y}$

Data / Parameter:	Flare operation parameter
Data unit:	min/h
Description:	Minutes that flare is detected during the hour h
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.6	0
Description of measurement methods and procedures to be applied:	Measured continuously using a flame detector
QA/QC procedures to be applied:	
Any comment:	Used for the calculation of $PE_{stack,y}$

Data / Parameter:	T
Data unit:	°C
Description:	Temperature of the biogas
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.6	N/A – not estimated *ex ante* as density assumed to be 0.00065tCH_4/$m^3$$CH_4$. However, temperature after blowers is 60 – 70°C.
Description of measurement methods and procedures to be applied:	This parameter will be measured continuously/periodically by a meter. The measured data is used to determine the density of methane ρ_{CH4} . No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing biogas volumes in normalized cubic meters.
QA/QC procedures to be applied:	Meter will be subject to a regular maintenance and calibrated in accordance with the national or international approved standards and procedures.
Any comment:	Used for the calculation of $PE_{stack,y}$

Data / Parameter:	P
Data unit:	bar
Description:	Pressure of the biogas
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.6	N/A – not estimated *ex ante* as density assumed to be 0.00065tCH_4/m$^3CH_4$. However, pressure after blowers is approximately 450mb g.
Description of measurement methods and procedures to be applied:	This parameter will be measured continuously/periodically by a meter. The measured data is used to determine the density of methane ρ_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing biogas volumes in normalized cubic meters.
QA/QC procedures to be applied:	Meter will be subject to a regular maintenance and calibrated in accordance with the national or international approved standards and procedures.
Any comment:	Used for the calculation of $PE_{stack,y}$

Data / Parameter:	$Q_{burner\_stack,y}$
Data unit:	m^3/yr
Description:	Amount of burner stack gas in year *y*
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected emission reductions in section B.6	N/A – for the purpose of the *ex ante* estimation, $PE_{stack,y}$ was approximated as a percentage of methane fed to the burner.
Description of measurement methods and procedures to be applied:	This parameter will be obtained from the flow rate of the burner stack gas and the amount of time the gas is combusted in the burner.
QA/QC procedures to be applied:	Standard calibration will be carried out.
Any comment:	Used for the calculation of $PE_{stack,y}$

Data / Parameter:	w_{CH4_stack}
Data unit:	m$^3CH_4$/m^{3}stack gas
Description:	Fraction of methane in burner stack gas
Source of data to be used:	SQS, directly measured
Value of data applied for the purpose of calculating expected	0.995

emission reductions in section B.6	
Description of measurement methods and procedures to be applied:	This parameter will be measured at least quarterly, in line with AM0013.
QA/QC procedures to be applied:	Meter will be subject to a regular maintenance and calibrated in accordance with the national or international approved standards and procedures.
Any comment:	Used for the calculation of $PE_{stack,y}$

Data / Parameter:	Regulations and incentives relevant to wastewater
Data unit:	-
Description:	Thai regulations and/or incentives relevant to wastewater that may impact the baseline
Source of data to be used:	Thai official documents
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:	Will be assessed at the renewal of the crediting period
QA/QC procedures to be applied:	N/A
Any comment:	N/A

B.7.2 Description of the monitoring plan:

SQS will appoint an executive to be responsible for all data monitoring, acquisition and recording for CDM purposes. Staff will be trained in the operation of all monitoring equipment and all readings will be taken in a systematic and transparent manner under the supervision of management. Quality control and assurance procedures are to be undertaken for data monitored as outlined in the monitoring plan, which will be developed. A database will be maintained to record all relevant data as in the monitoring plan.

The management team will review the data archived and submit a complete set of documentation, which indicates the calculation procedure as well as the *ex post* emission reduction estimate, to the general manager regularly. In addition to the internal verification by general manager, this properly recorded documentation will also be verified externally by an independent Designated Operational Entity (DOE) on an annual basis.

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 study was completed in April 2007 by MUS.

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MUS is a project participant as defined by the CDM Executive Board. Contact details are provided in Annex 1.

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

31/03/2005

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

10 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:

This section is intentionally left blank.

C.2.1.2. Length of the first crediting period:

This section is intentionally left blank.

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

01/01/2008

C.2.2.2. Length:

10 years

SECTION D. Environmental impacts

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

The Project will contribute to the following major positive environmental impacts:

- Improvement of local air quality – odour. One of the major problems associated with wastewater treatment is the pungent odour arising from the open lagoons, during the long decomposition process. By treating the wastewater from the starch factory in a digester that allows accelerated decomposition in a controlled environment, this will significantly improve the air quality, which is important not only beyond the SQS factory's borders, but also to SQS staff within the grounds.

- Improvement of local air quality – fossil fuel. By using the methane contained in the recovered biogas, the Project taps into an unused, environmentally friendly and renewable energy source. In doing so, it will reduce the consumption of fuel oil at the SQS factory.

- Improvement of security of local ground water. Since the biodigester is lined and covered with PE sheet, there is greater security against leakage of waste water into the water sources around the factory compared with open lagoons which could seep or overflow. This has proven to be an important point with the local stakeholders.

No negative impacts are identified with the Project.

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:

Under Thai regulations, no environmental impact assessment or equivalent were required for the project activity.

SECTION E. Stakeholders’ comments

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

SQS invited local leaders to inspect its factory premises on May 2, 2006. A total of 38 persons, including the management and committee members of the Khokrerngrom and Khokphechrphattana Tambol Administrative Councils[2] and a Kamnan and Village Head from the Khokrerngrom area attended the session. SQS was represented by the following personnel:

Mr. Weerasit Mahattanakhun	Assistant Administration.Division Manager
Mr. Sampart Rerkchawee	Engineering Section Manager
Mr. Wiratn Wosri	Assist. Personnel Section Manager
Ms. Phentip Jatunawaratn	Quality Control Officer
Ms. Saengduan Em-O	Quality Systems Officer
Mr. Pleumjit Buasri	Project Engineer
Mr. Anant Thipprathum	Electrical Technician
Mr. Nikul Jekthao	Mechanical Technician
Mr. Sura Narongchai	Personnel Officer

The session included:

- Opening remarks by Mr. Weerasit Mahattanakhun
- A video presentation about SQS
- A presentation of Production Facilities
- A presentation of Wastewater Treatment System
- A presentation of Biogas Plant
- Inspection of the Factory

[2] A Tambol consists of a cluster of 5 - 10 villages

Figure 4: The presentation of the Project by the Engineering Section Manager

Figure 5: Visitors inspecting the biogas plant

E.2. Summary of the comments received:

Two main issues were raised during the session:

1. It was requested that SQS stop discharge of all water, including rainwater, to the nearby irrigation canal to ensure no contamination of the water;
2. The bad smell from the wastewater treatment plant is causing nausea to people in the new village of Somboon Wattana during the rainy season and when prevailing winds blow in that direction;

Other issues such as payment to local farmers for the tapioca root and local taxes were also discussed.

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

1. In response to the complaint of discharge, the participants were invited to inspect the wastewater channel and shown how soil subsidence caused runoff into the nearby creek. It was explained that this fault had been rectified and the participants were also informed of measures that would prevent a repetition of the runoff. Moreover, the participants made their own recommendations on how to prevent rainwater from flowing into the irrigation channel, which is mistaken for wastewater discharge, and SQS made a commitment to following their recommendations in the future;
2. It was explained to the attendees that by installing an advanced system which will allow for a faster treatment of wastewater in an enclosed environment, the Project will dramatically reduce the bad odour affecting the villagers. This was received enthusiastically by the participants;

As a result of the session, the local representatives were impressed that SQS was willing to take the lead in implementing an advanced solution to not only effectively treat wastewater but one that would drastically reduce the bad odour. They were satisfied that they will be able to report back positively to villagers to whom they are ultimately accountable.

Annex 1

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

The Project does not involve funding from an Annex I country.

Annex 3

BASELINE INFORMATION

Please refer to Section B.6. for details.

Annex 4

MONITORING INFORMATION

Please refer to Section B.7. for details.

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