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

CONTENTS

Revision history of this document

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

SECTION A. General description of small-scale project activity

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

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Ratchaburi Farms Biogas Project at SPM Farm

Document Version 05

Date 10/06/10

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

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Ratchaburi Farms Biogas Project at SPM Farm ("the project") involves the capture of methane (CH_4) rich biogas produced during the treatment of swine barn flushing wash waters and its combustion for power generation at SPM Farm in the Ratchaburi Province of Thailand. With a swine rearing capacity of 83,000 fattening swine, SPM Farm has recently invested in a high-rate continuous flow closed anaerobic treatment reactors to treat 100% of all barn flushing effluents produced from their swine rearing operations. SPM Farm has constructed these facilities to replace low-rate open anaerobic lagoon barn flushing effluent treatment systems.

The treatment of swine wastes by way of anaerobic degradation processes leads to the production of a biogas consisting of 60-70% CH_4. In the previous open lagoon system, generated methane is released directly to the atmosphere. In the closed high-rate system, the vast majority is collected and, because of the high calorific value (between 28-34 MJ/m^3), is combusted using spark ignition engines for the production of electricity for use on-site. This power will replace electricity produced and distributed through the Thai national electricity grid.

Investment in these treatment facilities has been prompted by the potential revenue available to the farmers from the sale of certified emissions reductions (CERs) to Danish Ministry of Climate and Energy. Revenue from the sale of CERs will serve to offset of some the significant financial and technical risks involved for the farmer in making this type of investment.

The purpose of the project activity can be summarised as:

- ⇒ Treatment of swine barn flushing wastewaters so as to improve the quality of effluent to the level where it can be recycled for use on the farm for barn flushing purposes;
- ⇒ Avoidance of CH_4 emissions from the conventional open anaerobic lagoon system previously used to treat barn flushing wastewater;
- ⇒ Capture of biogas for use in onsite power generation;
- ⇒ Reduction of atmospheric emissions of the greenhouse gas (GHG) CH_4 and reduction in the indirect emissions of GHG associated with bought-in grid electricity, by virtue of biogas capture and onsite power generation, and;
- ⇒ Use of the CDM process to offset some of the financial and technical risks associated with the investments through the sale of CERs to the Danish Ministry of Climate and Energy.

The project can expect to deliver multiple benefits in respect of sustainable development in Thailand, including:

⇒ Reduction of GHG emissions associated with previous open anaerobic lagoon treatment system;
⇒ Reduction in the odour and fly nuisance associated with the old open lagoon treatment system;
⇒ Elimination of the use of fossil-derived imported grid electricity in the swine rearing facility;
⇒ Access to low-cost [free except for additional system capital, operating and maintenance costs] power for swine producers;
⇒ Promoting technological excellence and innovation in Thailand;
⇒ Building confidence for farmers and other potential project developers in the efficacy, cost and safety of biogas systems as an emerging swine rearing waste-to-energy technology within the SE Asia region;
⇒ Enhancing the nutritional intake of local children through the free distribution of a portion of the dried sludge to local schools for use as fertiliser for a local *student food programme*;
⇒ Enhancing the productivity and finances of local farmers through the availability of high quality natural dried sludge fertiliser supplied at low cost. Effluent from the facultative ponds can also be supplied to local farmers as liquid fertilisers upon request.
⇒ Elimination of problems related to disposal of solid waste through improvement of sludge handling system, and;
⇒ Reduction in the dependency on imports because most components can be manufactured in Thailand.

A.3 Project participants:

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Name of Party involved (*) ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Thailand (Host Party)	• S P M Feed Mill Co., Ltd.	No
Denmark	• Danish Ministry of Climate and Energy.	Yes
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party (ies) involved is required.		

Contact information of each project participant is provided in Annex 1.

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

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The project involves the application of high rate continuous flow anaerobic wastewater reactors to treat 100% of the barn flushing wastewaters produced from swine rearing barns at the farms. Swine barn flushing wastewaters consist of a combination of swine manure (dung and excreta) along with wash-water used for barn flushing. It is typified by a high organic strength (COD) approximately 10-15,000 mg O_2/L) and high suspended solids content (10-15,000 mg TSS/L). Prior to implementation of the project, swine barn flushing wastewaters were treated in an extensive open anaerobic lagoon system. This is the only manure management system employed at the farm.

The high-rate anaerobic wastewater treatment reactors used in the project are based on the *high suspended solids upflow anaerobic sludge blanket* (H-UASB) system, which is a modification of the UASB concept that has been predominantly developed over the last 20 years by the University of Wageningen in the Netherlands for the treatment of various wastewaters. In the H-UASB concept, a preliminary hydrolytic tank (or "buffer tank") is added upstream of the conventional UASB plant; this configuration allows the majority of enzymatic breakdown of the solids fraction to occur in isolation from the other main steps of the anaerobic digestion process, a critical element in anaerobic digester design because this step is rate limiting. When this step is not isolated under high solids loading conditions, such as those present in the treatment of swine barn flushing wastewaters, clogging of the sludge blanket often occurs. Because the enzymatic breakdown is rate-limiting, such clogging often leads to plant failure in conventional UASB designs when exposed to high solids loading. Consequently, the H-UASB system is well suited to treating swine barn flushing wastewaters in this way.

Biogas from the H-UASB treatment plants is captured and stored under a polyethylene cover placed over the buffer tank, and from there is piped to two set of 870 kW biogas electricity generators, producing a 3-phase supply for use in electrical power applications on the farm, such as water and wastewater pumping, fans and sprays for barn cooling, lighting, etc. This will displace electrical power that was previously bought-in from the Thai electricity grid. Any excess electricity will be exported to the national grid.

Final effluent from the anaerobic treatment plants is percolated across a series of sand filter beds in a batch-fed system, operating on a 4-5 day batch cycle. The sand filter beds remove much of the solid load present in the anaerobic plant effluent. The removed solids are aerobically dried on the top of the filter bed, and once dry, removed for use as a fertiliser (see *Section A.2* above).

Percolate from the sand filter beds is channelled to series of polishing lagoon(s), where further facultative breakdown of the organic load occurs. From there, the final effluent is recycled – usually via a final purification process such as a packaged high-rate sand filter plant – and reused in barn flushing operations. This helps close the water cycle at the local level (***Error! Reference source not found.****a and 1b* below).

Figure 1a Layout of the system prior project implementation

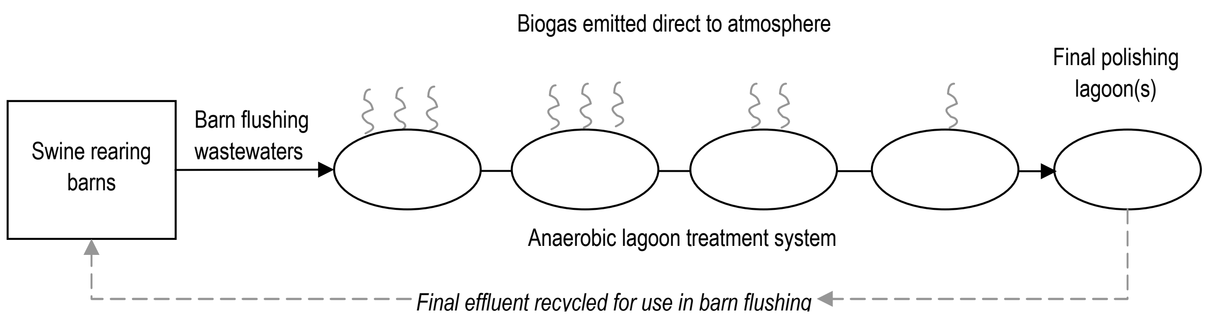
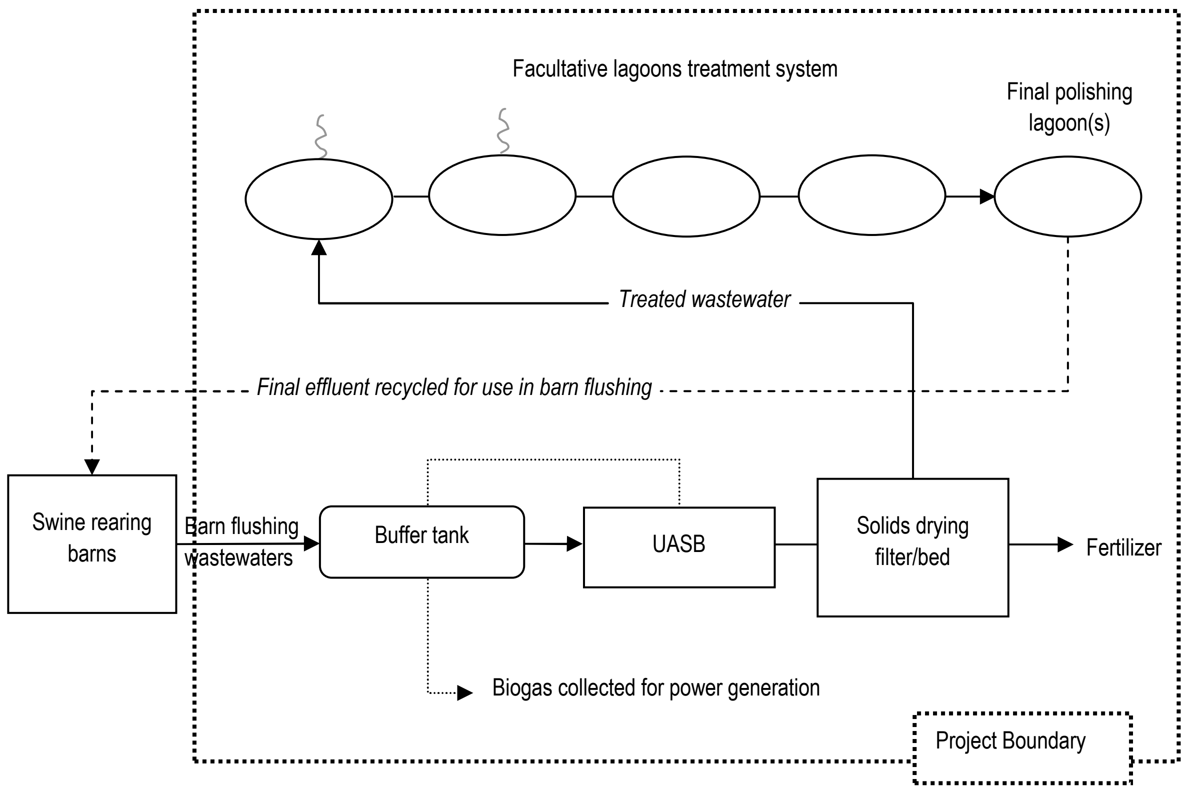


Figure 1b ***Layout of the system in the project implementation***



It is important to note that at SPM Farm both pre- and post-implementation of the project, the barn-flushing wastewater treatment operation is a closed system, with final effluent being recycled for use on the farm. This means that in both systems, the level of pollutant removal achieved (97-99% COD removal).

Box 1 ***Buffer tank, SPM Farm***

The old anaerobic lagoon treatment system did not include a solids removal step, with the solids remaining as sediment in the lagoons. This system actually leads to further anaerobic breakdown of the volatile components in the swine waste compared with the new system with solids drying. Consequently, in addition to the combusting of CH_4, the new system also avoids CH_4 emissions by increasing the volume of swine waste treated aerobically. However, this factor is not considered part of the emissions reductions calculations for the system in order for the estimate to be considered conservative.

The old system also employed a final polishing lagoon, with recycle of the final effluent for use reuse in barn flushing operations.

Box 2 Final effluent solids drying bed, SPM Farm

Box 3 Part of the old open lagoon system, SPM Farm

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

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See below.

A.4.1.1 Host Party(ies):

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The Kingdom of Thailand

A.4.1.2 Region/State/Province etc.:

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Ratchaburi Province

A.4.1.3 City/Town/Community etc:

>>
Pak Thor District

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

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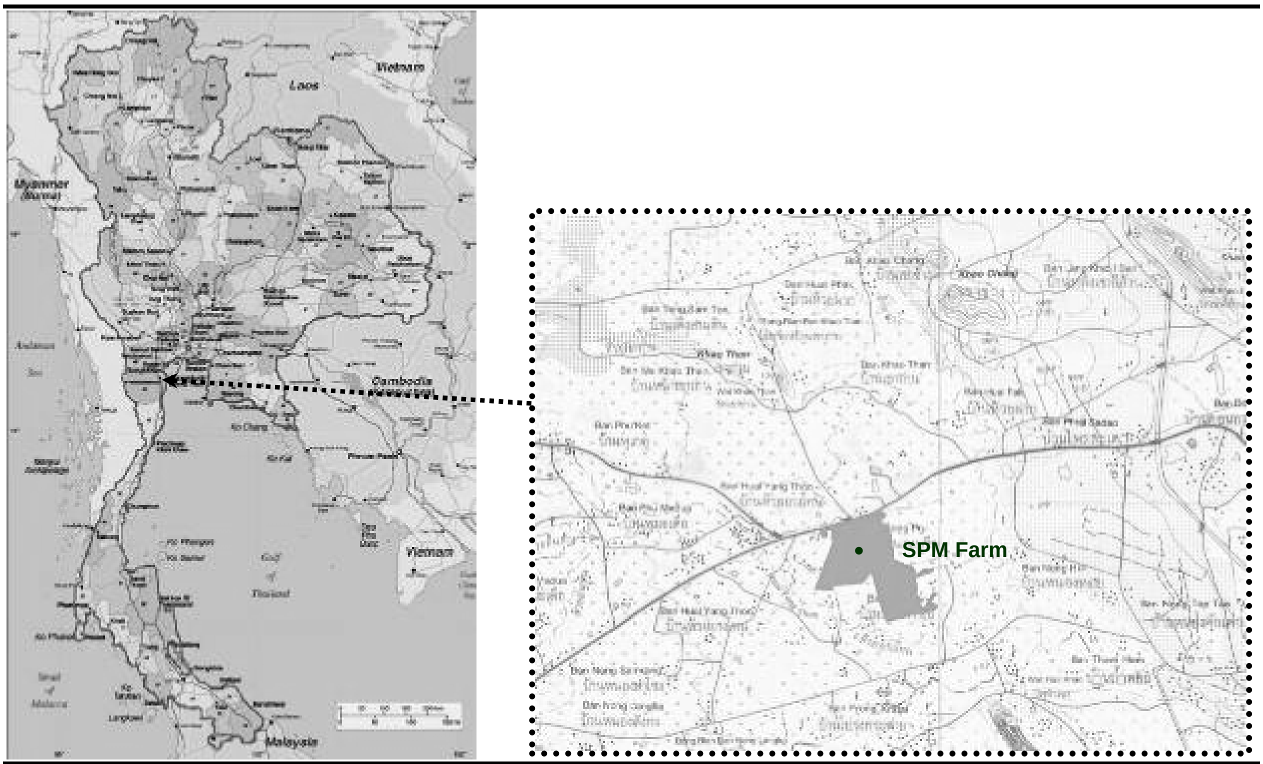
SPM Farm is located in Pak Thor District, Ratchaburi Province, Thailand, approximately 100 km to the west of Bangkok. The specific location of the farm is provided below:

Mailing address	Moo 8, Don Sai Sub-district, Pak Thor District, Ratchaburi
GPS Coordinates:	13°21.409N 99°44.908E (SPM1)
	13°21.343N 99°44.434E (SPM2)
	13°21.046N 99°45.062E (SPM3)

The map showing the location of SPM farm is depicted in ***Error! Reference source not found.***.

Box 4 ***Location of the project activities***



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

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Type III.D – Methane recovery in agricultural and agro industrial activities

The project involves the recovery of CH_4 from anaerobic barn flushing wastewater treatment reactors. Anaerobic treatment of swine wastes in traditional open lagoon systems leads to the direct atmospheric emission of biogas consisting of around 60-70% CH_4. The project activity involves the recovery of a large fraction of this biogas. This leads to a reduction in anthropogenic GHG emissions; the project has estimated GHG emissions of 3,559 tonnes carbon dioxide equivalent per year. The project implementation leads to calculated emission reduction per year below 60,000 tCO_2 hence corresponding to the requirements of the EB. If the emission reductions exceed the reference value of 60,000 tCO_2e in any year of the crediting period, the annual emission reductions for that particular year will be capped at 60,000 tCO_2e.

Type I.D- Renewable electricity generation for a grid

The CH_4-containing biogas generated in the anaerobic wastewater treatment reactors is recovered via a gas collection system and combusted in spark-ignition engines for electricity generation for the farm distribution grid, which displaces bought-in grid electricity.

Comments on technology transfer

The Thai government has recently been supporting the development of biogas projects in Thailand. The purpose of the government sponsored programme is twofold:

- *To build in-country capacity for biogas technology development*: a number of expert centres have emerged in Thailand, including the Chiang Mai University - Biogas Advisory Unit (CMU-BAU), King Monkutt University of Technology Thonburi (KMUTT), and Thammasat University. These centres have been customising a number of anaerobic treatment plant designs for the treatment of various wastewaters produced in Thailand, including swine wastes, palm oil mill effluents, tapioca/cassava processing, and pulp and paper wastes. The principal technology option emerging for swine rearing wastes are variants of the *Upflow Anaerobic Sludge Blanket* (UASB) reactor being developed by CMU-BAU; the original design concept for the UASB emerged in the Netherlands in the 1980's. The variant developed by CMU-BAU is a technology which they call H-UASB (H for High Suspended Solids), which has been optimised to effectively handle high suspended solids loads associated with raw swine barn flushing wastewaters. CMU-BAU has been developing this system in co-operation with universities in the Netherlands, and as such, can be considered as an important technology transfer process. A number of Thai biogas experts, encouraged by the results of the scheme, are now innovating with biogas plant designs so as to optimise performance, and reduce the overall construction and operational costs.

- *To build confidence for biogas project developers:* the EPPO grant funding programme has given an impetus to develop pilot scale projects in some industries, although reluctance remains amongst farmers to invest in biogas plant schemes for a number of reasons:
  - the scheme only provides partial funding for projects;
  - the opportunity cost is high relative to investing in additional livestock, which has a payback of less than 2 years, compared to 8 or 9 for biogas plants;
  - most swine farmers in Thailand have little or no access to cheap capital;
  - there continues to be low confidence amongst investors in the efficacy and operating costs of anaerobic treatment technologies as the technology is unproven as yet on a commercial scale in Thailand, and;
  - there is a lack of any other incentives to make such risky investments

  Effective communication and knowledge sharing is ongoing, and confidence amongst investors and developers is beginning to emerge. Nevertheless, project financing still remains a significant hurdle, and presently only a few biogas plants are in operation in the country. However, the advent of the CDM is also adding further incentives and stimulus to make the investment, by building confidence in investors that further returns on investment is possible, in additional to just the offsetting of electricity costs. Thus the CDM is helping mitigate the effects of these financing barriers.

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

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Years	Annual estimation of emission reductions in tonnes of CO_2 e
2008 (Mar – Dec)	26,234
2009	32,872
2010	32,872
2011	32,872
2012	32,872
2013	32,872
2014	32,872
2015	32,872
2016	32,872
2017	32,872

2018 (Jan – Feb)	5,479
Total estimated reductions (tonnes of CO_2 e)	**327,563**
Total number of crediting years	**10**
Annual average over the crediting period of estimated reductions (tones of CO_2 e)	**32,756**

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

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No Annex-I country financial support for this project has been received.

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

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The project is not part of a debundled larger project activity.

SECTION B. Application of a baseline and monitoring methodology

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

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AMS-III.D Methane recovery in agricultural and agro industrial activities, version 11 dated 23 December 2006

AMS-I.D Grid connected renewable electricity generation, version 10, dated 23 December 2006

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

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Type III.D Methane recovery in agricultural and agro industrial activities

In accordance with the Approved Small-Scale Methodology AMS-III.D (applicable to category Type III.D projects), the baseline for the project is considered to be:

- The emission baseline is the amount of methane that would be emitted to the atmosphere during the crediting period in the absence of the project activity. For each year during the crediting period, emissions are calculated as specified in paragraph a and paragraph b below and lower of the two values is used
  (a) Actual monitored amount of methane captured and destroyed by the project activity.
  (b) The methane emissions calculated ex ante using the amount of the waste or raw material that would decay anaerobically in the absence of the project activity, with the most recent IPCC tier 2 approach

This is considered appropriate for the following reasons:

The degradation of organic wastewaters is the principal means for reducing the organic strength of the swine barn flushing wastewaters used in both baseline and project scenario. This activity is necessary in order to produce a final effluent suitable for recycling and reuse in barn flushing systems (1).

In the baseline scenario, business as usual would mean the ongoing use of the open anaerobic lagoon barn flushing treatment system. In these systems, the biogas generated during the degradation process is released directly to the atmosphere. This biogas contains a large fraction of CH_4, which is a powerful GHG (21 times the global warming potential (GWP) of CO_2).

In the project scenario, the same fundamental biological anaerobic processes are employed, albeit in a closed, high-rate reactor configuration. In this system, the produced biogas can be easily collected and used for energy generation. This prevents the release of CH_4 to the atmosphere. The combustion of biogas converts CH_4 to CO_2. The CO_2 emitted from biogas combustion is considered to be of biogenic origin and thus is excluded from project emissions as this does not constitute a change in carbon stocks.

The process performance and efficiency of both the open lagoon system and the closed high rate system is considered to be the similar in terms of the removal of organic material and its conversion to CH_4. Therefore, the amount of biogas produced in both systems will be broadly similar. Hence, the monitoring of the amount of methane produced in the project scenario is considered to be equal to that produced in the baseline scenario. For this reason, this choice of baseline is considered appropriate for this project.

Type I.D Renewable energy generation for a grid

In accordance with the Approved Small Scale Methodology AMS-I.D (applicable to Type I.D projects), the baseline is considered to be:

- Calculated in accordance with paragraph 9 of the AMS-I.D, namely the kWh produced by the renewable generating unit multiplied by an emissions coefficient (in kg CO_2e/kWh) calculated in a transparent and consistent manner.
- The emissions coefficient is weighted average emissions of the current grid generation mix in Thailand. This factor is, for example, 0.550 kg CO_2/kWh for 2008, based on data from the *Electricity Generating Authority of Thailand and Energy Policy and Planning Office (EPPO)* (2). The calculation of grid emission coefficients is presented in *Annex 3*.

This is considered appropriate as biogas will be used at all times of the day and night for electricity generation. The farm is currently not planning to use the electricity for load-lopping or peak demand matching, thus the average grid emissions factor for the Thai grid is considered appropriate.

The biogas generation sets are new-build equipment i.e. have not been transferred from another activity or to another activity, and therefore leakage is not considered.

B.3 Description of the project boundary:

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(1) Note: there is no discharge of final effluents from the farms, although Notification No.3 of the Thai Ministry of Science, Technology and the Environment requires total suspended solids to be below 150 mg/L and BOD of less than 60 mg/L from swine farms.
(2) Based on EGAT's Annual Report, 2008, and EPPO Energy statistics, 2008.

The project boundary for the project is considered to be the following:

The site of the anaerobic treatment facility downstream of the swine barns (see *Figure 1b* above), and the electricity generation set.

B.4 Description of baseline and its development:

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As specified in Appendix B:

• The appropriate baseline for project category Type I.D (AMS-I.D) is found in paragraphs 9.
• The appropriate baseline for project category Type III.D (AMS-III.D) is found in paragraphs 6 and 7.

The total baseline emission ($TB_{emissions}$) is defined as follows:

$$TB_{emissions} = E_{baseline} + FE_{baseline}$$

Where:
$E_{baseline}$: Baseline electricity generation emissions (tCO_2e/year) – (AMS-I.D)
$FE_{baseline}$: Baseline fugitive GHG emissions (tCO_2e/year) – (AMS-III.D)

For AMS-I.D:
Baseline electricity generation emissions are given by:

$$E_{baseline} = EP_{BIO} \times CEF_{grid}$$

Where:
$E_{baseline}$: Baseline electricity generation emissions (tCO_2e/year)
EP_{BIO}: Electricity produced by the biogas generator unit for grid electricity replacement (MWh)
CEF_{grid}: Emission coefficient for electricity grid (kg CO_2e/kWh)

For AMS-III.D:
Baseline fugitive GHG emissions are:

$$FE_{baseline} = FM_{baseline} \times GWP$$

Where:
$FE_{baseline}$: Baseline fugitive GHG emissions (tCO_2e/year)
$FM_{baseline}$: Baseline fugitive methane emissions (tCH_4/year)
GWP: Global warming potential for methane (tCO_2e/tCH_4)

Baseline fugitive methane emissions are:

$$FM_{baseline} = EF_i \times Pop$$

Where:
$FM_{baseline}$: Baseline fugitive methane emissions (tCH_4/year)
EF_i: Annual emission factor of the animal type i (kg CH_4)
Pop: Swine population

Annual emission factor for swine is:

$$EF_i = VS_i \times 365\ days/year \times B_{oi} \times 0.67\ kg/m^3 \times \sum MCF/100 \times MS\%$$

Where:
EF_i: Annual emission factor for swine (kg CH_4)
VS_i: Daily volatile solid excreted for swine (kg)
B_{oi}: Maximum methane producing capacity (m^3 CH_4/kg of VS) for manure produced by swine
MCF: Methane conversion factor for the swine manure management system (%)
MS%: Fraction of swine manure handled using manure system

$$VS = [GE \times (1-DE\%/100) + (UE \times GE)] \times (1-ASH\%/18.45)$$

Where:
VS: Volatile solid excretion per day on a dry weight basis (kg)
GE: Estimated daily average feed of feed intake (MJ/day)
UE × GE: Urinal energy expressed as fraction of GE (MJ/day)
DE%: Digestibility of the feed (%)
ASH%: Ash content of the manure (%)

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

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Swine rearing operations in Thailand broadly adopt four strategies to the management manure and barn flushing from swine barns:

(i) Collection of solid material (dung) from slatted floor barns for sale, donation or use, followed by barn flushing, with the treatment of barn flushing wastewaters in open anaerobic lagoons;
(ii) Direct flushing of all swine barn wastes (dung and wash-waters) with treatment in open anaerobic lagoons;
(iii) High-rate or batch treatment of manure and/or wash-waters with or without collection of biogas;
(iv) Discharge direct to local canals with little or no treatment, or;
(v) A combination of these.

SPM Farm has most recently adopted the second strategy (ii), which is by far the most common form of treatment for swine rearing wastewaters (*Table 11*). Only 14% of Thai swine farmers are recovering biogas from wastewaters (*Table 11*); the farms in this project are making the transition to this type of system.

Table 1 Swine manure management in Thailand (based on survey results)

Swine Manure Management	Farm Size: Small (20) (1-100)	Medium Low (70) (>100-500)	Medium High (42) (>501-1000)	Large (42) (>1000)	Total (174)
Manure use on farms					
Discharge to Biogas digester	1 (5%)	9 (13%)	6 (14%)	5 (12%)	21 (12%)
Wastewater use on farms					
Discharge into own pond	9 (45%)	59 (84%)	38 (90%)	39 (93%)	145 (83%)
Discharge into a water treatment pond	6 (30%)	36 (51%)	23 (55%)	27 (64%)	92 (63%)
Use it for biogas	1 (5%)	9 (13%)	6 (14%)	5 (12%)	21 (14%)

Source: *Policy, Technical, and Environmental Determinants and Implications of the Scaling-Up of Livestock Production in Four Fast-Growing Developing Countries: A Synthesis; Final Research Report of Phase II.* C.L. Delgado, Narrod, C.A. and Tiongco, M.M. Food and Agriculture Organisation, 2001.

In Thailand, although *Notification No.3 of the Thai Ministry of Science, Technology and the Environment* requires effluent discharges into watercourses from swine farms to have total suspended solids of below 150 mg/L and BOD of less than 60 mg O_2/L, there is not prescriptive approach to identifying how this is to be achieved. As such, open lagoons are generally sufficient and much cheaper than high-rate systems. Furthermore, many farms operate closed water cycle systems, with final effluent recycling and little or no discharges to the aquatic environment. Moreover, Thailand does not enforce any controls on the emission of CH_4 from wastewater treatment facilities in any sector. Whilst the Thai government has taken steps to promote the use of high-rate biogas systems with biogas collection and combustion for power generation (e.g. the EPPO grant scheme) the uptake for these systems remains low (as outlined in *Table* 1 *1*, and in *Section A4.2* under notes on technology transfer).

According to *Attachment A of Appendix B* of the *Simplified modalities and procedures for small-scale CDM project activities*, a selection of at least one of the barriers tests may be employed for small-scale project activities, covering: investment barriers, technological barriers; prevailing practice or other barriers. In the case of the swine rearing industry in Thailand, there are multiple reasons for the low take-up of biogas systems amongst swine farmers, covering aspects of all of these barriers, as follows:

Investment barriers:
The opportunity cost for investment into biogas systems is high relative to investing in additional swine livestock. The purchase of additional fattening pigs can deliver a payback on investment of less than 2 years, compared to 8 or 9 years or more for biogas plants. As such, the preferred investment of most farmers is into new livestock rather than manure/wastewater management systems. Furthermore, the capital expenditure involved with building high-rate biogas systems can be potentially prohibitive (up to THB 70 million for a 70,000 swine rearing facility), and most swine farmers have only moderate equity, and lack access to cheap capital. The EPPO scheme can provide some funding towards these costs, but there has not been widespread uptake for other reasons, as outlined below.

Technological barriers:
There continues to be low confidence amongst investors in the efficacy and operating costs of anaerobic treatment technologies as it is largely unproven as yet on a commercial scale in Thailand. Moreover, only recently has there been an emergence of skilled biogas plant designers and engineers, brought about

through both the EPPO programme and the emergence of the CDM as a business opportunity for Thai project developers.

Prevailing practice:
The prevailing practice for the management of swine manures and barn flushing wastewaters is outlined above (*Table* 1*1*). These data clearly suggested that there is only a very low uptake of biogas systems for the treatment of swine rearing wastes in Thailand.

Other barriers:
Energy use on most swine farms is fairly low, and not a major cost for swine farmers. As such, many would face a surplus supply of energy when installing biogas systems with energy recovery. In order to export electricity to the Thai grid, a power purchase agreement (PPA) must be negotiated with the *Energy Generating Authority of Thailand* (EGAT) or *Provincial Electricity Authority* (PEA). Often, most farmers are not willing to enter into such complex negotiations and, depending on the quantity of power delivered and the type of PPA agreed, could also face major penalty charges for not meeting obligations once an agreement is in place. In addition, project developers in other sectors have faced protracted negotiations and delays when attempting to enter into PPA negotiations.

B.6 Emission reductions:

B.6.1 Explanation of methodological choices:

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Emission reductions

The project involves recovery of methane by implementation of a biogas system that treats manure from pig farm. The installation will recover and combust the captured methane and will result in a total yearly emission reduction less than 60,000 tCO_2e. These technical facts correspond to the criteria of AMS-III.D and AMS-I.D.

AMS-I.D:
The electricity generated by the biogas multiplied by the CO_2 emission coefficient for the displaced electricity from the grid and of the displaced fossil fuel.

AMS-III.D:
The lower of the two values of (1) actual monitored amount of methane captured and destroyed by the project activity and, (2) the methane emissions calculated ex ante using the amount of waste or raw material that would decay anaerobically in the absence of the project activity, with the most recent IPCC tier 2 approach.

Project direct emissions

AMS-I.D:
As the Project is utilizing biogas with biogenic origins to produce renewable energy, and the design of the system include only smaller electrical appliances, the anthropogenic emissions from this component are considered to be zero.

AMS-III.D:

Project emissions due to the project activity are:

$$PE_{project} = E_{digester} + E_{flare} + E_{non\text{-}biogenic} + E_{power} + E_{sludge}$$

Where:

$PE_{project}$:	Project emissions (tCO_2e/year)
$E_{digester}$:	Methane not captured by the Project and released to the atmosphere (tCO_2e/year) (i)
E_{flare}:	Methane captured and not flared (tCO_2e/year) (ii)
$E_{non\text{-}biogenic}$:	CO_2 emissions from combustion of non-biogenic methane (tCO_2e/year) (iii)
E_{power}:	CO_2 emissions from use of fossil fuel or electricity for the operation (tCO_2e/year) (iv)
E_{sludge}:	Methane emissions from anaerobic treatment/disposal of sludge leaving the digester (tCO_2e/year) (v)

(i) $E_{digester,}$ methane not captured by the Project and released to the atmosphere

$$E_{digester} = FE_{baseline} \times 10\%$$

The methane recovery facility, the project, is designed and constructed to collect all the biogas generated from the digester. However, 10% of the total biogas captured is accounted as project emissions ex-ante, as conservative approach.

During the crediting period, the gas meter will reflect only the methane captured by the project. The biogas not captured by the project would not be included as a part of the ex-post baseline. Therefore 10% deduction of meter reading will not be included in ex-post estimate. Physical leakage from the pipeline is discussed separately in the following paragraphs.

(ii) E_{flare} , methane captured and not flared (e.g. physical leakage, flare inefficiency, flare availability);

$$E_{flare} = Q_{flare} \times (1\text{- flare efficiency})$$

Where:

Q_{flare}: Amount of methane sent to the flare. (tCO_2e/year)

It is unlikely that there will be any leakage from the flares, as the flares will only be in use in emergency case when there is more biogas than can be combusted in the generator or collected in the system. Nonetheless, the Project uses a default flare efficiency of 50% used for ex ante estimations of CERs. However, no biogas is expected to be sent to the flare. Ex-post determination will be defined after the measurement of the flare efficiency is attempted.

It is unlikely that there will be any un-combusted methane from the generator, given the generator has been designed for high performance.

(iii) $E_{non\text{-}biogenic}$, CO_2 emissions from combustion of non-biogenic methane;

Not applicable. No other fuel than biogas will be used.

(iv) E_{power}, CO_2 emissions from use of fossil fuels or electricity for the operation of the facility;

$$E_{power} = EC_{Aux} \times CEF$$

Where:
EC_{Aux}: Power consumption by the auxiliary equipments in the project activity. (MWh/year)

It is estimated that total power consumption by the auxiliary equipments in the project activity according to AMS-III.D is 461.65 MWh/year.

(v) E_{sludge}, the aerobic treatment and/or proper soil application of the sludge leaving the digester in the project activity shall also be ensured and monitored. If the sludge is treated and/or disposed anaerobically, the resulting methane emissions shall be considered as project emissions.

Not applicable to ex-ante estimate. No emissions are anticipated as the potential sludge will be treated aerobically as explained earlier in the PDD. However, this is still to be a part of the monitoring plan for ex-post calculation.

Leakage

AMS-I.D, paragraph 12, states that no leakage calculation is required since the equipment is not being transferred to or from another activity.

AMS-III.D, paragraph 8, states that no leakage calculation is required.

Baseline

The total baseline emissions ($TB_{emissions}$) are:

$$TB_{emissions} = FE_{baseline} + E_{baseline}$$

Therefore, the total emission reductions are:

$$ER = FE_{baseline} + E_{baseline} - PE_{project}$$

Refer to section B.4 for details of the calculations of each source.

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

>>

Data / Parameter:	CEF
Data unit:	tCO_2/MWh
Description:	Grid Carbon Emission Factor
Source of data used:	Calculated value
Value applied:	0.550 (For the year 2008)
Justification of the choice of data or description of measurement methods	The project activity involves displacement of grid electricity. As per the AMS-I.D methodology, the CEF of the grid which is calculated based on weighted average of the emissions of the current generation mix in tCO_2e/MWh.

and procedures actually applied :	
Any comment:	The value changes every year, based on the changes in the grid mix.

Data / Parameter:	Pop
Data unit:	Heads
Description:	Animal population in Farm
Source of data used:	Data provided by the farm (A conservative swine population is used which is lower than data provided by the farm)
Value applied:	70,000
Justification of the choice of data or description of measurement methods and procedures actually applied :	The average animal population of the farm during past 3 years is 82,000 heads however we use only 70,000 heads for conservative calculation of emission reductions. For each year during the crediting period, emission reductions will be the lower value of the two, (1) the monitored methane captured and destroyed and (2) the ex-ante estimate number.
Any comment:	

Data / Parameter:	Capacity
Data unit:	kW
Description:	Installed generator capacity in Farm
Source of data used:	Data collected at the farm
Value applied:	870 kW (2×435)
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	Manure management system usage
Data unit:	%
Description:	Fraction of manure being treated by the system
Source of data used:	Farm data
Value applied:	100%
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	GE
Data unit:	MJ/day
Description:	The average gross energy of feed intake per head per day

Source of data used:	Calculated from the farm data
Value applied:	34.62
Justification of the choice of data or description of measurement methods and procedures actually applied :	There are many formulas of swine feed used in SPM farm and each formula has its unique gross energy. GE (MJ/day) = [Feed mass (kg/day) × Average GE of every feed formulas used in farm (kcal/kg) × 4.2 (kcal/kg)] / 1000 (kJ/MJ) = [2.1 × 3,925 × 4.2] / 1,000 = 34.62 MJ/day
Any comment:	This parameter depends on the feed formula used in farm. If there is any change of swine feed, the value should be recalculated from time to time.

B.6.3 Ex-ante calculation of emission reductions:

>>

AMS-I.D:

Baseline emissions are calculated using the following data:

Parameter	Value	Unit	Source
a. Biogas Generate	3,614,045	m^3/yr	Daily gas generation rate from Calculation for baseline of AMS-III.D below (9,901×365)
b. Electricity Generation Rate	1.00 (2008)	kWh/m^3	Farm Data
	1.70 (2009-2018)	kWh/m^3	Farm Data
c. Annual Electricity Generation	3,614 (2008)	MWh/yr	Calculated (a×b / 1000)
	6,144 (2009-2018)	MWh/yr	Calculated (a×b / 1000)
d. Emissions Coefficient (y2008)	0.550	tCO_2/MWh	Calculated as shown in annex 3
Annual CO_2 emission reduction from electricity generation	**1,656 (2008)**	**tCO_2/yr**	**Calculated (c×d×10/12)**
	3,379 (2009-2018)	**tCO_2/yr**	**Calculated (c×d)**

Estimated annual baseline emissions of the electricity displacement component of the project activities are 1,656 tCO_2/year in 2008 and 3,379 tCO_2/year during 2009 to 2018.

Project emissions:

The Project is utilizing biogas with biogenic origins to produce renewable energy, and the design of the system does include only few smaller electrical appliances. Hence, the anthropogenic emissions from this component are considered to be negligible.

Leakage:

AMS-I.D, paragraph 12, states that no leakage calculation is required since the equipment is not being transferred to or from another activity.

AMS-III.D:

Baseline emissions are calculated as the following:

Parameter	Value	Unit	Source
a. Swine population	70,000	heads	Farm data

b. Gross Energy Intake per Head	34.62	MJ/day	Calculated (see Section B.6.2)
c. Digestibility	80	%	IPCC 2006 T.10.2
d. Urinary Energy (UE×GE)	0.02×34.62		IPCC2006 p10.42
e. Ash Content	4	%	IPCC 1996
f. Daily Volatile Solids Excretion	0.396	kg/day	Calculated based on IPCC tier 2 ([b×(1-c)+b×d] × [(1-e)/18.45])
g. Maximum Methane-Producing Capacity	0.29		IPCC 2006 T.10A-8
h. Methane Conversion Factor	80	%	IPCC 2006 T.10A-8
i. EF, Annual Emission Factor	22.48	kg/head/yr	Calculated (f×365×g×k×h×100%)
j. Annual Methane Capture	1,574	Ton/yr	Calculated (a×i/1000)
k. Methane Density	0.67	kg/m^3	EB28 Meeting Report Annex 13 page 12
l. Methane Content	65	%	Farm data
m. Daily Biogas Off take	9,901	m^3/day	Calculated ((j/0.67/l)/365×1000)
n. GWP Methane	21		
Annual CO_2 emission reduction from methane recovery	**33,052**	**tCO_2/yr**	**Calculated (j×n)**

Estimated annual baseline emissions of the methane component of the project activities are 33,052 tCO_2/year

Project emissions due to project activities are:

Parameter	Value	Unit	Source
a. Leakage from the digester	10	%	Default from ACM0010 Ver2
b. Methane not captured by the project	3,305	tCO_2/yr	Calculated (III.D baseline×a)
c. Flare Efficiency	50	%	AMS-III.H Ver4
d. Expected methane sent to Flare	0	tCO_2/yr	No biogas is expected to send to flare by Project owner
e. Methane captured and not flared	0	tCO_2/yr	Calculated
f. CO_2 emission from non-biogenic methane	0	tCO_2/yr	No other fuel than biogas is used.
g. Annual Electricity Consumption	461.65	MWh/yr	Farm data
h. Emissions Coefficient (y2008)	0.550	tCO_2/MWh	Calculated as shown in annex 3
i. Annual CO_2 emission from electricity consumption	253.91	tCO_2/yr	Calculated (g×h)
j. Methane emission from anaerobic treatment of sludge	0	tCO_2/yr	No sludge is expected during the crediting period
k. Annual CO_2 emission from project	3,559	tCO_2/yr	Calculated (b+e+f+i+j)

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

>>

Year	Estimation of project emission (tCO_2e)	Estimation of baseline emission (tCO_2e)	Estimation of leakage (tCO_2e)	Estimation of overall emission reductions (tCO_2e)
2008 (Mar – Dec)	2,966	29,200	0	26,234
2009	3,559	36,431	0	32,872
2010	3,559	36,431	0	32,872
2011	3,559	36,431	0	32,872
2012	3,559	36,431	0	32,872
2013	3,559	36,431	0	32,872
2014	3,559	36,431	0	32,872
2015	3,559	36,431	0	32,872
2016	3,559	36,431	0	32,872
2017	3,559	36,431	0	32,872
2018 (Jan – Feb)	593	6,072	0	5,479
Total	**35,591**	**364,314**	**0**	**327,563**

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

>>

The baseline of the project will be assessed each year throughout the period where the project will generate emission reductions. The methodology prescribes that for each year during the crediting period, the emissions are calculated as specified in paragraph (a) and paragraph (b) below and the lower of the two values is used as the baseline for that particular year:

(a) Actual monitored amount of methane captured and destroyed by the project activity.

(b) The methane emissions calculated ex ante using the amount of the waste or raw material that would decay anaerobically in the absence of the project activity, with the most recent IPCC tier 2 approach.

Metering the electricity generated and monitoring the amount of methane used as fuel or combusted as described in Appendix B of the simplified modalities and procedures for small-scale CDM project activities.

The approved monitoring methodologies applied to this project are as follows:

AMS-I.D Grid Connected Renewable Electricity Generation – (13) Monitoring shall consist of metering the electricity generated by the renewable technology.

AMS-III.D Methane Recovery in Agricultural and Agro Industrial Activities – (9) The amount of methane used as fuel or combusted shall be monitored, using flow meters and analyzing the methane content of the combusted gases with samples taken at least quarterly, and more frequently if the results show significant deviations from previous values; (10) Regular maintenance should ensure optimal operation of flares. The flare efficiency, defined as the fraction of time in which the gas is combusted in the flare, multiplied by the efficiency of the flaring process, shall be monitored; and (11) Flow meters, sampling devices and gas analyzers shall be subject to regular maintenance, testing and calibration to ensure accuracy.

The methodology was selected as suggested by the simplified monitoring methodologies for small-scale CDM projects. Measuring the amount of methane recovered and metering the amount of electricity generated are the most appropriate methods of monitoring the project activity.

All the monitored data will be kept for at least two years after the end of the crediting period or at the last issuance of CERs for this project activity, whichever occurs later.

B.7.1 Data and parameters monitored:

>>

Data / Parameter:	Q_G
Data unit:	m^3/day
Description:	Biogas flow to gas engine
Source of data to be used:	Meter readings
Value of data	9,901
Description of measurement methods and procedures to be applied:	Biogas flow will be measured using orifice plate metering devices in all systems. The meter will be calibrated on installation. In general, orifice plate meters can provide a level of data accuracy of +/-5%. Ultrasonic meters can provide high levels of accuracy (+/-2.5%), but a significantly higher capital cost.
QA/QC procedures to be applied:	Biogas meters should be subjected to a regular maintenance and testing regime to ensure accuracy. Where erroneous meter readings are encountered, specialist contractors will be employed to recalibrate meters.
Any comment:	at 20°C and 1 atm

Data / Parameter:	CEF
Data unit:	tCO_2/MWh
Description:	Grid Carbon Emission Factor
Source of data used:	Calculated value.
Value applied:	0.550 (For the year 2008) – subsequently, each year's specific CEF will be calculated through out the crediting period, based on updates from EGAT.
Justification of the choice of data or description of measurement methods and procedures actually applied :	The project activity involves displacement of grid electricity. As per the AMS-I.D methodology, the CEF of the grid which is calculated based on weighted average of the emissions of the current generation mix in tCO_2e/MWh.
Any comment:	The value changes every year, based on the changes in the grid mix.

Data / Parameter:	$f_{G,CH4}$

Data unit:	-
Description:	Methane content in biogas
Source of data to be used:	Direct measurement
Value of data	65.0%
Description of measurement methods and procedures to be applied:	Quarterly (or more frequent) readings of the CH_4 content of the biogas will be made, most likely employing specialist contractors equipped with a gas analyzer probe. These devices can generally achieve accuracy up to +/-2.5%, depending on calibration frequency. Gas analysis a using chromatography can provide more accurate results, but is technically more challenging, and more costly. Analysis results will be stored in the spreadsheet RatchaburiFarms.xls developed for the purpose of implementing the monitoring plan.
QA/QC procedures to be applied:	Biogas methane concentration should be measured by near infrared spectrometry or other quantitative process.
Any comment:	Measured by near infrared spectrometry (extremely accurate).

Data / Parameter:	$KW_{E,GENERATED}$
Data unit:	MWh/year
Description:	Electricity generated
Source of data to be used:	Meter readings
Value of data	6,144
Description of measurement methods and procedures to be applied:	Standard electricity metering devices, integrated with the power generating sets, will be the basis for collection of data on these parameters. It is not envisioned that these devices would perform unduly badly relative to any other electricity meter. Data will be stored in the spreadsheet RatchaburiFarms.xls developed for the purpose of implementing the monitoring plan.
QA/QC procedures to be applied:	The meters should be subject to a regular maintenance and testing regime to ensure accuracy. Where erroneous meter readings are encountered, specialist contractors will be employed to recalibrate meters.
Any comment:	

Data / Parameter:	E_{power}
Data unit:	MWh/year
Description:	Electricity consumption
Source of data to be used:	Calculated value
Value of data	461.65
Description of measurement methods and procedures to be applied:	Calculate based on the equipments rated power
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	Biogas Flared

Data unit:	m^3/year
Description:	Amount of the biogas sent to the flare
Source of data to be used:	Meter readings
Value of data	0
Description of measurement methods and procedures to be applied:	Biogas sent to the flare will be monitored through the use of biogas flow meter.
QA/QC procedures to be applied:	This parameter will only be monitored when there is surplus gas from the Project and a flare is installed.
Any comment:	

Data / Parameter:	Flare efficiency
Data unit:	%
Description:	The fraction of methane destroyed. The flare efficiency is defined as the fraction of time in which the gas is combusted in the flare, multiplied by the efficiency of the flaring process.
Source of data to be used:	Default value
Value of data	50%
Description of measurement methods and procedures to be applied:	In case of open flares, the flare efficiency in the hour h ($\eta_{flare,h}$) is • 0% if the flame is not detected for more than 20 minutes. • 50%, if the flare is detected for more than 20 minutes.
QA/QC procedures to be applied:	Maintenance of the flare is to be conducted once a year to ensure optimal operation.
Any comment:	

Data / Parameter:	Sludge application
Data unit:	Tonnes /year
Description:	Quantity of sludge removed from the treatment system and its application.
Source of data to be used:	Measurement of truck weight and application of the sludge
Value of data	-
Description of measurement methods and procedures to be applied:	Sludge removal and its application will be measured whenever the sludge is removed from the biogas reactor and open lagoon system and a record will be maintained in the farm.
QA/QC procedures to be applied:	Measurement will be carried out adhering to internationally recognized procedures
Any comment:	

B.7.2 Description of the monitoring plan:

>>

The Farm shall designate sufficient staff responsible for reading and archiving the data according to the monitoring plan. Data shall be archived and analyzed for the purpose of verification.

Before the initial verification of the project activity, the following procedures need to be developed and implemented:

- Establish a data measurement and recording protocol for all relevant data needed, based on the monitoring plan outlined, and taking into account the QA/QC comments in *Section B.7.1*;
- Development of procedures for archiving data (electronic and paper);
- Coordination of basic training procedures for operational staff so that they are able to fulfill the requirements the proposed monitoring plan, taking into account the QA/QC issues highlighted in *Section B.7.1*;
- Identification of specialist local contractors able to undertake the support needed (meter calibration, gas analysis);
- Procedures for project performance review before submitted for verification
- Procedure for corrective actions to improve future monitoring and reporting.

SPM Farm will implement an Emergency Preparedness Plan and Procedures at the plant. The procedure will contain instructions on how to handle an emergency situation in the plant, and measures to be taken to ensure that there is no unintended methane leakage from the system. All the plant operators will be trained in these procedures.

A portable 'gas detector' will be available at the plant, to avoid accidents when maintaining the plant.

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

>>
Date of completion of the methodology: 10/06/10

Contact information of the person(s)/entity (ies) responsible for the application of the baseline and monitoring methodology to the project activity:

Organization	Danish Energy Management A/S
Contact person	Mr. Karsten M. Holm
Telephone no.	+66(0) 2305 6606
Email address	kah@dem.dk
Date of completion	10/06/10

Danish Energy Management A/S is not a "project participant" listed 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:

>>
17/10/03

C.1.2 Expected operational lifetime of the project activity:

>>
20y-0m. Based on an estimate of civil engineering asset life for precast and *in situ* concrete.

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

>>
Fixed crediting period

C.2.1 Renewable crediting period

C.2.1.1 Starting date of the first crediting period:

>>
Not applicable

C.2.1.2 Length of the first crediting period:

>>
Not applicable

C.2.2 Fixed crediting period:

C.2.2.1 Starting date:

>>
1 March 2008 or when registered with the EB.

C.2.2.2 Length:

>>
10 years

SECTION D. Environmental impacts

>>

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

>>
Although an approval of an Environmental Impact Assessment (EIA) report is not required by Thai laws for this type of project, the project participants have undertaken an analysis of the environmental impacts of the project activity to ensure minimum impacts on the environment and to determine any mitigation measures if such impacts are significant. The analysis of environmental impacts of the project activities was undertaken in comparison of the impacts of the old anaerobic lagoon system. The findings of the analysis is summarised below and the report is exhibited in Annex 4.

Four aspects of environmental impacts were identified as a result of the wastewater treatment operation, which are:

- **Odour** – since the new wastewater treatment system operates in a closed system, undesirable odour will be significantly reduced;
- **Wastewater pollution** – the new wastewater system can remove more than 90% of organic matter in the wastewater so that environmental impacts of possible overflow during the rainy season or of groundwater contamination will be significantly reduced;
- **Solid waste disposal** – the new system has installed a sand bed filter for sludge separation which will improve the handling of solid waste, whereby the environmental impacts is reduced, and;
- **Safety** – since biogas will be stored in large quantity, the issue of gas safety becomes a concern. However, the risk of any explosion will be very unlikely because the biogas, once leaked from its storage, will disperse quickly upward and will not build up above ground surface. Nonetheless, to avoid any risk of fire, no matter how unlikely, ignition sources, including smoking in the proximity of the biogas plant must be strictly prohibited.

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:

>>

Overall, impact assessment of the new wastewater treatment operation compared with the old system operation shows a satisfactory result. Most environmental aspects are actually expected to improve after implementing the UASB system. Only gas safety will have negative impacts compared to the anaerobic lagoons, but such impact is not significant and mitigations measures are, therefore, not required except for a no-smoking sign.

SECTION E. Stakeholders' comments

>>

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

>>

The process by which comments by local stakeholders was received is through a public meeting, an attitude survey, and posting of impact assessment report.

Public meetings

Public meetings were organized at SPM Farm on 15 August 2005. Participants to the meetings were called from villages adjacent to the site. The main activities during the meeting include:

- Project introduction;
- VDO presentation about biogas generation technology;
- Site visit;
- Questions and answers; and
- Attitude survey using questionnaire.

Some pictures from the public meetings are provided in *Box 5*.

Box 5 Public meetings at SPM Farm

Attitude surveys

In addition to the meetings, additional knock-door attitude surveys were also conducted. A brief summary of wastewater treatment system and biogas was introduced to the respondents prior to asking the questions and filling in the questionnaire forms.

The target areas for attitude survey covered all the villages adjacent to the sites as they were most likely to be affected by the projects' operation. Numbers of households to be surveyed were based on 10% of households in the target villages as provided in *Table 1* below.

Table 1 Villages adjacent to SPM Farm

Farm	Sub-district	Villages	Households
SPM	• Don Sai	• Moo 5 Ban Khao Than	208
	• Huai Yang Thon	• Moo 1 Ban Hua Khao Chin	134
		• Moo 2 Ban Huai Yang Thon	143
		• Moo 4 Ban Phu Kate	199
		Total	**684**
		Target sampling size	**69**

Posting of impact assessment report

Further comments from the local community were also welcome from posting of the impact assessment report in Thai at the relevant local governmental office (Tambon Adminstration Organisation). Any comments can be addressed directly to the farm or through the government official.

E.2 Summary of the comments received:

>>

Comments received through public meetings and through knock-door attitude survey were consolidated and summarised below.

SPM Farm

- Number of respondents: 71
- 80% agreed with the project activity
- Most respondents believed the project would benefit their community through increased employment (69%), village development (62%), health and sanitation (53%), and improved air quality.
- Major concern was gas explosion (55%).

The report of attitude survey can be found in Annex 4. No further comments have yet been received to date through posting of the environmental impact assessment report.

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

>>

As explained in the environmental impact assessment section above, the risk of explosion is unlikely because when there is a gas leak, the leaked biogas will disperse quickly upward into the sky as it is lighter than air. Since, methane will not build up above the ground surface, the resulting gas explosion, therefore, does not appear possible.

Nonetheless, to reduce all the possibilities of fire, the following measures must be undertaken.

- Ignition sources, including smoking in the proximity of the biogas plant must be strictly prohibited. A warning sign should be made and affixed at the biogas storage area. Such warning signs might read, for example, ‘no-smoking, matches or open flames’, or ‘flammable gas, keep fire away’;
- All staff working at the biogas plant shall receive adequate training on fire safety;
- The farm shall set up a routine check to ensure no leakage of biogas; and
- The farm shall supply sufficient fire fighting equipment located within the gas storage area and maintain them in good condition

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	S P M Feed Mill Co., Ltd.
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

Not applicable. There is no public funding from Annex I countries involved in the project activities.

Annex 3

BASELINE INFORMATION

A. Grid Emission Factor for Thailand

Description of CEF based on weighted average

Type of Fuel	Conversion Factor		Unit	2008
Hydroelectric			GWh	6,951
			$ktCO_2$	0
			tCO_2/MWh	0
Natural GAS			GWh	104,480
			MMSCFD	2,423
	1.02	TJ/mmscfd	TJ	902,083
	15.3	tC/TJ	$ktCO_2$	50,607
			tCO_2/MWh	0.484
Heavy Oil			GWh	990
			MLitres	247
	39.77	TJ/MLitre	TJ	9,823
	21.1	tC/TJ	$ktCO_2$	760
			tCO_2/MWh	0.768
Diesel Oil			GWh	23
			MLitres	50
	36.42	TJ/MLitre	TJ	1,821
	20.2	tC/TJ	$ktCO_2$	135
			tCO_2/MWh	5.794
Lignite			GWh	18,679
			MTonnes	16.41
	10.47	TJ/kt	TJ	171,786
	27.6	tC/TJ	$ktCO_2$	17,384.77
			tCO_2/MWh	0.931
Imported Coal			GWh	12,064
			MTons	5.05
	26.37	TJ/kt	TJ	133,051
	25.8	tC/TJ	$ktCO_2$	12,587
			tCO_2/MWh	1.043
Renewable Energy			GWh	2,250
			$ktCO_2$	0
			tCO_2/MWh	0
TNB			GWh	2,784
			$ktCO_2$	0
			tCO_2/MWh	0
Nuclear			GWh	0
			$ktCO_2$	0
			tCO_2/MWh	0
Total			**GWh**	**148,220.95**
			$ktCO_2$	**81,473.14**
CEF			**tCO_2/MWh**	**0.550**

Sources: Thailand power generation fuel mix from EGAT, Annual Report 2008 and Energy statistics from Energy Policy and Planning Office (EPPO); Conversion factors and emission factors for different fuels established from Revised IPCC 2006 Guidelines for National Greenhouse Gas Inventories, and where applicable from Department of Alternative Energy Development and Efficiency, Thailand Energy Situation 2008.

CO_2 emission from electricity consumption is estimated using the methodology and is listed in the following table.

Type of generation	Amount of CO_2 Emission

Hydroelectric	0	kt CO_2e
Natural gas	50,607	kt CO_2e
Heavy oil	760	kt CO_2e
Diesel oil	135	kt CO_2e
Lignite	17,384.77	kt CO_2e
Imported coal	12,587	kt CO_2e
Renewable energy	0	kt CO_2e
TNB	0	kt CO_2e
Nuclear	0	kt CO_2e
Total for the year	**81,473.14**	**kt CO_2e**

CO_2 emission for all generation types was obtained using the grid fuel consumption given in the table above. A sample calculation method is given below, for CO_2 estimation for lignite (for the year 2008).

Estimated Grid Emission ($ktCO_2$ /year)	=	Grid fuel consumption (kt)	*	NCV[3] (TJ/kt)	*	CEF (tC/TJ)	*	Fraction of C oxidised	*	MCF (tCO_2/tC)
	=	$16.41 * 10^3$	*	10.47	*	27.6	*	1	*	44/12
	=	17,384.77	$ktCO_2$							

The grid CO_2 emission is similarly estimated for each generation type, following the same procedure as for lignite. The values are summed up to get the annual CO_2 emission.

Now, grid CO_2 emission factor = Total Grid CO_2 Emission (tCO_2)/ Total electricity generated (MWh)
= 81,473,140/148,220,950
= 0.550 tCO_2/MWh
= 0.550 kCO_2/kWh

[3] Department of Alternative Energy Development and Efficiency (DEDE) Thailand Energy Situation 2008, p.32

Annex 4

ANALYSIS OF ENVIRONMENTAL AND SOCIAL IMPACTS

This analysis of environmental and social impacts was undertaken to support the development of anaerobic wastewater treatment projects for SPM farm in Ratchaburi province, Thailand. The project activity will replace the old anaerobic lagoon treatment system with an Up-flow Anaerobic Sludge Blanket (UASB), whereby the biogas generated will be captured and utilised for power and heat generation. An approval of an Environmental Impact Assessment (EIA) report is not required by Thai laws for this type of project.

The analysis of environmental impacts of the project activities was undertaken in comparison of the impacts of the old anaerobic lagoon system. The analysis of social impacts was undertaken by means of public meetings and attitude survey in the local communities.

Environmental Setting

SPM farm is located in Pak Thor District, Ratchaburi Province, Thailand. General information of the area is provided below.

Topology

Ratchaburi province is located in the southwest of Thailand, approximately 100 km to the west of Bangkok. The province covers an area of 5,133 km^2, stretching between Latitude 13°09′N and 13°57′N, Longitude 99°10′E and 100°05′E. Pak Thor District is situated on the edge of the central plain of Thailand. Based on the 1:50,000 topographical map, the majority of Pak Thor District can be described as plain and hills. To the west are the highlands and hills, a part of Tanao Sri Mountains. The area slopes eastwards to the Gulf of Thailand. Watercourses in the area are natural streams and irrigation canals.

Climate

Based on 10 years climatologic record (1992-2001) of Ratchaburi Climatology Station which is the nearest station to the sites, mean annual temperature is approximately 28.3°C, with the lowest average minimum temperature of 20.0°C in December and the highest average maximum temperature of 36.3°C in April.

Wind direction is from the southeast during February to May, from the west during June to October and from the north during November to January. Mean annual wind speed is quite mild ranging from 0.7 to 1.5 m/s.

The average annual rainfall quantity is 1,224.7 mm, with a maximum record of 304.9 mm within 24 hours over the period of 10 years. January is the driest month with the minimum recorded rainfall of 1.4 mm, while October has the maximum of 268.0 mm. Greatest rainfall amount is found during May to October.

The climatologic record at Ratchaburi Climatology Station during 1992 - 2001 is shown in *Table 1*.

Table 1 Climatologic Records at Ratchaburi Climatology Station During 1992 - 2001

Latitude 13.5 N
Longitude 99.8 E
Elevation of station above MSL 5.00 m

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Year
Air Temperature (°C)													
Mean	26.3	27.5	29.1	30.7	30.2	29.5	29.0	28.8	28.6	27.7	26.4	25.5	**28.3**
Mean max	32.6	34.1	35.1	36.3	35.4	34.0	33.5	32.9	32.8	31.4	30.6	30.5	**33.3**
Mean min	20.0	21.1	23.4	25.0	25.3	25.1	24.7	24.8	24.5	24.0	22.2	20.3	**23.4**
Relative Humidity (%)													
Mean	66	65	66	67	69	73	74	76	77	79	75	70	**71**
Mean max	93	92	93	92	91	93	93	94	94	95	95	92	**93**
Mean min	41	39	40	41	48	54	55	57	61	63	56	47	**50**
Rainfall (mm)													
Total amount	1.4	4.9	41.6	51.2	157.6	132.2	126.9	123.7	249.6	268.0	62.5	5.1	**1,224.7**
No. rainy days	1	1	5	5	15	15	16	18	20	18	6	2	**122**
Greatest in 24 hr	7.1	16.0	49.1	46.6	61.8	65.3	77.7	91.7	79.1	114.8	304.9	22.3	**304.9**
Wind													
Wind Direction	N	SE	SE	SE	SE	W	W	W	W	N	N	N	
Wind Speed (m/s)	0.8	1.2	1.2	1.0	1.0	0.7	0.8	0.9	0.7	0.8	1.2	1.5	

Source: Meteorology Department, 2002

SPM Farm

SPM Farm is located at Moo 8 , Don Sai Sub-district, Pak Thor District, Ratchaburi Province. This site is located in a plain area with the elevation of approximately 24-30 m above MSL. A 104 m high hill, Khao Than, is located approximately 2 km northwest of the site. Networks of watercourses within the study area include Huai Pak, Huai Yang Thon, Huai Ang Hin and Huai Lin Chang. Nearest watercourse is Huai Pak, which is adjacent to the south of the site.

The main source of water for household consumption in this area is tap water, and some areas use groundwater. Landuse in the area is mainly for agricultural and farming purposes. Communities are scattered around the area. The villages adjacent to the site include:

- Moo 5 Ban Khao Than, Don Sai Sub-district, located east of the site;
- Moo 2 Ban Huai Yang Thon, Huai Yang Thon Sub-district, located west of the site;
- Moo 1 Ban Hua Khao Chin, Huai Yang Thon Sub-district, located south of the site; and
- Moo 4 Ban Phu Ket, Huai Yang Thon Sub-district, located north of the site.

It should be noted that there are a total of 13 swine farms in this sub-district, of which SPM and Kanchana Hybrid Farms are large farms and the remaining are medium size farms.

Environmental Impact Assessment

The environmental assessment of SPM Farm covers the area within 3-5 km radius of the farm. Secondary data were taken from relevant authorities in Pak Thor District to identify sensitive receptors in the study areas.

At the time of the assessment, the H-UASB treatment systems have been constructed and some operated. However, this study assesses the environmental impacts from the operation of H-UASB system, compared to the pre-biogas operation condition (use of anaerobic lagoon system).

Old System Operation

Generally, swine farms in Thailand use anaerobic lagoon to treat their barn flushing effluent. This system comprises a series of earthen ponds to treat the wastewater/manure by mean of biological treatment. As wastewater decomposes slowly through a series of open ponds, undesirable odour and flies are often found in this type of wastewater treatment system. In addition, discharge of nutrient rich wastewater off-site may result in downstream eutrophication and decrease of rice production rate.

Impact assessment and Mitigation Measures

Wastewater from swine rearing facilities contains high concentration of organic compound and must be treated before discharging outside the facility. Four aspects of environmental impacts were identified as a result of the wastewater treatment operation, which are odour, wastewater pollution, solid waste disposal and safety. In this analysis, each environmental impact of the proposed UASB wastewater treatment system is evaluated compared to the old anaerobic lagoon system.

1. Odour

Air pollution occurred as a result of swine farm wastewater treatment plant can generally be limited to undesirable odour. Other aspects of air pollution such as smoke, dust, etc. are not significant and, therefore, can be neglected.

Wastewater from swine farms generates a large quantity of malodorous gases as a result of the decomposition of organic matter. In the old anaerobic lagoon treatment system, wastewater from swine farms is detained in a series of deep open ponds which allows organic matters to decompose biologically over a long period of time. Since these ponds are not covered, the undesirable odours cause annoyance to nearby communities.

Odours at low concentration can cause psychological stress rather than physical harm to the body. Offensive odours can cause poor appetite for food, lowered water consumption, impaired respiration, nausea and vomiting and mental perturbation. These effects can have an impact on socio-economic condition in the community such as deterioration of human health, a decline in property value and lowered capital investment.

Considering the use of the new system, UASB, manure and barn flushing wastewater are routed to buffer tank and UASB tank. Most of the gas generated will be captured and stored under a polyethylene cover placed over the buffer tank. Due to its economic value, the biogas will be combusted for power or heat generation and not released directly to the atmosphere. Therefore, when the UASB plant is operating properly, the odour problem will be reduced significantly compared with the anaerobic lagoon system.

2. Wastewater Pollution

Although SPM Farm has already installed the wastewater treatment system, there are 3 possible aspects of environmental impacts that should still be considered, which are:

- Non-standard effluent discharge;
- Wastewater overflow; and
- Groundwater contamination

Non-standard effluent discharge

Although the anaerobic lagoon and UASB system, when designed properly, can remove more than 90% of organic matter from swine wastewater, the effluent from both systems is still rich in nutrients. A post treatment system is required before the effluent can be discharged outside the facilities so as to meet the wastewater effluent standards (See *Table 2*). Generally, it is a good practice to design the system such that the water quality in the final pond meets the effluent standards, even though water is reused within the farm and not discharged outside. Since both old and new systems have put in facultative ponds as post-treatment system and all farms plan to reuse all the treated wastewater for barn flushing the impact from non-standard effluent discharge is unlikely under both circumstances.

Table 2 Large scale swine farm effluent standard in Thailand

Parameters	Units	Standard
pH	-	5.5 - 6
BOD	mg/l	< 60
COD	mg/l	< 300
SS	mg/l	< 150
TKN	mg/l as N	< 120

Source: Pollution Control Department, Ministry of Natural Resources and Environment, Thailand (2002)

Wastewater overflow

Wastewater overflow might happen during the rainy reason if the precipitation rate is higher than the outflow rate of the final pond for a sustained period of time. Wastewater overflow can lead to a variety of problems that have significant environmental impacts. Excess nutrients in the wastewater will stimulate excessive plant growth which can disrupt normal functioning of the ecosystem, known as eutrophication. High nitrogen concentration will also lead to excessive growth of rice leaves while decreasing the rice yield in nearby paddy field. Such problem could also lead to social conflicts within the community.

While wastewater can overflow from any ponds in the old anaerobic lagoon, the overflow can only happen from the post-treatment ponds in the UASB system. Since the average water quality in the UASB post-treatment ponds is better than that in the anaerobic lagoon ponds, the environmental impacts from overflow of wastewater will be significantly reduced.

Groundwater contamination

The possibility of groundwater contamination is determined by the properties of the overlying soil and water table depth. Soil permeability is defined as the rate at which a contaminant travels through soils. Soils with higher permeability facilitate the transport of pollutants into groundwater. Thus, high permeability is an indicator of increased risk of ground water contamination. General data of soil permeability is shown in *Table 3*.

Table 3 Typically data of soil permeability

Soil	Permeability Coefficient		Relative Permeability
	Centimetre /second	Per year	
Coarse gravel	$>10^{-1}$	31,536 m/year	High
Sand, Clean	10^{-1} - 10^{-3}	315 - 31,536 m/year	Medium
Sand, dirty	10^{-3} - 10^{-5}	3.15 - 315 m/year	Low
Silt	10^{-5} - 10^{-7}	3.15 - 315 cm /year	Very low
Clay	$< 10^{-7}$	<3.15 cm/year	Impervious

Source: Geology and Soil Mechanic, UW-Stout.

The old anaerobic lagoons system comprises a series of unlined earthen ponds which is classified into silt soil. From *Table 3*, the permeability coefficient of slit ranges between 3.15-315 cm/year. The soil characteristics of the swine farm site indicate that the ground water level is approximately 40-100 metres from the ground surface. Assuming the middle value of permeability coefficient for silt soil of 31.5 cm/year, it would take 126 years to penetrate 40 metres or 317 years to penetrate 100 metres.

Although it would take more than a life span for wastewater to permeate into groundwater, it will eventually occur. However, since the UASB system is constructed using concrete lining with a much lower permeability coefficient, its impacts on groundwater contamination will be significantly reduced.

3. Solid Waste Disposal

Suspended solids or sludge are produced by the biological conversion of organic substance (BOD or COD) in wastewater. Every wastewater treatment systems always produce the standard effluent and excess sludge. From this point, the first treatment unit is likely to produce more sludge than the final treatment pond, because it reduces more COD. Therefore, the pre-treatment unit should be the focus of attention because it is where solid waste pollution is most likely to occur.

Anaerobic lagoon treatment is generally not designed for handling excessive sludge, so the sludge will be accumulated at the bottom of the ponds. Removal of these solids will be undertaken once the pond is full. The removed sludge will be dried by land spreading and then released filtrate will disperse over a wide area because there is no proper method for controlling filtrate, high nutrient water releasing from sludge. In addition, if the removed sludge is not completely digested, usually sludge from the first pond, it can cause a number of undesirable impacts such as odour flies and insects.

In contrast, sludge from the UASB treatment system is constantly released from the tank bottom and is dried on sand bed filter. The filtrate will percolate through the sand to the post-treatment system. After a few days the dried sludge will be removed for use as fertilizer. It is seen that this system will significantly reduce the impact that might occur from the old system.

4. Safety

Since a large quantity of methane will be captured and stored, gas safety must be taken into consideration. Two safety issues are of concern when dealing with explosive gas storage, which are:

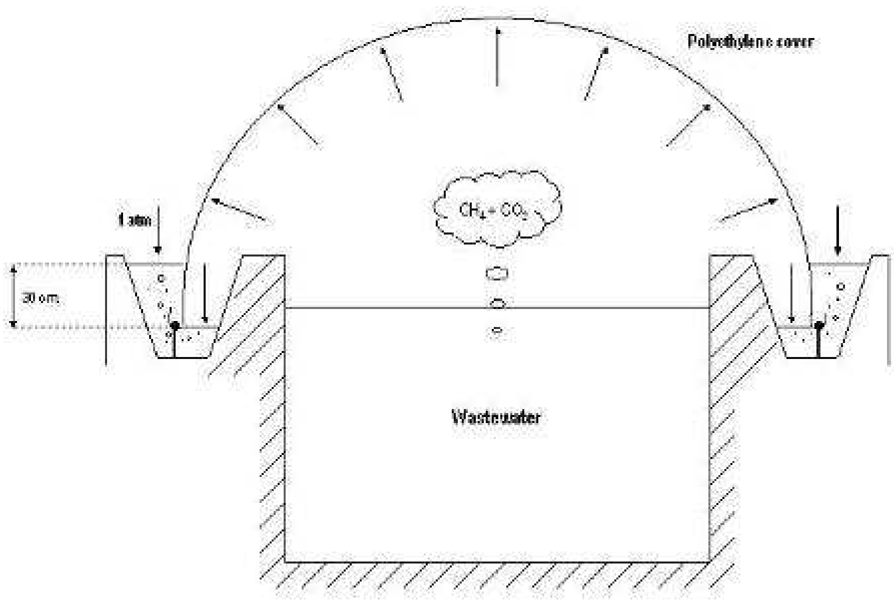
- Conflagration
- Asphyxiation

Conflagration

Conflagration refers a large destructive fire, with large amount of heat released during a rapid, self-sustaining exothermic oxidation of fuel. The flammable range of methane (CH_4) concentration is between 5-15% in the presence of oxygen. Since methane concentration in biogas is typically very high around 60-70%, with the remaining made up of carbon dioxide, explosion inside the biogas storage is therefore impossible even in the presence of ignition.

Although the risk of conflagration is unlikely, it is still possible that biogas could leak from its polyethylene cover. In such cases, it can be highly flammable when mixed with air. Biogas might be released to the atmosphere due to severe pressure inside the storage. There is a pressure control system at the storage, using the water level around the polyethylene cover. As the pressure inside the biogas storage builds up to 30 cm H_2O above atmospheric pressure, the biogas will be released, as shown in *Figure 1*. Thus, the risk that the polyethylene cover will explode is, therefore, not possible.

Figure 1 Automatic Pressure Release in Buffer tank



If there is a puncture in the polyethylene cover, biogas will be released continuously to the atmosphere. Should the gas stream be ignited, a jet fire will occur. However, the scale of fire will be small since the pressure in the biogas cover is only a little higher than atmospheric pressure, and once the pressure inside the cover drops, gas will stop leaking.

If the leaked biogas is not ignited, methane will disperse quickly upward into the sky because it is lighter than air. Since, methane will not accumulate on the ground surface, the resulting gas explosion, therefore, does not appear possible. Nonetheless, to reduce all the possibilities of fire, ignition sources, including smoking in the proximity of the biogas plant must be strictly prohibited.

Asphyxiation

Asphyxiation is the unconsciousness and ultimately death which happens when the supply of oxygen to your brain is cut off. In low concentration, methane is not hazardous to human. However, if it builds up to 90% of concentration, asphyxiation is expected within 5 minutes. Asphyxiation hazard from high methane concentration usually occurs inside underground sewage system or underground coalmines where air circulation is inhibited. As explain above, the concentration of methane in biogas is around 60-70% and once released to the atmosphere, it will disperse quickly upward and will not accumulate near the ground surface. The risk of asphyxiation is, therefore, insignificant.

According to the *Ministerial Order on Condition for Storage and Possession of Flammable Material 2005*, the storage of flammable gas must comply with the following conditions:

- Keep away from heat and flame, explosive material, oxidizing agent, radioactive material, as well as other incompatible materials;
- The gas storage must be affixed to the ground to prevent it from falling over and the storage must be maintained in good condition;
- Put up adequate and appropriate warning signs and ensure that they are followed strictly;
- Control temperature and ventilation that is suitable for the gas characteristics;
- Provide sufficient fire fighting equipment that is ready for use;

Most of the above conditions have already been complied except for putting up appropriate warning signs and ensuring that they are followed strictly. Such warning signs might read, for example, 'no-smoking, matches or open flames', or 'flammable gas, keep fire away', as shown in *Figure 2*. All staff working at the biogas plant should also receive adequate training on fire safety. In addition, the farm shall supply sufficient fire fighting equipment located within the gas storage area and maintain them in good condition.

Figure 2 Example of Warning Signs

Source: Seton Australia http://www.seton.net.au/templates/signs_flammable.cfm

Summary of Environmental Impact Assessment

Impact assessment of the new wastewater treatment operation compared with the old operation can be summarized as shown in *Table 4*. As we can see, most environmental aspects are actually expected to improve after implementing the UASB system. Only gas safety will have negative impacts compared to the anaerobic lagoons, but such impacts will be insignificant as explained before, and mitigations measures are, therefore, not required except for an appropriate warning sign and its enforcement. Sufficient fire fighting equipment should also be arranged and maintained in good condition.

Table 4 Impact assessment of the new wastewater treatment operation compared with the old operation.

Aspect	**Impact (UASB vs. Anaerobic lagoon)**	**Mitigation required**
Air pollution		
- Odour	Significantly improved	-
- Others	Not relevant	-
Wastewater pollution		
- Non-standard effluent discharge	Not affected	-
- Wastewater overflow	Significantly improved	-
- Groundwater contamination	Significantly improved	-
Solid waste pollution		
- Non-managed solid waste disposal	Significantly improved	-
Safety		
- Conflagration	Not significant	Put up an appropriate warning sign, install fire fighting equipment
- Asphyxiation	Not significant	-

Attitude Survey

As part of the public participation programme, community attitude survey was conducted on 16 August 2003 to receive local communities' views and their concerns regarding the project.

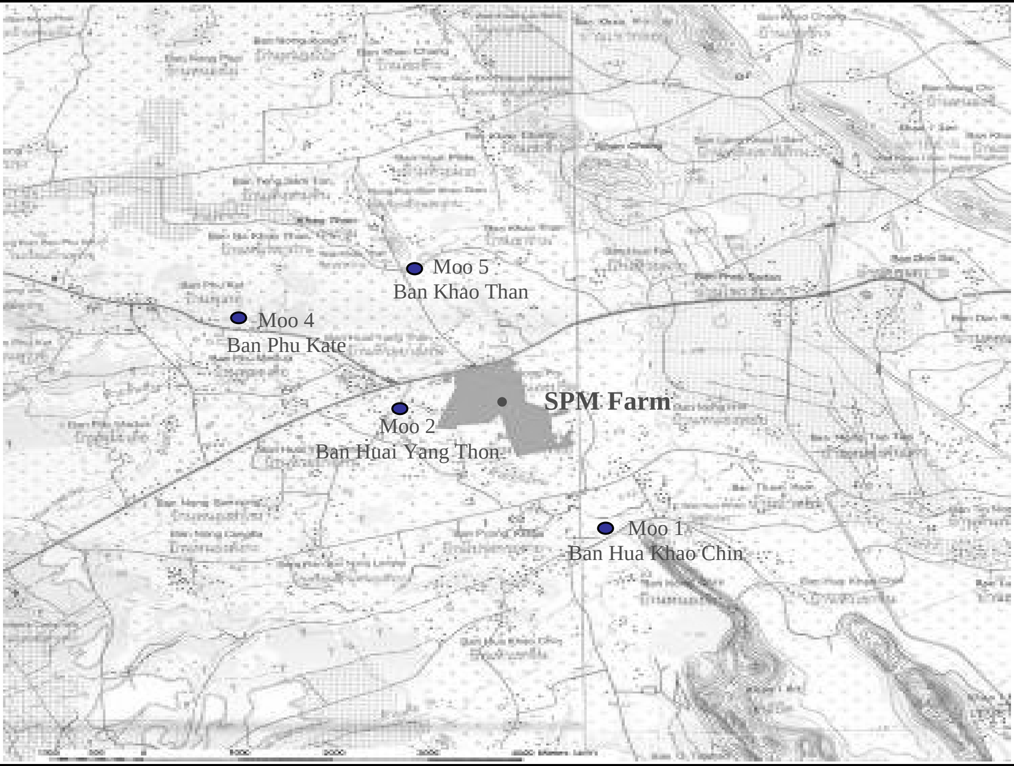
The target areas for attitude survey covered all the villages adjacent to the sites as they were most likely to be affected by the projects' operation. Numbers of households to be surveyed were based on 10% of households in the target villages as provided in *Table 5* below.

Table 5 Villages adjacent to SPM Farm

Farm	**Sub-district**	**Villages**	**Households**
SPM	• Don Sai	• Moo 5 Ban Khao Than	208
	• Huai Yang Thon	• Moo 1 Ban Hua Khao Chin	134
		• Moo 2 Ban Huai Yang Thon	143
		• Moo 4 Ban Phu Kate	199
		Total	**684**
		Target sampling size	**69**

Locations of villages surrounding SPM Farm are shown in *Figure 3*.

Figure 3 Locations of Villages Adjacent to SPM Farm



Source: 1:50,000 Topographic Map No 4935I and 4935 IV, Royal Thai Survey, 1993

Survey Activities

In order to introduce the project activities to local communities, meetings were organized at the site on 16 August 2005. Participants to the meetings were called from villages adjacent to the farm. The main activities during the meeting include:

- Project introduction;
- VDO presentation about biogas generation technology;
- Site visit;
- Questions and answers; and
- Attitude survey using questionnaire.

Photos from the meetings are provided in *Figure 4*.

Figure 4 Meeting at SPM Farm

In addition to the meetings, additional knock-door attitude surveys were also conducted. A brief summary of wastewater treatment system and biogas was introduced to the respondents prior to asking the questions and filling in the questionnaire forms.

Attitude Survey Results

There were a total of 71 respondents, from 3 sub-districts including:

- Huai Yang Thon sub-district (38 respondents or 54%);
- Don Sai sub-district (28 respondents or 39%); and
- Other sub-district e.g. Pak Tor sub-district (5 respondents or 7%)

From the total of 71 respondents, 38% were male and 62% were female. The majority of the respondents were in the age of 40-50 years (27%) and received only primary education (58%). 54% of respondents were born in the village where the survey took place while 21% migrated from other places in Pak Thor District. The majority of the respondents worked in agricultural sector on their own farms (27%), were employed in agricultural sector (13%), and worked for government sector (12%).

The environmental problems that the respondents were experiencing include:

- nuisance odour (31%);
- degradation of water quality in water courses (31%);
- degradation of water quality within the villages (21%); and
- air quality (18%).

Regarding the knowledge and attitude towards biogas and project, 73% of respondents had heard about biogas but 43% did not understand what it was, while 27% had never heard of it before. The respondents expected that the biogas project would help reduce the nuisance odour (61%), and that air and water quality would also expected to be improved (59%).

The majority of the respondents perceived that the biogas project operation would result in benefits to themselves and their families in the following areas:

- increased employment (69%);
- village development (62%);
- health and sanitation (53%); and

- air quality and odour (51%).

Only a few people believe that the project would lead to disadvantages, for example:
- noise disturbance (11%);
- air quality and odour (7%);
- water quality (7%);
- health and sanitation (3%); and
- agriculture (3%).

The issue of greatest concern was explosion of gas tank (55% of respondents were concerned about this issue), followed by gas leak (52%), and the insecurity around the project area (41%). Other issues e.g. fouling of water courses, gassy smell from the treatment process, air quality and noise disturbance were of lower concerns.

Overall, the majority of the respondents (80%) agreed with the development, while 9% provided negative responses towards the project. The remaining 11% provided no comment.

Overall Comments/Recommendations

On the whole, the projects were very well received by the local communities. However, they were still concerned about odour, gas safety and overflow of wastewater that could damage the rice production. Some of the respondents requested that farms monitor their system regularly, and would like to know more about benefits/disadvantages of the system. In addition, some respondents expected that electricity would be provided at cheap price.

<u>Summaries and Conclusions</u>

The analysis of environmental and social impacts has been undertaken for the development of UASB system at SPM Farm to replace the old anaerobic lagoon system. The analysis of environmental impacts of the project activities was undertaken in comparison of the impacts of the old anaerobic lagoon system. The analysis of social impacts was undertaken by means of public meetings and attitude survey in the local communities.

Four aspects of environmental impacts were identified as a result of the wastewater treatment operation, which are:
- Odour;
- Wastewater pollution;
- Solid waste disposal; and
- Safety.

Impact assessment of the new wastewater treatment operation compared with the old system operation shows a satisfactory result. Most environmental aspects are actually expected to improve after implementing the UASB system. Only gas safety will have negative impacts compared to the anaerobic lagoons, but such impacts is not significant as explained before, and mitigations measures are, therefore, not required except for putting up an appropriate warning sign. All staff working at the biogas plant should also receive adequate training on fire safety. In addition, the farm shall supply sufficient fire fighting equipment located within the gas storage area and maintain them in good condition.

On the social impacts, the projects were very well received by the local communities. However, they were still concerned about odour, gas safety and overflow of wastewater that could damage the rice production. Some of the respondents requested that farms monitor their system regularly, and would like to know more about benefits/disadvantages of the system. In addition, some respondents expected that electricity would be provided at cheap price.

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