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

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Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

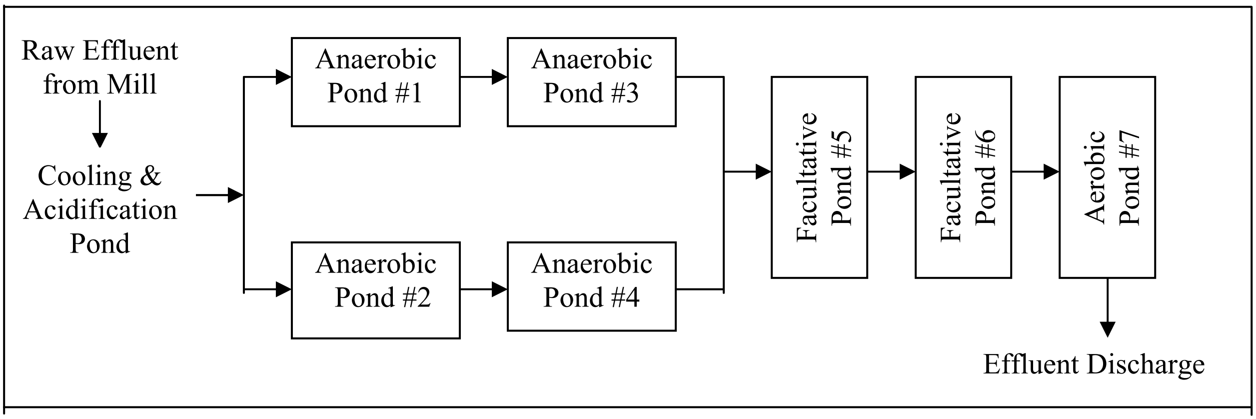
Methane recovery and utilisation project at TSH Kunak Oil Palm Mill, Sabah, Malaysia.

Version 5, 15 May 2007.

A.2. Description of the project activity:

The project activity involves the installation of a closed continuous-flow stirred tank reactor (CSTR) anaerobic digester plant for the treatment of palm oil mill effluent at TSH Kunak Oil Palm Mill at Tawau, Sabah, Malaysia. The biogas generated will be captured in the enclosed anaerobic digester tanks. The captured biogas will be utilised for power generation where electricity generated will be supplied to an industrial plant located within the same integrated industrial complex. Excess biogas, if it occurs, will be flared.

The anaerobic digester plant will replace the existing treatment system for the raw palm oil mill effluent (POME) from TSH Kunak Oil Palm Mill which is based on the common open lagoon treatment method widely adopted by the palm oil industry in Malaysia. The existing method involves the application of deep open lagoons (6.5 m depth) (Pond # 1, 2, 3 & 4) for anaerobic digestion of the POME, followed by facultative treatment in Pond # 5 & 6), and finally subject to aerobic conditioning in Pond # 7, before discharging to open watercourse as illustrated in the following schematic diagram.



The depth of Anaerobic Ponds # 1, 2, 3 & 4 is 6.5 m, with a total combined pond capacity of 78,000 m^3. The depth of Facultative Ponds #5 & 6 is 3-3.5 m, with a total capacity of 20,825 m^3. Aerobic Pond #7 has a depth of 3.5 m and capacity of 11,900 m^3.

Under the baseline situation, the COD level in the raw POME input is reduced from 76,752 mg/L to 3,852 mg/L and BOD from 37,300 mg/L to 392 mg/L after going through Anaerobic Ponds #1 - #4. The final effluent after being treated in Facultative Ponds #5 & #6 and Aerobic Pond #7 is discharged to the open watercourse with an average of 542 mg/l for COD and 81 mg/l for BOD. Biogas produced from the anaerobic process of the open ponds, constituting mainly methane and carbon dioxide, and traces of hydrogen sulphide, is emitted to the atmosphere. The mill presently operates under a licence issued by the Department of Environment of Malaysia as a Prescribed Premises for Crude Palm Oil for which the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977[1] are applicable. Reports on the quality of the final effluent discharge are required to be submitted to the Department of Environment of Malaysia quarterly. The quarterly reports show that the mill has been in general compliance with the licensed effluent discharge standards, where the key parameter BOD limit is set at 100 mg/l.

The project activity contributes to greenhouse gas (GHG) emission reductions by recovering the methane gas generated from the anaerobic digestion process in the closed-tank digester system, as well as by utilising the biogas captured for power generation, which will displace the grid electricity that would be consumed at the project site in the absence of the project activity.

The project activity will contribute to the sustainable development policies of Malaysia which is outlined as follows.

Contribution to Environmental Sustainability:

i. The project activity will reduce the uncontrolled emissions of methane from the open pond POME treatment system, thus reducing the GHG emission into the atmosphere and the impact on global warming.
ii. The use of the captured methane for power generation will contribute to reducing the use of fossil fuels for power supply from the grid or from generator sets.
iii. The project activity will be in line with Malaysian Government's Fuel Diversification Policy, Third Outline Perspective Plan for the 2001 – 2010 (OPP3) and the Eight Malaysia Plan which has identified Renewable Energy as the fifth source of fuel.
iv. The project activity will contribute to improved efficiency in the POME treatment and controlling the emission of biogas with objectionable odour and possible health hazard, thus minimising pollution to the environment.

Contribution to Economic Sustainability:

i. The utilisation of the methane captured to generate electricity contributes to economic returns in supporting the capital and operating and maintenance of the closed-tank anaerobic digester plant.
ii. The avoidance of grid electricity and/or the use of fossil fuel-based electricity generation will contribute to reduction of the national fossil fuel import bill.

Contribution to Social Sustainability:

i. The odour caused by the biogas released to the surrounding will be avoided.
ii. The project activity will provide opportunities for management and operators to acquire new technological knowledge and skills.
iii. The project activity will provide employment opportunity to the community during construction as well as for the long term operation and maintenance. The local workforce technical skills and knowledge will improve thus leading to capacity and knowledge building.

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[1] Laws of Malaysia. Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977 in: *Environmental Quality Act and Regulations* (All amendments up to April, 2006). Published by PDC Publishers Sdn Bhd.

A.3. Project participants:

Name of Party involved (*) (host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Malaysia (Host)	Private entity: TSH Bio-Gas Sdn. Bhd, TB 9, KM7, TSH Industrial Estate, Apas Road, 91000 Tawau, Sabah, Malaysia	No
Switzerland	Private Entity: Climate Cent Foundation, Freiestrasse 167, 8032 Zürich, Switzerland.	No
(*) 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 not have provided its approval. At the time of requesting registration, the approval by the party(ies) involved is required.		

Malaysia ratified the Kyoto Protocol on 4th September, 2002 and

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

The project activity will be located at TSH Kunak Oil Palm Mill, km 56, Tawau-Kunak Highway, 91000, Tawau, Sabah, Malaysia.

A.4.1.1. Host Party(ies):

Malaysia

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

Sabah State

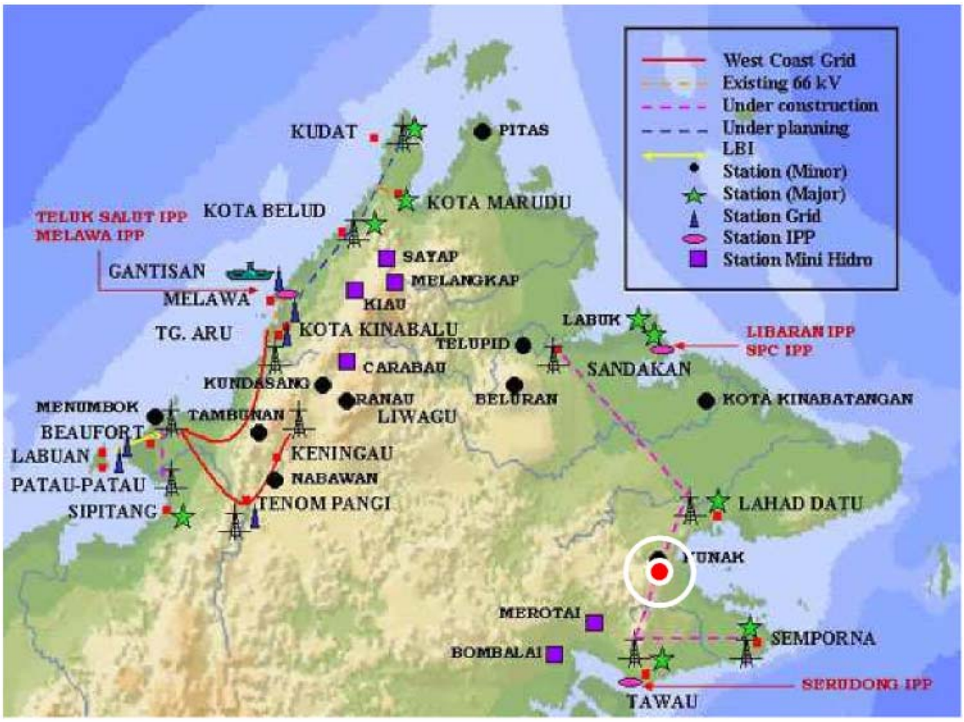
A.4.1.3. City/Town/Community etc:

Kunak Town

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

The proposed project activity will be situated within the premises of the TSH Kunak Oil Palm Mill on TSH Integrated Industrial Complex. The mill itself is located 28 km from Kunak town, which is populated with 7000 inhabitants. The new anaerobic digester plant will be located next to the present open lagoons treatment system for the palm oil mill effluent treatment.

The following shows the map location of the project activity.



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

This project activity comes under Sectoral Scope No. 13 on: "Waste handling and disposal" and Sectoral Scope No. 1 on: "Energy industries (renewable - / non-renewable sources)".

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

POME is generated during palm oil production processes at a rate of about 0.6 m^3/t of oil palm fresh fruit bunches (FFB). It is characterised by the very high organic matter contents derived from the organic fractions of the palm oil production process, typically with an average BOD and COD level of 25,000 and 55,000 mg/L, respectively. POME is ranked among the strongest industrial wastewater in terms of organic matter contents in the world, and the most significant because of its large volume generated from the palm oil industry.

The project activity involves the replacement of the existing conventional open-lagoon method for POME treatment (Ponds #1 - #6 will be replaced) with a closed-tank anaerobic digester plant based on the continuous flow stirred tank reactor (CSTR) technology.

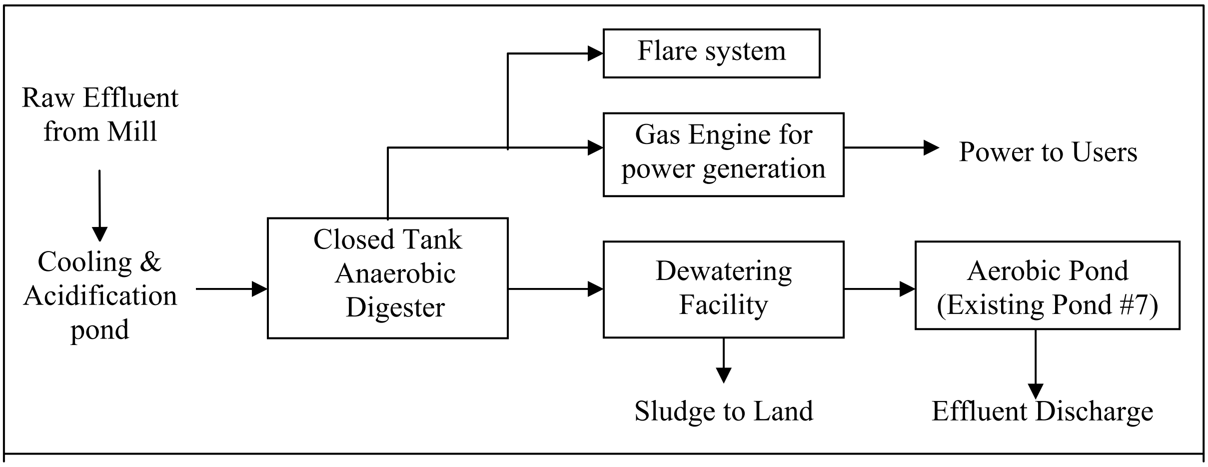
The CSTR digester system design has been optimised with respect to its treatment efficiency with the incorporation of a dual function mixing system in the digester tanks and maintaining adequate hydraulic retention time (~18 days). The proposed system for the project activity comprises two (2) floating-roof tanks of 3,000 m^3 each and four (4) fixed-roof tanks of 3,800 m^3 each, operating in parallel. The floating-roof tanks designed with liquid (the effluent) seal provide a combined biogas buffer-storage space of approximately 1,600 m^3. The anaerobic digester design takes into consideration the unique characteristics of POME in terms of its very high level of BOD, COD, in both dissolved and semi-solids form, concurrent with the presence of emulsified oil and high level of suspended solids.

The treated effluent with the residual sludge from the anaerobic digester tanks will be led to a sludge dewatering facility, consisting of a sludge settling tank and sand drying bed. The total thickness of the coarse and fine sand layers of the sand drying beds designed will be less than or about 300 mm. The feeding of the residual concentrated sludge liquor from the anaerobic treatment to the sludge drying beds will be carried out on rotation over the sand drying beds in sequence so that the sludge liquor layer will not exceed 300 mm. The total thickness of the sludge liquor and sand layers will not exceed 600 mm at any time. This is significantly less than the 1 m limit where the default value of fraction of degradation under anaerobic conditions due to depth of sludge pit will be 0. The dewatered sludge will be scrapped off using a mechanical sludge scrapper from the sand drying bed with manual operation within a week. The sludge feeding and dewatering cycle will be maintained to ensure no sludge storage will take place in the sand drying bed.

The dried sludge will be disposed off to the plantation as fertilisers on a weekly basis. Trucks will be used for the transportation and the sludge is applied by spreading to the ground surrounding the oil palm trees in shallow layer to ensure an aerobic condition. The rate of application will be designed as a fertiliser supplement, in line with the regular fertiliser application scheme for the plantation, and will be controlled to maximise the anerobic decomposition of the sludge. In case of any disruptions to the weekly disposal schedule, no dried sludge shall accumulate in piles of more than 0.5 m height on plant site, to ensure that no anaerobic degradation will take place prior to disposal to the plantation.

The effluent from the settling tank and sand drying bed will be directed to the existing open lagoon (Pond #7) for aerobic treatment. The effluent will be treated to comply with the effluent discharge standards under the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977 of the Department of Environment, Malaysia before discharging to the watercourse.

The following is a flow diagram of the proposed project activity:



The design and construction of the anaerobic digester plant will comply with the national Technical Specifications and Standards, basically referencing to the British Standard Specifications and the National Standard and Code and Practice. Precautions are specially taken to ensure that the anaerobic digester tanks and biogas pipeline will be free from any leakages. The followings are measures to be undertaken:

1. The fabrication and installation of the digester tanks, of both the fixed-roof and floating-roof types, will follow strictly the Technical Specifications and Standards where defect-free welding will be ensured. The completed tanks, with the pressure gauges installed, shall be subjected to hydrostatic test and gas-leakage test before commissioning. For the gas-leakage test, both fixed-roof and floating-roof tanks with the liquid seal will be tested at an expected maximum internal gas pressure of up to 300 mm water column (approximately 3.0 kPa). Any welding defects shall be immediately rectified. Certified test reports in accordance with the standard procedures will be obtained. During operation, the normal pressure of the biogas in the digester tank is expected to be in the range of 120 – 200 mm water column. Due to the relatively low pressure of the biogas in the digester tanks, the engineering design and fabrication will ensure a leak-free system for the containment and collection of the biogas generated during operation.

2. The piping system and biogas pipeline will be fabricated and installed following strictly the required Technical Specifications and Standards similarly. After fabrication and installation, including the necessary pressure gauges, the pipeline will be pressure tested and check for leaks along the pipeline as per the standard procedures for the test. Any connection or welding defects shall be rectified immediately. A test report in accordance with the standard procedures will be obtained from the testers.

The CSTR digester system is capable of achieving 85% treatment efficiency or better in terms of anaerobic conversion and removal of COD input to the system. The balanced 15% of COD remaining in the effluent from the bio-digester are mostly (about 10-12%) in the form of wasted anaerobic bacteria sludge and non-digestible fibres. The biogas production rate is expected to be approximately 28 m^3/m^3-POME. The closed-tank CSTR digester system allows for complete recovery of methane produced. The normal range of the biogas composition is as follows: 60-65% CH_4, 39-34% CO_2, 1,500-2,500 ppm H_2S, and the balance mainly of water vapour.

Power generation and flaring of excess biogas

The biogas captured will be utilised for power generation using gas engines. The power output from the gas engines is estimated to be approximately 2.50 MW. A total of four (4) units of gas engines of 700 kW rated power output will be installed for the power generation. The electricity will be supplied to an associated industrial plant located within the same integrated industrial complex, displacing the equivalent amount of electricity from the grid that would be consumed in the absence of the project activity. A conservative operational loading factor of 80% of the estimated electricity generation capacity is applied.

A scrubber system for the removal of hydrogen sulphide impurities in the biogas is necessary and will be installed to ensure that biogas with H_2S below a certain level is fed to the gas engines.

Excess biogas, if it occurs, will be flared in an enclosed flaring system.

Technology improvements in methane recovery from POME treatment and utilisation for power generation

The specific closed-tank CSTR technology applied for the anaerobic digestion of POME is developed locally and incorporated the key beneficial features of world-wide experience and advancement in CSTR technology and principles. The technology applied represents significant improvements over the common practice adopted by the industry in POME treatment in terms:

- The CSTR technology offers an advanced automated mechanical engineering system to replace the conventional stagnant treatment approach of effluent in open lagoons.
- Efficient recovery of methane generated in the anaerobic digestion of POME will result in significant reduction of methane emissions as a GHG.
- Odour and air pollution due to the emissions of traces of hydrogen sulphide is avoided.
- The utilisation of the biogas for power generation using gas engines in this case will promote the development for harnessing biogas as a significant renewable energy source in Malaysia.

Training on operation and maintenance of the Plant

The contractor for the Plant shall provide necessary on the job training for the plant personnel on the operation and maintenance of the plant, inclusive of both the closed-tank CSTR anaerobic digester system and the biogas-fired gas engine power generation plant. The personnel for the training shall include engineers, technicians and operators assigned to the operation and maintenance of the plant. The training shall cover all aspects of the operational principles, procedures, service and maintenance techniques and schedule. Training on the monitoring requirements will be elaborated in the section of the PDD on monitoring plan. In addition, the project participant intends to engage the services of the contractor to provide key personnel for the operation and maintenance of the biodigester and gas engine plants, for at least an initial period of one year.

The on the job training and contract services of the contractor will ensure the performance of the biodigester and gas engine plants will be able to meet the specifications set in the output of the biogas and the power generation.

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

The estimated amount of emission reductions over the first crediting period of the 3 x 7 years is summarised in the table below.

Years	Estimation of annual emission reductions, t CO2-e
2007 (Oct - Dec)	12,202
2008	77,640
2009	77,640
2010	77,640
2011	77,640
2012	77,640
2013	77,640
2014	58,230
Total estimated reductions	**536,272**
Total number of crediting years of first crediting period	7 years
Annual average over the crediting period of estimated reductions	**76,610**

A.4.5. Public funding of the project activity:

No public funding is provided to the 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 project activity:

Approved baseline and monitoring methodology AM0013 Version 04, Sectoral Scope: 13, EB 28 on: “Avoided methane emissions from organic waste-water treatment” is applied to the project activity. The methodology applied is based on the baseline approach, paragraph 48 of the CDM modalities and procedures on: “Existing actual or historical emission as applicable”.

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

The approved methodology AM0013 applied has been developed based on the "Bumibiopower Methane Extraction and Power Generation Project, Malaysia" (NM0039), for palm oil mill effluent treatment, which is the same as the proposed project activity.

The proposed project activity fulfils the applicability criteria defined in the applied approved methodology AM0013 Version 04, as follows:

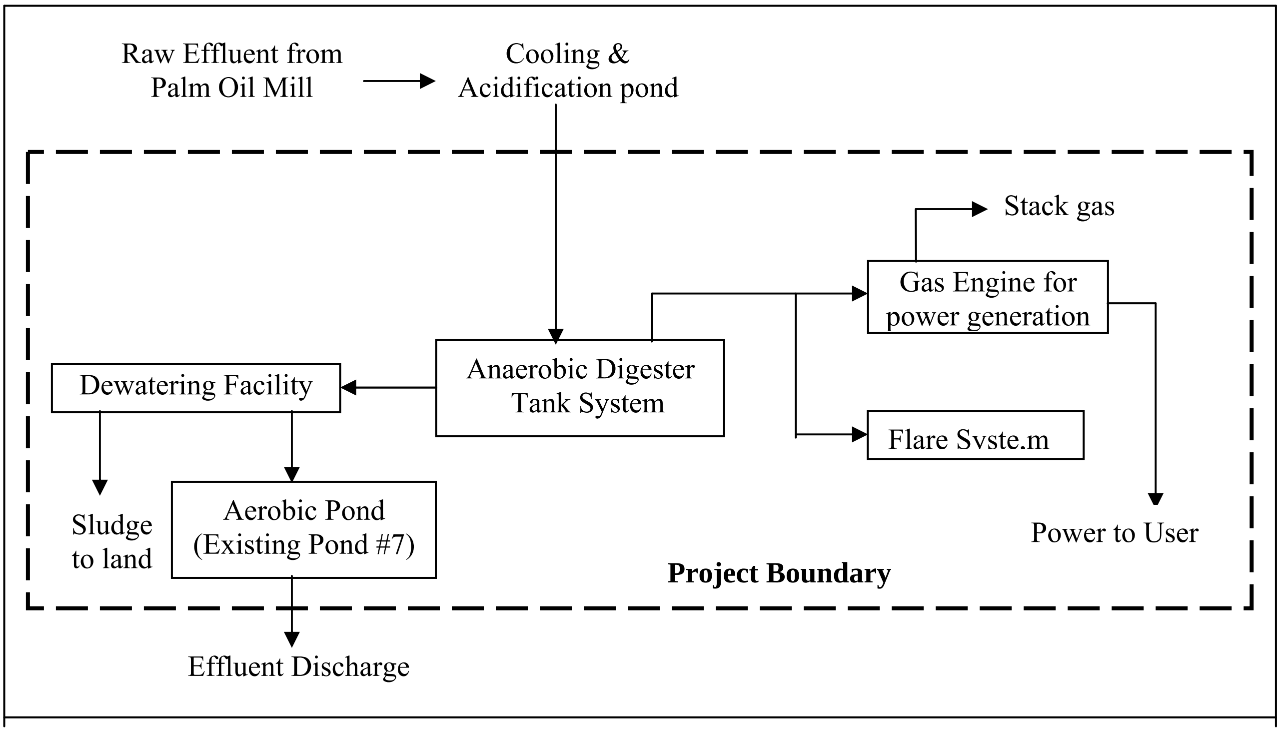
Applicability criteria as defined in AM0013:	**Criteria met by project activity**
• The existing waste water treatment system is an open lagoon system with an 'active' anaerobic condition, which is characterized as follows:	Yes
o The depth of the open lagoon system is at least 1 m;	The existing anaerobic ponds are about 6.5 m in depth.
o The temperature of the anaerobic lagoons is higher than 10°C. If monthly average 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.	Historical ambient temperature of the region is between 22.8 – 31.8 ^{o}C with an annual mean of 26.6 ^{o}C [2].
o The residence time of the organic matter should be at least 30 days.	Residence time in the anaerobic lagoons with a total capacity of 78,000 m^3 is approximately 65 days.
• Sludge produced during project activity is not to be stored onsite before land application to avoid any possible methane emissions from anaerobic degradation.	No storage of sludge produced on site.
• This baseline methodology shall be used in conjunction with the approved monitoring methodology AM0013 Version 04, dated 19th May, 2006 ("Avoided methane emissions from organic waste-water treatment").	Yes
• The project activity involves the avoidance of methane emissions from open lagoons through <u>one or combination</u> of the following treatment options:	Yes
o Installation of an anaerobic digester with biogas extraction capacity at an existing organic wastewater treatment plant to treat the majority of the degradable organic content in the wastewater. In this case, there is a process change from open lagoon to accelerated CH_4 generation in a closed tank digester	Yes.

[2] The POME temperature leaving the palm oil mill will be about 80^{o}C and after acidification and hydrolysis, the effluent entering the bio-digesters will be about 45 – 50 ^{o}C. The maximum and minimum annual temperatures recorded over the last 3 years (2003-2005) at the nearest meteorological station, Tawau, Sabah were 31.8 ^{0}C and 22.8^{0}C, respectively, with an annual mean of 26.6 ^{0}C. (Ref: Malaysian Metrological Department, Annual Summary of Metrological Observation.) Thus there is no opportunity of the effluent/sludge cooling below 10^{o}C.

	or similar technology. Therefore, depending only on the amount of captured methane emissions to establish baseline emissions will not be adequate as the project activity may extract more CH_4 than would be emitted in the baseline case.	
	▪ The extracted biogas may be flared or used to generate electricity and/or heat. The project activity therefore reduces the amount of CH_4 allowed to dissipate into the atmosphere. By also utilising the biogas, instead of flaring the CH_4, the project will also contribute to the displacement of grid electricity or fossil fuel consumption, further reducing GHG emissions.	Methane captured is used for power generation. The electricity generated will displace grid electricity that would be consumed at the project site in the absence of the project.
	▪ The residual from the anaerobic digester after treatment is either dewatered and applied to land or directed to anaerobic lagoons.	The residual sludge in the effluent from the anaerobic digester is dewatered and applied to land.
o	Treatment of the sludge in aerobic conditions through dewatering and land application.	This option is not applicable for wastewater from palm oil mill. The suspended solids-sludge content is only ~2%. No practical technologies known for dewatering suspended solid sludge in raw POME.

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

Raw effluent from the palm oil mill is subject to pre-treatment in a cooling and acidification pond. The project boundary is shown in the following schematic diagram. The raw effluent after the pre-treatment is fed to the anaerobic digester tank system. The residual effluent from anaerobic digesters will go through a sludge dewatering facility, consisting of a settling tank and sand drying beds. The dried sludge recovered will be disposed off in the plantation as fertilisers. The effluent will be directed to the existing open lagoon (Pond #7) for aerobic treatment. The final effluent will be discharged in accordance with the requirements of the Department of Environment, Malaysia. Biogas captured will be used in gas engines for power generation and supplied to the user at the project site.



The emission sources and type of GHG which are included or excluded within the project boundary are shown in the following table:

	Source	Gas	Included?	Justification / Explanation
Baseline	Direct emissions from the waste treatment processes	CO_2	No	CO_2 emissions from the decomposition of organic matter are not accounted (carbon neutral).
		CH_4	Yes	The major source of emission in the baseline.
		N_2O	No	Excluded for simplification. This is conservative
	Emissions from electricity consumption / generation	CO_2	Yes	Electricity baseline emissions are relevant, since electricity generation is intended (resulting in electricity displacement from the grid or from fossil fuel generator sets).
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
	Emissions from thermal energy generation	CO_2	No	CO_2 emissions from thermal energy are excluded, since no thermal energy generation is intended.
		CH_4	No	Excluded since no thermal energy generation is intended.
		N_2O	No	Excluded since no thermal energy generation is intended.

Project Activity	Emissions after anaerobic tank digester	CO_2	No	CO_2 emissions from the decomposition of organic matter are not accounted (carbon neutral).
		CH_4	Yes	CH_4 emissions from effluent from the digesters and dewatering facility to the open lagoon. .
		N_2O	No	N_2O emissions are avoided, same as above.
	Leakage from biodigesters	CO_2	No	CO_2 emissions due to leakage from the decomposition of organic matter are not accounted (carbon neutral).
		CH_4	Yes	CH_4 emissions are assumed to be zero by design.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	Stack emission from flare of excess biogas	CO_2	No	Not accounted since biogas is sourced carbon neutral.
		CH_4	Yes	CH_4 emissions due to incomplete combustion in the flare are accounted for.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	Stack emission from electricity generation equipment	CO_2	No	Not accounted since biogas is sourced carbon neutral.
		CH_4	Yes	CH_4 emissions due to incomplete combustion in the electricity generation equipment are accounted for.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from on-site electricity used	CO_2	Yes	Electricity sourced from the grid for the pumping and other equipment in the digester tank farm.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	Emission from land application of sludge	CO_2	No	CO_2 emissions from the decomposition of organic matter is not accounted (carbon neutral).
		CH_4	Yes	Included due to possible methane emissions from sludge applied as fertilizers to land.
		N_2O	Yes	Included to account for nitrous oxide emissions from sludge containing nitrogen.

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

Identification and description of baseline Scenario:

The most plausible baseline scenario is identified through the application of the various steps outlined in approved methodology AM0013 Version 04 as stated below. The identified baseline scenario is also described.

Step 1: A list of possible realistic and credible alternative for the treatment of the palm oil mill effluent, both as sludge and as wastewater, is drawn up as follows:

Palm oil mill effluent (POME) has been well characterised in Malaysia. The sludge in POME is present as suspended solids at relatively low level with an average concentration of about 1.8%[3]. The known approaches applied to POME treatment in Malaysia have been based on technologies applicable to POME as wastewater. Sludge separation from the wastewater and dewatering is only possible after the anaerobic treatment process. No realistic and credible approaches or technologies have been known in Malaysia for the direct dewatering of suspended solid sludge from the raw POME. Therefore, baseline alternatives for treatment of POME as wastewater only are considered. The alternative treatment methods for POME and the sludge from the treatment process are discussed below.

Among the list of commonly used treatment methods shown in the approved methodology AM0013 Version 04, only the following are considered realistic and credible alternative for the treatment of the palm oil mill effluent:

- Anaerobic digestion in deep open lagoons (BAU).
- Methane recovery and flare.
- Methane recovery and utilisation for electricity or heat generation.
- Aerobic composting (or treatment).
- Land application of the sludge (or wastewater).

i) **Treatment of palm oil mill effluent in open lagoons or open tanks (BAU)**:

a. Treatment in open lagoons

There are over 380 palm oil mills currently in operation in Malaysia. Among these, most of the mills treat their effluent in open lagoons, consisting of both deep lagoons (2-7 m deep) for anaerobic digestion, followed by shallower lagoons (1-3 m deep) for facultative/aerobic treatment. The lagoons are desludged once every few years, when the sludge level has built up to such a level that the treated effluent water quality is being affected. The sludge removed from the lagoons is normally applied to land in the plantation as fertiliser supplement. The aerobic application and dewatering of sludge are normally not practised in this alternative. The mills are required to treat the effluent to meet the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977 set by the Department of Environment, Malaysia before the effluent is permitted to discharge to waterways or for land application. No limit has been set under these regulations for the control of the emissions of methane. The use of methane is not justifiable as the mills are having abundant biomass energy sources, for steam and power generation. The biomass from the mill production process has to be disposed off to the plantation if not use for energy purpose.

The current practice at Kunak Palm Oil Mill falls under this scenario. The mill effluent is treated in open lagoons, consisting of both anaerobic and aerobic types. Treated effluent after facultative/aerobic treatment is discharged into the waterways.

b. Treatment of palm oil mill effluent in open tanks:

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[3] http//www.mpob.gov.my/palm info/environment/

There is a small number of the mills employing open tanks for the anaerobic treatment of the effluent, prior to subjecting the effluent for facultative/aerobic treatment in shallow lagoons, some may be with the use of mechanical aerators. The mills are required to treat the effluent to meet the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977 set by the Department of Environment, Malaysia before the effluent is permitted to discharge to waterways or for land application. The lagoons will need to be desludged once every few years, when the sludge level has built up to a level that the treated effluent water quality is being affected. The sludge removed from the lagoons is normally applied to land in the plantation as fertiliser supplement. The aerobic application and dewatering of sludge is not emphasised in this alternative. These cases are similar as the above scenario where methane generated is emitted to the atmosphere. Due to the abundant biomass energy available, it is also never justifiable to recover the methane for use in these mills. This is a BAU scenario for those mills where land space availability is limited.

ii) Treatment of palm oil mill effluent where methane is recovered and flared:

By this treatment method, closed tanks of very large capacity will be necessary to facilitate the anaerobic digestion of POME and the recovery of methane for flaring. The effluent from the anaerobic digester will need to be treated further, possibly in facultative and aerobic lagoons. The mills are required to treat the effluent to meet the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977 set by the Department of Environment, Malaysia before the effluent is permitted to discharge to waterways or for land application. The lagoons will need to be desludged once every few years, when the sludge level has built up to such a level that the treated effluent water quality is being affected. The sludge removed from the lagoons is normally applied to land in the plantation as fertiliser supplement. The aerobic application and dewatering of sludge are normally not practised in this alternative. For anaerobic digestion operating under mesophilic conditions, total tank capacity corresponding to retention time of 15-20 days for the POME is necessary in order to achieve appropriate treatment efficiency.

No POME treatment system of this type with methane recovery followed by flaring is known to be in existence among the palm oil mills in Malaysia.

iii) Treatment of palm oil mill effluent where methane is recovered and utilised for electricity or heat generation:

This treatment method is similar as that described above under ii), except the methane recovered will be utilised for electricity or heat generation.

Only one system of this type has been reported to have been built in one of the palm oil mills in Malaysia where the methane recovered is used to displace diesel fuel in the high pressure boiler in a related industry next to the mill.

iv) Treatment by aerobic composting or digestion:

Aerobic composting for palm oil mill effluent is not practical because of the low solid content (about 1.8%) and the very high BOD concentration (20,000 mg/l – 30,000 mg/l). Composting is only feasible for the concentrated sludge of POME after anaerobic digestion and the BOD level has been much reduced. The concentrated sludge may then be mixed with other biomass waste, such as empty fruit bunches for composting.

Treatment of wastewater by aerobic digestion requires large quantity of air or oxygen supply, due to the very high Biochemical Oxygen Demand (BOD) level (20,000 mg/l – 30,000 mg/l), in order to reduce the organic pollutant loads (in terms of BOD & COD) to a level in compliance with the effluent discharge standards. Aerobic bacteria will not be able to grow in the effluent in an aerobic digestion system with such a high BOD concentration unless very high dilution (in the order of 100X) to the effluent is applied. Such system is not practical because of the very high costs in construction and operations.

v) Land application of the palm oil mill effluent:

By this approach, the palm oil mill effluent will be applied directly to the land. Due to the very high organic loading, the application of palm oil mill effluent without prior treatment would require very large land area. Due to the high rain falls in Malaysia, land application of effluent of very high BOD/COD loads can contribute to serious watercourse pollution resulting from runoff. No direct land application of raw palm oil mill effluent has been known in Malaysia.

The following treatment methods which are listed in the approved methodology are deemed to be unrealistic and non-credible for the treatment of palm oil mill effluent:

- Landfilling
- Mineralisation
- Composting

In addition to the reasons explained above, these three methods are considered unrealistic and non-credible for the treatment of palm oil mill effluent because of the relatively low percentage of suspended solids content (<2%) in the effluent.

Step 2: Eliminate alternatives that are not complying with applicable laws and regulations:

Based on the descriptions given above, treatment methods i)a., i)b., ii) and iii) are deemed capable to achieve compliance with the applicable laws and regulations.

It would involve very high costs for treatment method iv) to comply with the applicable laws and regulations set by the relevant authority with respect to the treated effluent discharge from palm oil mills.

Treatment method v) is not allowed under the applicable laws and regulations, i.e. Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977 set by the Department of Environment, Malaysia.

There is also no known plan of the Department of Environment of Malaysia to introduce any new regulations in the foreseeable future necessitating the industry to upgrade the prevalent method for POME treatment.

Step 3: Eliminate alternatives that face prohibitive barriers:

Treatment method iv) by direct aerobic composting or digestion of the palm oil mill wastewater would face prohibitive cost barrier in view of the extensive technological requirements. It is therefore eliminated.

The remaining realistic and credible treatment methods are methods i)a., i)b., ii) and iii).

Treatment methods i)a. adopted by most of the palm oil mills in Malaysia are considered the most practical and this represents the BAU scenario. The capital and operating and maintenance costs are the lowest and within an acceptable range to the palm oil mill owners. Treatment method i)b. is also considered as a BAU scenario and it has been adopted by a small number of the mills where land space availability is a limiting factor to opt for method i)a, although the need of open steel tanks for the anaerobic digestion contributes to significantly higher construction costs.

Treatment method ii) has not been adopted by any mills in Malaysia as it incurs much higher capital cost as compared to methods i)a. and i)b. without giving any returns to the mills. Treatment method iii), which uses closed tanks for anaerobic digestion with biogas recovery, so far has been reported to have been adopted only by one palm oil mill. The mill has a very unique situation where the mill has found a use of the biogas recovered for its high-pressure boilers to at least partially justify its investment costs. The capital cost and technology would be considered as prohibitive to other palm oil millers in comparison to treatment methods i)a. and i)b. and none of the mills would find any incentive to consider adopting treatment method iii).

It is therefore concluded that only treatment methods i)a. and i)b. are realistic and credible, and not facing prohibitive barriers.

Step 4. Compare economic attractiveness of remaining alternatives:

No comparison of economic attractiveness is required as all other treatment methods have been eliminated, except the BAU methods i)a and i)b.

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 proposed CDM project activity on “Methane recovery and utilisation project at TSH Kunak Oil Palm Mill, Sabah, Malaysia” contributes to the reductions of anthropogenic emissions by sources below those that would have occurred in the absence of the registered CDM project activity. The project activity would not have happened in the absence of the CDM.

Option A of the approved methodology is applied to demonstrate the additionality of the project as follows:

Investment barriers

Investment analysis has been conducted for the proposed project activity which has included the variables below:

- Engineering, Procurement and Construction cost;
- Labour cost;
- Operation and Maintenance cost;
- Administration cost;
- Fuel and power cost;
- Capital cost and interest; and

- Revenue from electricity or thermal energy sales.

The input data to the financial analysis for the proposed project activity are summarised as follows:

Table B.5: Input data in financial analysis

Parameter	**Value**
Capital cost inclusive of: Engineering, procurement & construction of anaerobic digester system and biogas engines for power generation	MYR16,500,000
Cost of interest (loan ratio: 60% of capital cost)	6% per annum
Operation & maintenance cost inclusive of: Biogas Plant: Salary & Admin Monitoring, Testing & Calibration Parts & Repairs Consumables Biogas Engine Power Plant: Salary & Admin Monitoring, Testing & Calibration Parts & Repairs Consumables	MYR825,000 per annum MYR120,000 MYR110,000 MYR90,000 MYR40,000 MYR160,000 MYR60,000 MYR165,000 MYR80,000
Revenue from internal electricity sales	MYR2,450,000 per annum
CER price	USD10/t CO2-e

Data sources used, which included both project-specific and typical industry values are identified in the Project IRR worksheet (Revision 7 September 2007) submitted to DOE for validation. Project-specific data used were within the range of accepted industry values.

The results of the financial analysis show that the IRR of the project without the CER income is ~~-0.8~~1.1%. This IRR value is far below the company norm and the level of the industrial benchmark of 15% IRR. In view of the risk also in the new technology adopted in the project, the company does not consider the investment in the project as viable without the CDM income.

The IRR value for the case of the project activity with the contribution of additional revenue from the sale of the CER estimated was ~~20.7~~21.8%. The income from CDM is essential to bring the IRR above the investment benchmark for the proposed project.

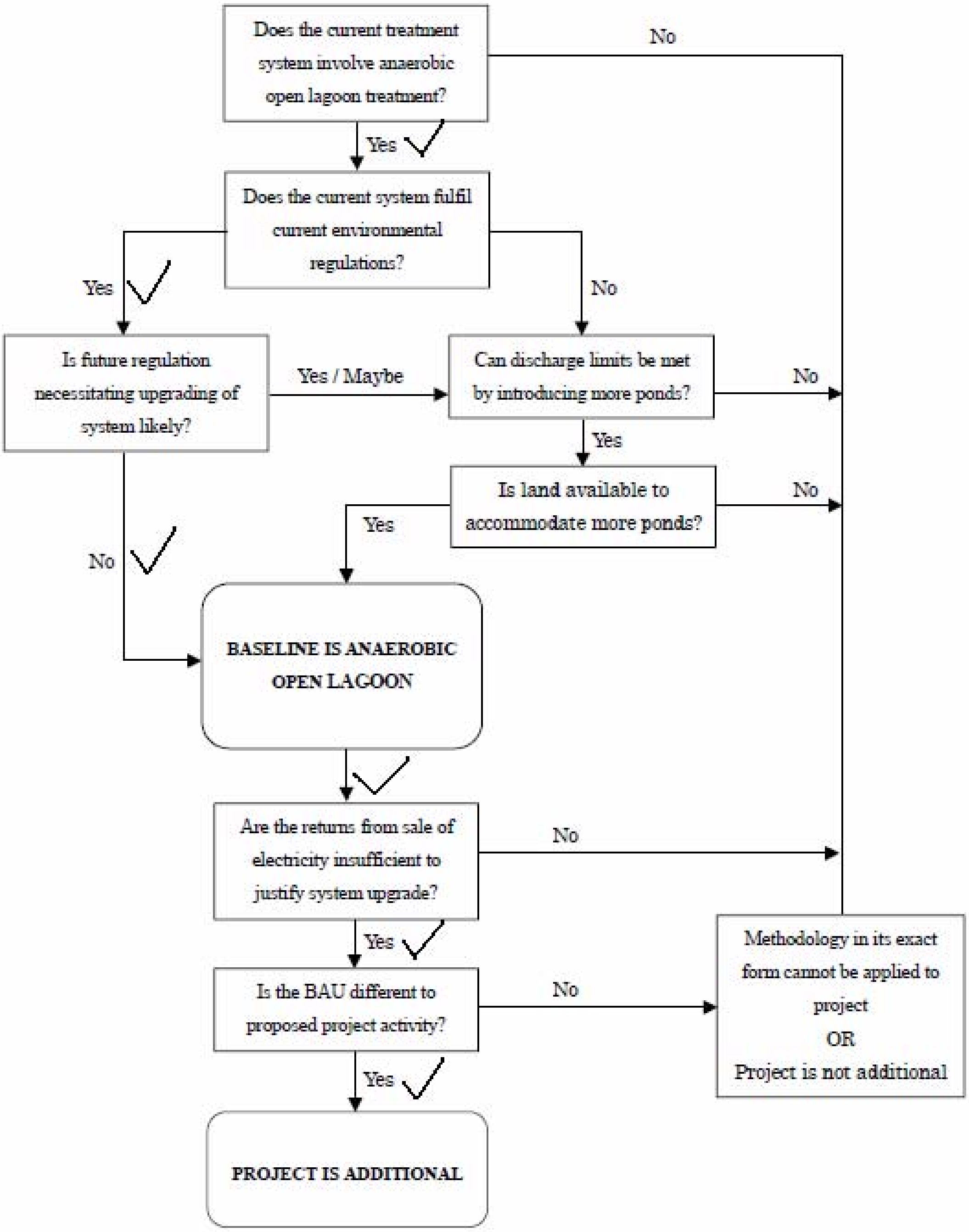
Current prevalent mode of organic wastewater treatment

The current prevalent mode of organic wastewater treatment has been described in the identified baseline scenario in Section B.4. There are at present more than 380 palm oil mills in Malaysia in operations. The current prevalent mode of treatment of palm oil mill effluent (POME) is through either: (i) use of open lagoon system which involves deep open lagoon for anaerobic digestion followed by aerobic treatment in shallow open lagoons or land application; or (ii) use of open tank anaerobic digestion for mills which have limited land space; this mode of treatment also involves an aerobic treatment stage in shallow open lagoons or land application. In both of these treatment methods, the bulk of the organic carbons in the effluent are converted to methane and carbon dioxide via the anaerobic treatment process which are emitted to the atmosphere. Residue organic carbons in the effluent will be further degraded via the aerobic treatment process in the shallow lagoons or applied to the plantation land.

The existing treatment system for the raw POME from TSH Kunak Oil Palm Mill involves the application of the prevalent open lagoon treatment method as described above.

The proposed project activity is thus additional and constitutes a new technological approach in this industry. There is a psychological hurdle for TSH Kunak Oil Palm Mill to invest in such a new, untraditional approach to its wastewater treatment. From the technical perspective, there is the risk of uncertainty of methane recoverable and relatively low value in the return from the methane produced as reflected in the financial analysis above.

The descriptions in Sections B.4. and B.5. above provide a positive response to each of the simplified steps for the identification of the baseline scenario and the project additionality in accordance with Option A approach as shown in the diagram below.


Does the current treatment system involve anaerobic open lagoon treatment?
No
Yes
Does the current system fulfil current environmental regulations?
Yes
No
Is future regulation necessitating upgrading of system likely?
Yes / Maybe
Can discharge limits be met by introducing more ponds?
No
Yes
Is land available to accommodate more ponds?
No
Yes
No
BASELINE IS ANAEROBIC OPEN LAGOON
Are the returns from sale of electricity insufficient to justify system upgrade?
No
Yes
Is the BAU different to proposed project activity?
No
Methodology in its exact form cannot be applied to project
OR
Project is not additional
Yes
PROJECT IS ADDITIONAL

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

The approved baseline methodology AM0013/Version 04 is applied for the calculation of the Baseline Emissions, Project Emissions, Leakage, and Emission Reductions for the proposed project activity as described below.

Baseline Emissions

Baseline emissions are the CH_4 emissions from open lagoon wastewater treatment systems, and the CO_2 emissions associated with electricity generation, either via the grid supply or from fossil fuel fired generator sets, which are displaced by the project.

(i) Lagoon baseline emissions

The baseline emissions from the lagoons of the proposed project will need to be considered for lagoons of two different depths: (A) anaerobic lagoons of depth >5 m, including Ponds #1, #2, #3 & #4; and (B) facultative/aerobic lagoons of depth 1-5 m, including Ponds #5, #6 & #7.

The baseline emissions from the lagoon are estimated based on the chemical oxygen demand (COD) of the effluent that would enter the lagoon in the absence of the project activity, the maximum methane producing capacity (Bo) and a methane conversion factor (MCF) that expresses what proportion of the effluent would be anaerobically digested in the open lagoons.

These CH_4 emissions from wastewater should be calculated according to the IPCC Guidelines as follows:

$$\underset{(kg/yr)}{CH_4\ emissions} = \underset{(kg\ COD/month)}{Total\ COD_{available,m}} \times \underset{(kg\ CH_4/kg\ COD)}{B_o} \times MCF_{baseline}$$

where:

$COD_{available,m}$ Is the monthly Chemical Oxygen Demand available for conversion which is equal to the monthly COD entering the digester or directed to land application $COD_{baseline,m}$ plus COD carried on from the previous month.

$COD_{baseline,m}$ Is the monthly Chemical Oxygen Demand of effluent entering lagoons or directed to land application (measured)

B_o Is the maximum methane producing capacity. The default IPCC value is 0.25 kg CH_4/kg COD. Taking into account the uncertainty of the estimate, a value of 0.21 kg CH_4/kg COD[4] should be used as a conservative estimate.

$MCF_{baseline}$ Is the monthly methane conversion factor (fraction)

[4] Lowest value provided by IPCC Good Practice guidance, 2000, Page 5.19 was adopted in AM0013, Version 4. However, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 6.21 recommended that: “If no country specific data are available, it is *good practice* to use the IPCC COD-default factor for B_o (0.25 kg CH_4/kg COD).” Pending further guidance, the lagoon baseline emissions will be modified accordingly.

Since there is an effluent from the lagoons in the baseline, $COD_{baseline}$ values should be adjusted by multiplying $COD_{baseline}$ by the following factor AD:

$$AD = 1 - \left[\frac{COD_{a,out}}{COD_{a,in}} \right]$$

where:

$COD_{a,out}$ is the COD that leaves the lagoon with the effluent
$COD_{a,in}$ is the COD that enters the lagoon

COD_{out} and COD_{in} should be based on one year historical data

$MCF_{baseline,m}$ is estimated as the product of the fraction of anaerobic degradation due to depth (f_d) and the fraction of anaerobic degradation due to temperature (f_t):

$$MCF_{baseline,m} = f_d * f_{t,monthly} * 0.89$$

where:

f_d is the fraction of anaerobic degradation due to depth as per table 1
f_t is the fraction of anaerobic degradation due to temperature
0.89 is an uncertainty conservativeness factor (for an uncertainty range of 30% to 50%) to account for the fact that the equation used to estimate $f_{t,monthly}$ assumes full anerobic degradation at 30 ^{o}C.

Table 1. Default values of fraction due to depth (f_d)

	Deep > 5m	**Medium depth 1-5 m**	**Small depth <1m**
Fraction of degradation under anaerobic conditions due to depth of sludge pit	70%	50%	0

$f_{t,monthly}$ is calculated as follows:

$$f_{t,monthly} = \exp\left[\frac{E * (T_2 - T_1)}{R * T_1 * T_2} \right]$$

where:
$f_{t,monthly}$ anaerobic degradation factor due to temperature.
E Activation energy constant (15,175 cal/mol).
T_2 Ambient temperature (Kelvin) for the climate.
T_1 303.16 (273.16° + 30°).
R Ideal gas constant (1.987 cal/Kmol).

The factor '$f_{t,monthly}$' represents the proportion of organic matter that are biologically available for conversion to methane based upon the temperature of the system. The assumed temperature is equal to the ambient temperature. The value of f_t to be used cannot exceed unity.

(ii) Electricity baseline emissions

The CO_2-neutral electricity generated from the project activity will be supplied to an associated industrial plant located within the same industrial complex at the project site. The electricity supply will displace the equivalent amount of electricity from the grid that would be consumed in the absence of the project activity. The electricity baseline emissions of the corresponding electricity from the grid are calculated using the following formula:

$$BE_{elec/heat} = EG_y * CEF_{Bl,elec,,y} + EG_{d,y} * CEF_{grid} + HG_{Bl,y} * CEF_{Bl,therm,y}$$

where,

EG_y	is the amount of electricity in the year y that would be consumed at the project site in the absence of the project activity (MWh).
$CEF_{Bl,, elec,y}$	is the CO_2 emission factor for electricity consumed at the project site in the absence of the project activity (tCO_2/MWh)
$EG_{d,y}$	is the amount of electricity generated utilizing the biogas collected during project activity and exported to the grid during the year y (MWh)
CEF_{grid}	is the CO_2 emission factor for the grid where electricity is exported (tCO_2/MWh)
$HG_{Bl,y}$	is the quantity of thermal energy that would be consumed in year y at the project site in the absence of the project activity (MJ) using fossil fuel.
$CEF_{Bl,therm}$	is the CO_2 emissions intensity for thermal energy generation (tCO_2 e/MJ)

Determination of $CEF_{Bl,elec}$:

- In the present case where electricity would in the absence of the project activity be purchased from the grid, the emission factor $CEF_{Bl,elec}$ should be calculated according to methodology ACM0002 ("Consolidated baseline methodology for grid-connected electricity generation from renewable sources"). If electricity consumption is less than small scale threshold (15 GWh/yr), AMS. 1.D.1 may be used.

Determination of CEF_{grid}:

- This is not necessary since there will be no electricity exported to the grid from the project activity.

Determination of $CEF_{Bl,therm}$:

- There is no thermal energy generation.

Project Emissions

The physical delineation of the project is defined as the plant site, including the power or thermal energy generation equipment. Project emissions mainly consist of methane emissions from the lagoons, physical leakage from the digester system, stack emissions from flaring and energy generating equipment, emissions related with the consumption of electricity or heat in the project activity, emissions from land application of sludge, and emissions from wastewater removed in the dewatering process.

(i) Methane emissions from lagoons

After the majority of the COD is treated and reduced in the anaerobic digester, the sludge in the residual effluent will be separated and dewatered. The residual effluent, including the dewatering effluent, will be directed to the existing open lagoons (Pond #7) for aerobic treatment. The final effluent which meets the standards of the Department of Environment of Malaysia will be discharged to open watercourse. As explained in para. (vi) below, the wastewater removed from the dewatering process of the residual sludge in the treated anaerobic digester effluent will be returned to the existing open lagoon (Pond #7) for aerobic treatment. The combined volume of the wastewater going into the open lagoon (Pond #7) is expected to be approximately equals to the wastewater flow to the anaerobic digesters, as a conservative estimate.

Due to the uncertainty regarding the exact extent of aerobic/anaerobic digestion after project implementation, the calculation of project CH_4 emissions for the residual effluent in the open lagoons is conservatively carried out in the same way as for the baseline, using the same values for Bo and the methane conversion factor (MCF):

CH_4 emissions = from open lagoon (kg/yr)	COD_{dig_out} (kg COD/yr)	x	B_o (kg CH_4/kg COD)	x	MCF_{dig_out}

where:

COD_{dig_out}	Is Chemical Oxygen Demand of effluent entering open lagoon (measured)
B_o	Is maximum methane producing capacity as in the baseline
MCF_{dig_out}	Is methane conversion factor (fraction) estimated as described in the baseline section above

The CH_4 emissions are translated into CO_2 equivalent emissions by multiplying by its global warming potential (GWP) of 21.

(ii) Physical Leakage from biodigesters

The emissions directly associated with the digesters involve the physical leakage from the digester system. IPCC guidelines specify physical leakage from anaerobic digesters as being 15% of total biogas production. However, since closed steel tanks are used for the anaerobic digestion, the project participant will use a lower value for the percentage of physical leakage. Data from measurements proving that this lower value is appropriate for the project will be provided in the ex-ante calculation in Section B.6.3.

(iii) Stack emissions from the flare or energy generation

Methane may be released as a result of incomplete combustion either in the flaring option or in case of biogas use for electricity and/or heat production. These emissions are estimated by monitoring:

(a) The amount of biogas collected in the outlet of the Biodigester using a continuous flow meter, $CH4_{bio}$.
(b) Percentage of biogas that is methane (P_{CH4}), which should be measured either with continuous analyzer or alternatively with periodical measurement at 95% confidence level using calibrated portable gas meters and taking a statistically valid number of samples.
(c) Parameters related for flare efficiency and project emissions due to flaring as per the monitoring requirements in the "*Tool to determine project emissions from flaring gases containing methane*".

In accordance with the *"Tool to determine project emissions from flaring gases containing methane"*, the first of the following two options is chosen to determine the flare efficiency for an enclosed flare:

(a) To use a 90% default value. Continuous monitoring of compliance with manufacturer's specification of flare (temperature, flow rate of residual gas at the inlet of the flare) must be performed. If in a specific hour any of the parameters are out of the limit of manufacturer's specifications, a 50% default value for the flare efficiency should be used for the calculations for this specific hour.
(b) Continuous monitoring of the methane destruction efficiency of the flare (flare efficiency).

During project implementation, continuous monitoring of compliance with manufacturer's specifications for the operation of the flare will be carried out, in accordance with the required data and procedures to monitor these specifications.

(iv) Emissions from heat use and electricity use due to the project activity ($PE_{elec/heat}$):

Emissions from heat use and/or electricity use due to the project activity will be calculated using the following equation:

$$PE_{elec/heat} = EL_y * CEF_d + HG_{Pr,y} * CEF_{Pr,therm,y}$$

where,

$EL_{P,y}$	is the amount of electricity in the year y that is consumed at the project site for the project activity (MWh).
CEF_d	is the CO_2 emissions factor for electricity consumed at the project site during the project activity (tCO2/MWh), estimated as described below. Factor is zero if biogas is used to produce electricity.
$HG_{Pr,y}$	is the quantity of thermal energy consumed in year y at the project site due to the project activity (MJ).
$CEF_{Pr,therm,y}$	is the CO_2 emissions intensity for thermal energy generation (tCO2e/MJ), estimated as per method described for baseline thermal energy use. Factor is zero if biogas is used for generating thermal energy.

Since there will be no heat use due to the project activity, $HG_{Pr,y} = 0$.

<u>*Determination of CEF_d:*</u> Where the project activity involves electricity generation from biogas, CEF_d should be chosen as follows:

- In case the generated electricity on-site fossil fuel fired power plant, the default emission factor for a diesel generator with a capacity of more than 200 kW for small-scale project activities (0.8 tCO_2/MWh, see AMS 1.D.1 in the simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories).
- In case the generated electricity is sourced the grid in the baseline, CEF_d should be calculated according to methodology ACM0002 ("Consolidated baseline methodology for grid-connected electricity generation from renewable sources"). If electricity consumption is less than small scale threshold (15 GWh/year), AMS. 1.D.1 may be used.

(v) Emissions from land application of sludge

For conservativeness, an MCF of 0.05 is to be used to estimate possible methane emissions from the land application treatment process to account for any possible anaerobic pockets. These emissions are to be estimated from the following equation:

$$\underset{(kg/yr)}{CH_4 \text{ emissions}} = \underset{(kg\ COD/yr)}{\text{Total } COD_{la}} \times \underset{(kg\ CH_4/kg\ COD)}{B_o} \times MCF_{la}$$

where:

COD_{la}	Is Chemical Oxygen Demand of the sludge used for land application after dewatering (measured)
B_o	Is maximum methane producing capacity. A value of 0.21 kg CH_4/kg COD is applied as for the baseline.
MCF_{la}	Is methane conversion factor (fraction) assumed to be equal to 0.05

Nitrous oxide emissions from land application of sludge are to be estimated as follows:

$$\underset{(kg/yr)}{N_2O \text{ emissions}} = \underset{(kg\ sludge/yr)}{S_a} \times \underset{(kg\ N/kg\ sludge)}{NC} \times EF_{N2O}$$

where:

S_a	Is the amount of sludge applied to land in kg per year
NC	Is the nitrogen content in the sludge in (Kg N/Kg sludge)
EF_{N2O}	Is the emission factor of nitrogen from sludge applied to land to be assumed 0.016 kg N_2O/ Kg N.

(vi) Emissions from wastewater removed in the dewatering process

The wastewater from the dewatering process for the sludge in the residual effluent after the anaerobic digesters may contain some organic matter that has not been degraded/removed. The wastewater removed from the dewatering process of the sludge will be returned to the existing open lagoon (Pond #7) for aerobic treatment, for which the methane emissions have already been accounted for in para. (i) above. Therefore no methane emissions from such wastewater need to be taken into account separately.

Leakage

No leakage is associated with the project activity.

Emission Reductions

Emission reductions are calculated as the difference between baseline and project emissions, taking into account any adjustments for leakage.

The calculation based on *ex ante* information is the following:

Baseline emissions (tCO_2/yr)	=	Baseline emissions from open lagoons ($t\ CO_2e/yr$)	+	Baseline emissions from grid electricity generation (tCO_2/yr)	+	Baseline emissions from the portion of fossil fuel displaced by biogas used in heating equipment (tCO_2/yr)

Emission reductions (tCO_2/yr)	=	Baseline Emissions (tCO_2e/yr)	-	Leakage ($t\ CO_2e/yr$)	-	Project emissions ($t\ CO_2e/yr$)

The *ex-ante* estimate of methane emissions reductions is the difference between "Baseline emissions from open lagoons" and "Project emission" (= $ER\_CH_{4exante}$).

Ex-post monitoring of the actual amount of CH_4 captured and flared or fed to the electricity generator and/or to the heating equipment leads to an *ex-post* estimate of methane emissions reductions (= $ER\_CH_{4expost}$).

The *ex-ante* baseline and project methane emissions to be reported in the CDM-PDD are based on estimation equations defined earlier. Whereas, for the purpose of claiming emissions reductions, the lower of the two shall be assumed as the baseline emissions:

(i) baseline methane emissions less the physical leakage;

(ii) the actual methane captured and flared/used for energy generation.

If (ii) above is the baseline emissions then physical leakage from anaerobic digester for estimating emissions reduction shall be taken as zero.

The value of the actual methane captured and flared should be multiplied by the flare efficiency. Flare efficiency is estimated as per procedure explained above and monitored as per the monitoring methodology.

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

Data / Parameter:	**Q_{FFB}**
Data unit:	t FFB/yr
Description:	Annual quantity of FFB (fresh fruit bunch) processed. This is a measure of the annual palm oil mill operating capacity.
Source of data used:	Mill owner
Value applied:	83,250 for Oct-Dec 2007; 499,500 for 2008 onwards
Justification of the	The present mill capacity is 50 t FFB/hr. By the end of 2007, the total installed

choice of data or description of measurement methods and procedures actually applied :	capacity of the mill will be upgraded to 80 t FFB/hr. Annual quantity of FFB processed: 2004: 249,460 t 2005: 286,974 t 2006: 288,589 t Projected for 2007 onwards: 2007: 320,000 t (83,250 t for Oct-Dec 2007) 2008 – 2014: 499,500 t Ex-post calculation will be based on actual FFB processed, of which records are kept in the mill based on weigh-bridge data, and also in the accounting department.
Any comment:	The value is used for the estimation of the POME flow, using the factor of 0.6 m^3 POME/t FFB processed which has been established for the mill.

Data / Parameter:	$\mathbf{F_{la}}$
Data unit:	m^3/day
Description:	Flow rate of the wastewater from the mill to the lagoons, including those from the processing of FFB, and the process of recovery of oil from the EFB (empty fruit bunch) juice.
Source of data used:	Mill operator.
Value applied:	1,200 m^3/day or 399,600 m^3/yr. (Except for Oct-Dec 2007, 883 m^3/day will be used.)
Justification of the choice of data or description of measurement methods and procedures actually applied :	Wastewater from the mill: (see table below) The mill also recovers the oil from EFB liquor, after which the liquor will be combined with the effluent from FFB processing. The volume of EFB liquor is estimated from the EFB processed. Ex-post calculation will be based on actual monitored flow rate of wastewater.
Any comment:	-

Year	Effluent from FFB processing, m^3/yr	EFB liquor for oil recovery, m^3/yr	Total
2004	149,676	30,636	180,312
2005	172,184	51,061	223,245
2006	173,153	71,485	244,638
2007	192,000	102,122	294,122
2008-14	299,700	102,122	401,822

Data / Parameter:	$\mathbf{D_{op}}$
Data unit:	Days/year
Description:	Operating days per year - This represents the number of days the mill is operating in a year.
Source of data used:	Mill operator.
Value applied:	333 days/year or 27.8 days/month
Justification of the choice of data or description of measurement methods	This is based on the historical records of the mill operator. Ex-post calculation will be based on actual operating days recorded.

and procedures actually applied :	
Any comment:	-

Data / Parameter:	$\mathbf{T_{amb}}$
Data unit:	deg C
Description:	Ambient temperature - Monthly maximum, minimum and average temperature at or near project site.
Source of data used:	Malaysian Meteorological Services (MMS) Department.
Value applied:	26.6 deg C (annual mean); 22.8 deg C (min.) and 31.8 deg C (max.).
Justification of the choice of data or description of measurement methods and procedures actually applied :	The values are obtained from MMS monitoring records for the last 3 years.
Any comment:	The ambient temperature is applied in the calculation of f_t, the fraction of anaerobic degradation due to temperature.

Data / Parameter:	$\mathbf{D_{la,an}}$
Data unit:	meter (m)
Description:	Depth of the existing anaerobic lagoons.
Source of data used:	Mill operator.
Value applied:	6.5 m (Ponds #1, #2, #3 & #4)
Justification of the choice of data or description of measurement methods and procedures actually applied :	Based on design drawing records and the anaerobic lagoons as built.
Any comment:	-

Data / Parameter:	$\mathbf{COD_{a,in(1)}}$
Data unit:	kg/m^3
Description:	COD that enters the anaerobic lagoon (Pond #1 & #2).
Source of data used:	Mill operator.
Value applied:	55.00 kg/m^3
Justification of the choice of data or description of measurement methods and procedures actually applied :	The value applied is chosen as a conservative estimate based on long-term data. Recent monitoring data show a COD level in raw palm oil mill effluent entering the anaerobic lagoons (Pond #1 & #2) at 76.75 kg/ m^3.
Any comment:	-

Data / Parameter:	$COD_{a,out(1)}$
Data unit:	kg/m^3
Description:	COD that leaves the anaerobic lagoon (Pond #3 & #4) with the effluent.
Source of data used:	Mill operator.
Value applied:	10.00 kg/m^3
Justification of the choice of data or description of measurement methods and procedures actually applied :	The value applied is based on the monitoring data records of the palm oil mill on the effluent that leaves the anaerobic lagoon with the effluent.
Any comment:	-

Data / Parameter:	$D_{la,fa}$
Data unit:	meter (m)
Description:	Depth of the existing facultative/aerobic lagoons (Pond #5, #6 & #7).
Source of data used:	Mill owner.
Value applied:	3-3.5 m
Justification of the choice of data or description of measurement methods and procedures actually applied :	Based on design drawing records and the facultative lagoons as built.
Any comment:	-

Data / Parameter:	$COD_{a,in(2)}$
Data unit:	kg/m^3
Description:	COD that enters the facultative lagoons (Pond #5).
Source of data used:	Mill operator.
Value applied:	10.00 kg/m^3
Justification of the choice of data or description of measurement methods and procedures actually applied :	The value applied is assumed to be the same as $COD_{a,out(1)}$.
Any comment:	-

Data / Parameter:	$COD_{a,out(2)}$
Data unit:	kg/m^3
Description:	COD that leaves the final lagoon (Pond #7) with the effluent.
Source of data used:	Mill operator.
Value applied:	0.542 kg/m^3
Justification of the choice of data or	The value applied is based on the monitoring data records of the palm oil mill on the effluent.

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

Data / Parameter:	$\mathbf{B_o}$
Data unit:	kg CH_4/kg COD
Description:	Maximum methane production potential.
Source of data used:	IPCC
Value applied:	0.21 kg CH_4/kg COD
Justification of the choice of data or description of measurement methods and procedures actually applied :	The default IPCC value for $\mathbf{B_o}$ is 0.25 kg CH_4/kg COD. Taking into account the uncertainty of this estimate, the project participant uses a value of 0.21 kg CH_4/kg COD[5] as a conservative assumption for $\mathbf{B_o}$.
Any comment:	-

Data / Parameter:	$\mathbf{f_{d(1)}}$
Data unit:	Fraction number
Description:	Fraction of anaerobic degradation due to depth.
Source of data used:	AM0013 Version 4
Value applied:	0.70
Justification of the choice of data or description of measurement methods and procedures actually applied :	This is the default value recommended in AM0013 Version 4 for anaerobic lagoon depth of >5 m.
Any comment:	-

Data / Parameter:	$\mathbf{f_{d(2)}}$
Data unit:	Fraction number
Description:	Fraction of anaerobic degradation in the facultative lagoons due to depth.
Source of data used:	AM0013 Version 4
Value applied:	0.50
Justification of the choice of data or description of	This is the default value recommended in AM0013 Version 4 for lagoon depth of 1-5 m.

[5] Lowest value provided by IPCC Good Practice guidance, 2000, Page 5.19 was adopted in AM0013, Version 4. However, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 6.21 recommended that: "If no country specific data are available, it is *good practice* to use the IPCC COD-default factor for B_o (0.25 kg CH_4/kg COD)." Pending further guidance, the lagoon baseline emissions will be modified accordingly.

measurement methods and procedures actually applied :	
Any comment:	-

Data / Parameter:	$\mathbf{CEF_{Bl,elec,y}}$
Data unit:	tCO_2/MWh
Description:	CO_2 emission factor for the baseline grid electricity which would be consumed at the project site in the absence of the project activity.
Source of data used:	Calculated from publicly available data.
Value applied:	0.80 t CO_2/MWh
Justification of the choice of data or description of measurement methods and procedures actually applied :	The CO_2 baseline emission factor was obtained for the East Coast Grid of Sabah by the Malaysian Energy Centre (Pusat Tenaga Malaysia, PTM) in a study on grid electricity sector baselines in Malaysia[6] by applying the Approved Consolidated Methodology, ACM 0002. The data used were based on data publicly available for the most recent three years (2002, 2003 and 2004).
Any comment:	-

Data / Parameter:	EF_{N2O}
Data unit:	kg N_2O/kg N
Description:	Emission factor of nitrogen from sludge applied to land.
Source of data used:	Approved baseline methodology AM0013 Version 4.
Value applied:	0.016 kg N_2O/kg N
Justification of the choice of data or description of measurement methods and procedures actually applied :	Recommended in AM0013 Version 4.
Any comment:	-

B.6.3 Ex-ante calculation of emission reductions:

Baseline Emissions

The *ex ante* calculations of the lagoon baseline emissions and electricity (or thermal energy) baseline emissions, by applying the formulae chosen in Section B.6.1 and the data and parameters which are available as listed in Section B.6.2, are shown as follows.

(i) Lagoon baseline emissions from open lagoons

[6] PTM/DANIDA, April 2006. Study on grid connected electricity sector baselines in Malaysia.

The calculation of lagoon baseline emissions from open lagoons is carried out by applying the formula chosen in Section B.6.1. For the project activity, lagoon baseline emissions are calculated for methane from: (A) anaerobic lagoons of depth >5 m (Ponds #1 - #4), and (B) facultative/aerobic lagoons of depth 1-5 m (Ponds #5 - #7). The results are shown as follows:

(A) Calculation of Monthly and Annual Cumulative CH_4 Emissions (for Main Anaerobic Lagoons, Depth > 5m)

SUMMARY OF DATA AND FORMULA USED:

$COD_{baseline,m}$ = 1,500,866 kg/m

$COD_{available,m}$ = $COD_{baseline,m} + COD_{carryon,fr\ pr\ m}$

$COD_{carryon,fr\ pr\ m}$ = $COD_{available,m}*(1-MCF_{baseline,m})-COD_{a,out}*1200*27.8$

$MCF_{baseline,m}$ = $f_d * f_{t,monthly} *0.89$
= 0.4682

B_o = 0.21 kg CH_4/kg COD

$CH_{4,emissions}$ tCO_2e/m = $COD_{available,m}*B_o*MCF_{baseline,m}*GWP$ tCO_2e/m

MONTHLY AND ANNUAL CUMMULATIVE CH_4 EMISSIONS (for Main Anaerobic Lagoons, Depth > 5m):

Month No.	$COD_{b.line,m}$ kg/m	$COD_{carry\ on}$ kg/m	$COD_{avai,m}$ kg/m	$COD_{re.slud}$ kg/m	f_t	f_d	$CH_{4,emis,m}$ kg/m
1	1,500,866	0	1,500,866	0	0.7515	0.7	**147,563**
2	1,500,866	464,561	1,965,427	0	0.7515	0.7	**193,238**
3	1,500,866	711,614	2,212,481	0	0.7515	0.7	**217,528**
4	1,500,866	842,997	2,343,864	0	0.7515	0.7	**230,446**
5	1,500,866	912,867	2,413,733	0	0.7515	0.7	**237,315**
6	1,500,866	950,023	2,450,890	0	0.7515	0.7	**240,968**
7	1,500,866	969,783	2,470,650	0	0.7515	0.7	**242,911**
8	1,500,866	980,291	2,481,158	0	0.7515	0.7	**243,944**
9	1,500,866	985,880	2,486,746	0	0.7515	0.7	**244,494**
10	1,500,866	988,852	2,489,718	0	0.7515	0.7	**244,786**
11	1,500,866	990,432	2,491,298	0	0.7515	0.7	**244,941**
12	1,500,866	991,273	2,492,139	0	0.7515	0.7	**245,024**
$CH_{4,emissions}$ (kg/yr)							**2,733,160**
Lagoon baseline emissions (1) (t CO_2-e/yr)							**57,396**

(B) Calculation of Monthly and Annual Cumulative CH_4 Emissions (for Facultative/Aerobic Lagoons, Depth 1- 5m)

SUMMARY OF DATA AND FORMULA USED:

$COD_{baseline,m}$ = 313,918 kg/m

$COD_{available,m}$ = $COD_{baseline,m} + COD_{carryon,fr\ pr\ m}$

$COD_{carryon,fr\ pr\ m}$ = $COD_{available,m}*(1-MCF_{baseline,m})-COD_{a,out}*1200*27.8$

$MCF_{baseline,m}$ = $f_d * f_{t,monthly} *0.89$

		=	0.3344
B_o		=	0.21 kg CH_4/kg COD
$CH_{4,emissions}$	(tCO_2e/m)	=	$COD_{available,m}*B_o*MCF_{baseline,m}*GWP$ tCO_2e/m

MONTHLY AND ANNUAL CUMMULATIVE CH_4 EMISSIONS (for Facultative/Aerobic Lagoons, depth 1- 5m):

Month No.	$COD_{b.line,m}$ kg/m	$COD_{carry\ on}$ kg/m	$COD_{avai,m}$ kg/m	$COD_{re.slud}$ kg/m	f_t	f_d	$CH_{4,emis,m}$ kg/m
1	313,918	0	313,918	0	0.7515	0.5	**22,045**
2	313,918	175,584	489,501	0	0.7515	0.5	**34,375**
3	313,918	292,452	606,370	0	0.7515	0.5	**42,582**
4	313,918	370,240	684,157	0	0.7515	0.5	**48,044**
5	313,918	422,015	735,933	0	0.7515	0.5	**51,680**
6	313,918	456,477	770,394	0	0.7515	0.5	**54,100**
7	313,918	479,414	793,332	0	0.7515	0.5	**55,711**
8	313,918	494,682	808,599	0	0.7515	0.5	**56,783**
9	313,918	504,844	818,761	0	0.7515	0.5	**57,497**
10	313,918	511,608	825,525	0	0.7515	0.5	**57,972**
11	313,918	516,110	830,027	0	0.7515	0.5	**58,288**
12	313,918	519,106	833,024	0	0.7515	0.5	**58,498**
$CH_{4,emissions}$ (kg/yr)							**597,574**
Lagoon baseline emissions (2) (t CO_2-e/yr)							**12,549**

(ii) Electricity (or thermal energy) baseline emissions

The electricity generated by the biogas-fired gas engines will displace electricity from the East Coast Grid of Sabah, which together with the West Coast Grid form the Sabah electricity grid system. The East Coast Grid was commissioned in 2003 and interconnects the cities of Tawau, Semporna and Sandakan (See map in A.4).

The CO_2 baseline emission factor has been obtained for the East Coast Grid of Sabah by the Malaysian Energy Centre (Pusat Tenaga Malaysia, PTM) in a study on grid electricity sector baselines in Malaysia[7] by applying the Approved Consolidated Methodology, ACM 0002. The data used were based on data publicly available for the most recent three years (2002, 2003 and 2004). The operational power plants of the East Coast Grid were using only diesel or fuel oil. The baseline emission factor $CEF_{Bl.,elec,,y}$ obtained is:

$$\mathbf{CEF_{Bl,elec,y}} = 0.80 \text{ t } CO_2/MWh$$

The electricity baseline emissions for the grid electricity displaced by the electricity generated from the project activity are calculated using the formula chosen in Section B.6.1 as follows:

[7] PTM/DANIDA, April 2006. Study on grid connected electricity sector baselines in Malaysia.

$BE_{elec/heat}$	=	**EG_y * $CEF_{Bl,elec,y}$**	+	**$EG_{d,y}$ * CEF_{grid}**	+	**$HG_{Bl,y}$ * $CEF_{Bl,therm,y}$**
(t CO_2/y)		(MWh/y) (t CO_2/MWh)		(MWh/y) (t CO_2/MWh)		(MJ/y) (t CO_2/MJ)
	=	2.5*8000*0.8*0.80	+	0	+	0
	=	12,800 t CO_2/y				

where:

EG_y = amount of electricity in the year y that would be consumed at the project site in the absence of the project activity (MWh).

= 2.5 MW for 8,000 hr/yr; a loading factor of 80% is used as a conservative estimate.

$EG_{d,y}$ = 0 since no electricity export to the grid is intended.

$HG_{Bl,y}$ = 0 since no thermal energy consumed on the site.

Total baseline emissions

The calculation of baseline emissions has taken into account POME flow of 883 m^3/day for the period of Oct-Dec 2007, and 1,200 m^3/day or 399,600 m^3/yr thereafter.

Baseline emissions for Year 1	=	Lagoon baseline emissions + electricity baseline emissions
	=	(52,124+11,458) tCO_2-e/yr + 12,800*(883/1200)*(3/12) tCO_2-e/yr + 12,800*(9/12) tCO_2-e/yr
	=	75,537 tCO_2-e/yr.
Baseline emissions for	=	Lagoon baseline emissions + electricity baseline emissions
Year 2 & onwards	=	(57,396+12,549) tCO_2-e/yr + 12,800 tCO_2-e/yr
	=	82,745 tCO_2-e/yr.

Project Emissions

The calculations of the various types and sources of project emissions, by applying the formulae chosen in Section B.6.1 and the data and parameters which are available as listed in Section B.6.2, are shown as follows.

(i) Project methane emission from lagoons

The effluent after the anaerobic digester will go through the sludge dewatering facility. The supernatant overflow will be discharged to the open lagoon (Pond #7). The filtrate from sludge dewatering process will be combined and also discharge to Pond #7. The combined flow rate would be slightly less than F_{dig_out}, due to the sludge being removed. The flow rate of effluent from the anaerobic digester F_{dig_out} will be used as a conservative estimate of the flow rate of effluent entering Pond #7. COD concentration of the effluent into the open lagoon based on monitoring data from similar anaerobic digester systems, after residual sludge in the effluent is removed in the sludge dewatering facility, is:

$$COD_{c,dig\_out} = 2.0\ kg/m^3$$

Actual COD_{c,dig_out} monitored will be used after implementation of the project activity.

Project methane emission from the open lagoon is calculated as follows:

$$\mathbf{CH_4\ emissions = COD_{dig\_out} * B_o * MCF_{dig\_out}}$$

from lagoon = 2.0 $kgCOD/m^3 * 1200m^3/d * 333d/yr$ * 0.21 kg CH_4/kg COD * 0.3344
= 56,123 kg CH_4/yr
= 1,179 t CO_2-e/yr

where $\mathbf{B_o}$ and $\mathbf{MCF_{dig\_out}}$ are the same as in the baseline.

(ii) Physical leakage from biodigesters

In accordance with AM0013, IPCC guidelines specify physical leakage from anaerobic digesters as being 15% of total biogas production. However, as the project participant has opted to use lower values for percentage of physical leakage, measurements proving that the lower value used is appropriate for the project are described below under the following two possible scenarios:

(a) Leakage from biodigester tanks

Steel tanks and steel piping systems are well known to be used widely for very low pressure to very high pressure gas storage and transfer without any significant leakage problems. The steel tank and steel piping-based anaerobic digester system, as in the present project activity, is therefore expected to be much less likely to encounter any physical leakage of biogas as compared to geo-membrane-covered, pond-based or other non-steel tank anaerobic digester system.

The leakage from the gas-containing upper sections of the steel-plate biodigester tank therefore will be assumed to be zero by means of taking the necessary preventive and leakage testing measures during fabrication and construction of the steel tanks following the necessary Technical Specifications and Standards, as described in Section A.4.3 of this PDD. The thickness of the steel plates is in the range of 6 – 10 mm. With proper engineering welding, the tank is guaranteed to provide 100% seal over the operational life of the project.

A report of the hydrostatic testing and gas leakage testing of the biodigester tanks proving the negligible leakage of the tanks during commissioning will be provided.

Nevertheless, during project operation, monitoring of possible physical leakage of the biodigester steel tanks will be included. The upper gas-containing sections of the tank will be monitored monthly by applying standard techniques for leak monitoring to ensure that no leakage takes place in the welding joints. Leakage if detected will be rectified immediately to ensure that the leaked amount will be minimal. The pressure inside the gas space of the biodigester tank, for accommodating the biogas as it is generated, is relatively low, normally only about 200 mm water column.

Should there be any leakage detected during any month, it will be recorded and the leaks will be sealed with the appropriate sealing material immediately. As a conservative measure, the default physical leakage of 15% will be applied during the month a leakage is detected, if this is judged to be necessary.

Nevertheless, as a conservative measure, a physical leakage of 1% is assumed for ex ante calculations. The corresponding project emission (PE_{CH4_leak}) is calculated as follows:

PE_{CH4_leak} = $Q_{CH4,y}$ * 1% * GWP
= 4,670 t CH_4/yr * 0.01 * 21 t CO_2-e/t CH_4
= 980.7 t CO_2-e

Where:

$Q_{CH4,y}$ = methane generated from anaerobic digester for year y

$Q_{CH4,y}$ is estimated by using the emission factor (EF) for industrial wastewater (POME), obtained from the application of: 2006 IPCC Guidelines for National Greenhouse Gas Inventories[8] as follows:

Annual input of COD in the POME to the anaerobic digester is calculated as:

COD_t = F_{dig} * 333 d/yr * $COD_{c,baseline}$

Where:

F_{dig} = Flow rate of organic wastewater into the digester, m^3/d
= 1,200 m^3/d

$COD_{c,baseline}$ = COD concentration of organic wastewater into the digester
= 55 kg COD/m^3

CH_4 Emission Factor for POME:

EF = B_o*MCF

Where:

Bo = maximum CH_4 producing capacity, kg CH_4/kg COD
= 0.25 kg CH_4/kg COD

MCF = methane correction factor (fraction)
= 0.85
(based on published data for POME anaerobic digester[9])

Quantity of methane generated per annum:

$Q_{CH4,y}$ = COD_t * EF
= 1,200 m^3/d * 333 d/yr * 55 kg COD/m^3 * 0.25 kg CH_4/kg COD *0.85
= 4,670,325 kg CH_4/yr
= 4,670 t CH_4/yr

(b) Physical leakage in biogas pipeline

The physical leakage in the pipeline from the anaerobic digester tanks to the heat generation equipment and the flaring system will be measured during project implementation using the following monitoring data: (1) Amount of biogas collected in the outlet of the biodigester FR_{bio} (Data #18); (2) Flow rate of the biogas entering the flare $FR_{f,inlet}$ (Data #20); and (3) Flow rate of the biogas entering the heat generation equipment $FR_{e,inlet}$ (Data #28). The monitoring data on the concentration of methane in the biogas also will be used. During project implementation, the physical leakage can be calculated as the amount of methane in the outlet of the biodigester minus the sum of the amount of methane entering the flare and the electricity generation equipment. This will be accounted for as the project emissions due to physical leakage.

(iii) Stack emissions from the flare or energy generation

For ex-ante calculations,

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[8] IPCC 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds.). Published: IGES, Japan.

[9] Tong S.L. and Jaafar A.B. 2005. POME Biogas Capture, Upgrading and Utilisation, in: Proceedings of the PIPOC 2005 International Pal Oil Congress (Chemistry and Technology). Published: MPOB, Malaysia.

Key information used are:

a) Methane generated from anaerobic digester for POME = 4,670 t/yr (from calculation in para. (ii) above)

b) Fraction of biogas for flare = 10%
(This is a conservative estimate. Actual fraction of biogas for flare will be less, as maximum biogas will be directed to the gas engine power generation. Monitoring data will be used for ex-post calculation.)

c) Fraction of biogas for electricity generation = 90%
(Estimated. Actual fraction of biogas for electricity generation based on monitoring data will be used for ex-post calculation.)

d) Fraction CH_4 released in stack due to incomplete flaring = 0.10 (Default value as per AM0013 Version 04 for enclosed flare)

CH_4 emissions due to incomplete combustion during flaring:

CH_4 emissions = 4,670 t/yr x 0.10 x 0.10 x 21 (GWP = 21)
= 980.7 tCO_2e/yr

CH_4 emissions due to incomplete combustion during electricity generation:

CH_4 emissions = 4,670 t/yr x 0.90 x 0.01 x 21 (GWP = 21)
= 882.0 tCO_2e/yr

(Assuming combustion of biogas in gas engines at 99% efficiency. Actual gas engine efficiency based on manufacturer specifications and monitoring data will be used for ex-post calculation.)

Total emissions due to incomplete flare and incomplete combustion in electricity generation:

= (980.7 + 882.0) tCO_2e/yr

= 1,863 t CO_2-e/yr

For ex-post calculation of project emissions due to incomplete combustion during flaring:

The methodological “Tool to determine project emissions from flaring gases containing methane” will be applied.

Project emissions from flaring are calculated as the sum of emissions from each hour *h* , based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour *h* ($\eta_{flare,h}$) , as follows:

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

Where:

Variable	SI Unit	Description
$PE_{flare,y}$	tCO_2e	Project emissions from flaring of the residual gas stream in year *Y*
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h*
$\eta_{flare,h}$	-	Flare efficiency in hour *h*

GWP_{CH4}	tCO_2e/tCH_4	Global Warming Potential of methane valid for the commitment Period

For the project activity, the option to use a 90% default value for the enclosed flare as the flare efficiency has been chosen. That is, continuous monitoring of the methane destruction efficiency of the flare will not be carried out. However, continuous monitoring of compliance with manufacturer's specification of flare (temperature, flow rate of residual gas at the inlet of the flare) will be performed. If in a specific hour any of the parameters are out of the limit of manufacturer's specifications, a 50% default value for the flare efficiency should be used for the calculations for this specific hour.

The parameters required for the calculation of the project emissions which are to be monitored are included in the Section B.7 on application of monitoring methodology.

(iv) Emission from heat use and electricity use due to the project activity

The following equation will be used for the calculation:

$$\mathbf{PE_{elect/heat} = EL_y \times CEF_d + HG_{Pr,y} \times CEF_{Pr,therm,y}}$$

Since there will be no thermal energy consumed due to the project activity,

$$\mathbf{HG_{Pr,y} = 0}$$

Followings are the assumptions of the electricity use due to the project activity:

a) The total electricity requirement due to the project activity is estimated to be 180 kW.
b) The anaerobic digester system will be in continuous operation for 24 hrs/d and 365 d/yr.
c) **Electricity consumed** due to the project activity is therefore estimated: **1,576.8 MWh/yr.**
d) It is anticipated that the electricity supply for the digester system operations will be derived from the gas engine power generation plant using the biogas produced.
e) A total of four (4) units of gas engines of 700 kW rated power output will be installed for the power generation using the biogas as stated previously.
f) It is anticipated that in the worst case, at least one gas engine will be running any time. A fraction of the output will be sufficient to supply the electricity required for the digester plant operations.
g) It is therefore perceivable that no external back-up electricity source is necessary for the continuous operation of the digester plant.

Since the operation of the anaerobic digester system will be drawing electricity solely from the gas engine power plant using biogas generation, which is CO_2-neutral, the CO_2 emission factor for the electricity consumed at the project during project activity would be:

$$\mathbf{CEF_d = 0}$$

Therefore, project emissions from electricity use due to the project activity would be:

$$\mathbf{PE_{elect/heat} = 0}$$

(v) Emissions from land application of sludge

The residual sludge from the anaerobic digester after treatment is dewatered and applied to the land. The dewatered sludge is expected to have a dry sludge solid content of 20%. The COD concentration and flow rate of the sludge are:

F_{la} = Flow rate of sludge for land application after dewatering (kg/yr)
= 6.0 kg/m^3 x 1,200 m^3/d x 333 d/yr
= 2,397,600 kg/yr

COD_{la} = COD concentrations of the sludge after dewatering for land application (kg/m^3)
= 6.0 kg/m^3 sludge in effluent (This is the concentration before dewatering)
= 0.2 t/m^3 dry sludge (Assuming a 33.3 times concentration factor after dewatering.)

Project emissions from land application of the residual sludge in terms of CH_4 and N_2O emissions are calculated as follows:

CH_4 emissions (kg/yr) = **Total COD_{la}** (kg COD/yr) x **B_o** (kg CH_4/kg COD) x **MCF_{la}**

Where:

COD_{la}	=	6.0 kg/m^3 (Concentration before dewatering)
Total COD_{la}	=	6.0 kg/m^3 x 1,200 m^3 x 333 d/yr = 2,397,600 kg/yr
B_o	=	0.21 kg CH_4/kg COD
MCF_{la}	=	0.05 (as recommended in AM0013)
CH_4 emissions	=	25,175 kg/yr
	=	**529 t CO2 -e/yr (GWP = 21)**

N_2O emissions (kg/yr) = **S_a** (kg sludge/yr) x **NC** (kg CH_4/kg COD) **x** **EF_{N2O}**

Where:

S_a	=	2,397,600 kg/yr
NC	=	0.0365 kg N/kg sludge (3.65% N in sludge based on laboratory test results.)
EF_{N2O}	=	0.016 (kg N_2O/kg N) (as recommended in AM0013)
N_2O emissions	=	383 kg/yr
	=	**434 t CO2-e/yr** (GWP = 310)

Total emissions for sludge land application = **1,082 t CO2-e/yr**

(vi) Emissions from wastewater removed in the dewatering process

As liquid effluent from dewatering is returned back to the open lagoon (Pond #7), the emissions have been included in the calculation in para (i) above for emissions from Pond #7.

Therefore, no emissions from wastewater removed in the dewatering process need to be accounted separately.

Project Emissions

Total project emissions are obtained by combining individual components of project emissions (i) – (vi):

Total project emissions = (1,179 + 981 + 1,863 + 0 + 1,082 + 0) t CO_2-e/yr
= **5,105 t CO_2-e/yr**

Leakage

No leakage is associated with the project activity in accordance with AM0013.

Emission Reductions

Emission reductions are calculated as the difference between baseline emissions and project emissions in line with the provisions in AM0013. While effective emission reductions will be determined *ex-post* on the basis of measured data, an *ex-ante* estimation of expected emission reductions of the first 7-year crediting period is provided below.

	Year 1	Year 2 & Onwards
Expected baseline emissions	75,527 t CO_2-e/yr	82,745 t CO_2-e/yr
Expected project emissions	5,105 t CO_2-e/yr	5,105 t CO_2-e/yr
Expected emission reductions (ex-ante)	**70,422 t CO_2-e/yr**	**77,640 t CO_2-e/yr**

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

The expected emission reductions for the first 7-year crediting period are provided below:

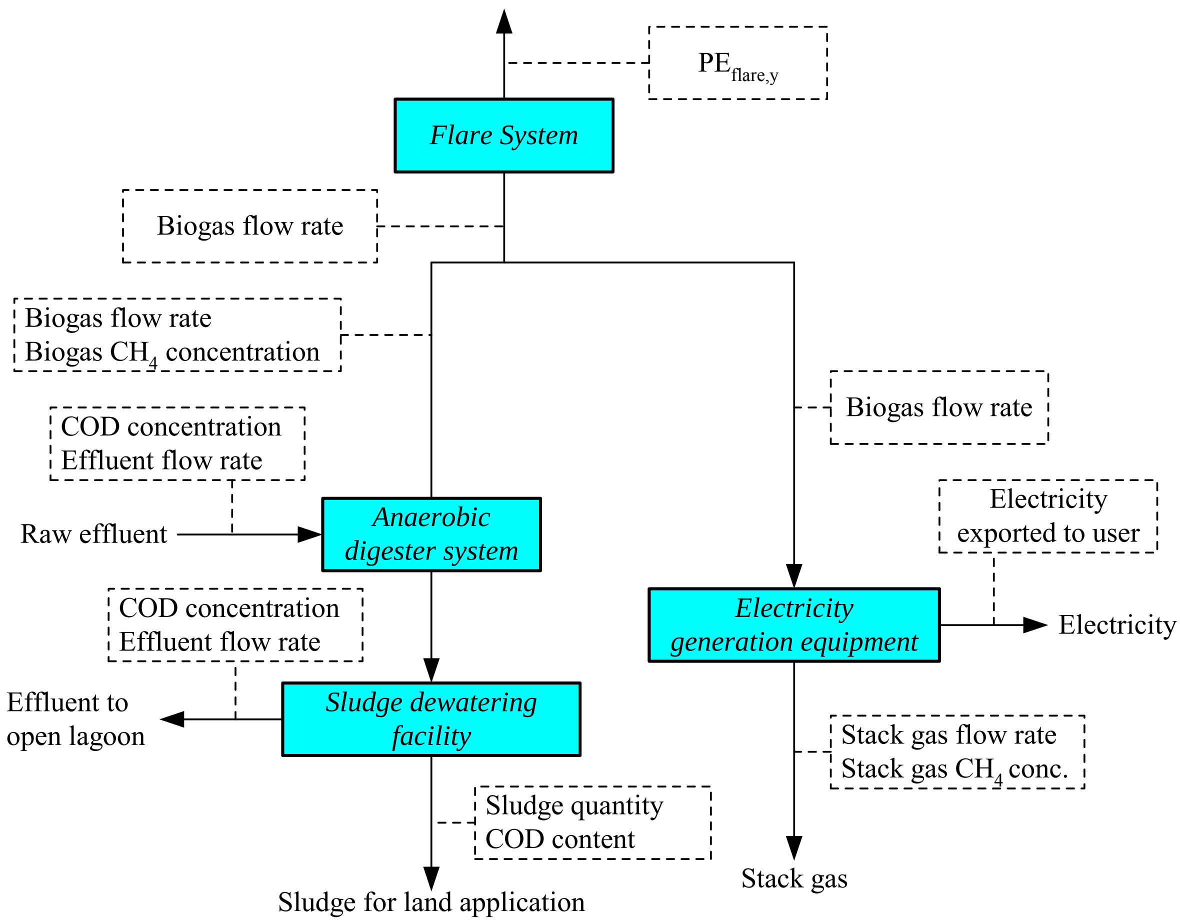
Year	Estimation of project activity emissions (tonnes of CO2 e)	Estimation of baseline emissions (tonnes of CO_2 e)	Estimation of leakage (tonnes of CO_2 e)	Estimation of overall emission reductions (tonnes of CO2 e)
2007 (Oct-Dec)	1,276	13,478	0	12,202
2008	5,105	82,745	0	77,640
2009	5,105	82,745	0	77,640
2010	5,105	82,745	0	77,640
2011	5,105	82,745	0	77,640
2012	5,105	82,745	0	77,640
2013	5,105	82,745	0	77,640
2014 (Jan-Sept)	3,829	62,059	0	58,230
Total	35,735	572,007	0	536,272

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

The approved monitoring methodology for AM0013 Version 04, Sectoral 13, EB 28 entitled: Revision to the approved monitoring methodology AM0013 "Avoided methane emissions from Organic Wastewater Treatment" is applied for the project activity. The project activity complies with the applicability conditions of the approved monitoring methodology.

Monitoring Methodology

The monitoring methodology will cover the parameters which are shown schematically in the figure below, showing the flows between the different parts of the project. The parameters for each of the process flows to be monitored are shown in dashed boxes.



The monitoring will involve the following parameters after project implementation:

For determining baseline emissions

1. Flow rate of organic wastewater into the digester F_{dig} (Data # 1)
2. $COD_{c,baseline}$ concentration of organic wastewater into the digester (Data # 2)
3. $COD_{a,out}$ is the COD that leaves the lagoon with the effluent (Data # 3)
4. $COD_{a,in}$ is the COD that enters the lagoon which is assumed to be equal to the COD input to the digester or to land application (Data # 4)
5. Maximum methane producing capacity B_o (Ex-ante)
6. Temperature of lagoon T_{lag} (Data # 5)
7. Depth of lagoon D_{lag} (Data # 6)
8. Amount of electricity that would be consumed in year y at the project site in the absence of the project activity using fossil fuel EG_y (Data # 7).
9. CO_2 emission factor for electricity consumed at the project in the absence of the project activity $CEF_{Bl,elec,}$(Ex-ante)

For determining project emissions

1. Flow rate of organic wastewater into the digester F_{dig_out} (Data # 10)
2. COD_{c,dig_out} concentrations in effluent from the anaerobic digester-sludge dewatering facility discharged to the open lagoons to estimate project CH_4 emissions (Data # 11).
3. Amount of electricity in the year y that is consumed at the project site due to the project activity $EL_{Pr,y}$ (Data # 12).
4. CO_2 emission factor for electricity consumed at the project site for the project activity CEF_d (Ex-ante).
5. Flow rate of sludge used for land application after dewatering F_{la}, from the anaerobic digester-sludge dewatering facility (Data # 14).
6. $COD_{c,la}$ of sludge used for land application after dewatering (Data # 15).
7. Maximum methane producing capacity B_o (Ex-ante).
8. Methane conversion factor for sludge used for land application MCF_{la} (Ex-ante).
9. Flow rate of organic wastewater from the dewatering process $F_{c,dw}$. (Data # 16).
10. $COD_{c,dw}$ of the wastewater from dewatering process. (Data # 17).
11. Amount of biogas collected in the outlet of the biodigester using a continuous flow meter FR_{bio} (Data # 18).
12. Percentage of biogas that is methane in the outlet of the biodigester $P_{CH4,bio}$ (Data # 19)
13. Flow rate of the biogas entering the flare $FR_{f,inlet}$ (Data # 20)
14. Project emissions from flaring of the residual gas stream in year y $PE_{flare,y}$. The parameters used for determining the project emissions from flaring of the residual gas stream in year y ($PE_{flare,y}$) should be monitored as per the "*Tool to determine project emissions from flaring gases containing Methane*". (Data #22)
15. Volumetric fraction of component *i* in the residual gas, $fv_{i,h}$, in the hour *h* where *i* = CH_4, CO, CO_2, O_2,H_2, N_2, specifically for CH_4 (Data #22a)
16. Volumetric flow rate of the residual gas, $FV_{RG,h}$, in dry basis at normal conditions in the hour *h*. (Data #22b)
17. Operation parameters of the flare - this should include all data and parameters that are required to monitor whether the flare operates within the range of operating conditions according to the manufacturer's specifications. (Data #22c)
18. Flow rate of the biogas entering the electricity generation equipment $FR_{e,inlet5}$ (Data # 24)
19. Flow rate of the electricity generation equipment stack gases $FR_{e,s}$ (Data # 25)
20. Methane content in stack gas of electricity generation equipment $P_{CH4,e,s}$ (Data #26)
21. Fraction of time gas is combusted in the electricity generation equipment $T_{comb,e}$ (Data # 27)

22. Amount of sludge applied to land in kg per year S_o (Data #32)
23. Nitrogen content in the sludge NC (Data # 33)
24. Emission factor of nitrogen from sludge applied to land to be assumed EF_{N2O} (Ex-ante).
25. Regulations and incentives relevant to effluent (Data #34)
26. Physical leakage of digester tanks (Data #35)

Data # 1:	
Data / Parameter:	$\mathbf{F_{dig}}$
Data unit:	m^3/month
Description:	Flow rate of organic wastewater into the digester.
Source of data to be used:	Measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.6	1,200 m^3/d. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Flow rate will be measured by magnetic flow meter installed in-line of the influent pipe to the digester. Measurements will be carried out continuously (100%). Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data will be low. Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	Parameter monitored continuously but aggregated monthly for calculations.

Data #2:	
Data / Parameter:	$\mathbf{COD_{c,baseline}}$
Data unit:	kg/m^3
Description:	COD concentration of organic wastewater into the digester.
Source of data to be used:	Measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.6	55.00 kg/m^3. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Measurements will be carried out monthly by MS ISO/IEC 17025 accredited laboratory following standard methods. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing will be carried out adhering to internationally recognised procedures.
Any comment:	

Data #3:

Data / Parameter:	**$COD_{a,out}$**
Data unit:	kg/m^3
Description:	Concentration of COD that leaves the lagoon with the effluent.
Source of data to be used:	Measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.6	10.00 kg/m^3. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Historical one year data. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing should adhere to internationally recognised procedures.
Any comment:	

Data #4:	
Data / Parameter:	**$COD_{a,in}$**
Data unit:	kg/m^3
Description:	COD that enters the open lagoon which is assumed to be equal to the COD input to the digester.
Source of data to be used:	Measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.6	55.00 kg/m^3. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Historical 1 year data or use **$COD_{c,baseline}$** (Data #2). Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing should adhere to internationally recognised procedures.
Any comment:	

Data #5:	
Data / Parameter:	**T_{lag}**
Data unit:	Degree C (to be converted to deg K)
Description:	Ambient temperature
Source of data to be used:	Daily mean, minimum and maximum temperature readings from the Malaysian Meteorological Services (MMS) for a temperature monitoring station closest to the project site will be obtained.
Value of data applied for the purpose of	An annual mean of 26.6 ^oC was applied. During implementation of the project activity, the actual monitored data will be applied.

calculating expected emission reductions in section B.6	
Description of measurement methods and procedures to be applied:	Daily data from MMS will be collected. International recognised standard methods are used by the Malaysian Meteorological Services in all its weather monitoring programmes. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	MMS adopts international recognised QA/QC procedures in its monitoring programmes.
Any comment:	Daily average is monitored but monthly average is used in the calculation.

Data #6:	
Data / Parameter:	**D_{lag}**
Data unit:	m (metre)
Description:	Depth of open lagoon.
Source of data to be used:	Measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.6	6.5 m (Ponds #1 - #4); 3 – 3.5 m (Ponds #5 - #7).
Description of measurement methods and procedures to be applied:	Depth of lagoon will be monitored daily using a depth measuring pole. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Random verification by supervisor/engineer-in-charge.
Any comment:	

Data #7:	
Data / Parameter:	**EG_y**
Data unit:	MWh/y
Description:	Quantity of electricity that would be consumed in year y at the project site in the absence of the project activity using fossil fuel.
Source of data to be used:	Electricity output meter recording.
Value of data applied for the purpose of calculating expected emission reductions in section B.6	2.5 MW x 8,000 h/y x 0.8 = 16,000 MWh. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	The electricity output from the biogas fired generator sets will be recorded continuously by the meter provided with the electricity generator set. Data will be archived electronically, minimum for two years, after last issuance of CERs.

QA/QC procedures to be applied:	Electricity meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company. Uncertainty of the meters to be obtained from the manufacturers. This uncertainty will be included in a conservative manner while calculating CERs.
Any comment:	

Data # 10:	
Data / Parameter:	$\mathbf{F_{dig\_out}}$
Data unit:	m^3/month
Description:	Flow rate of organic wastewater into the digester.
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	1,200 m^3/d. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Flow rate of organic wastewater from the digester $\mathbf{F_{dig\_out}}$ will be the same as flow rate of organic wastewater into the digester $\mathbf{F_{dig}}$ since there will be no loss of effluent volume during the digestion process in the complete-mixed digester system. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data will be low. Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	Parameter monitored continuously but aggregated annually for calculations.

Data #11:	
Data / Parameter:	$\mathbf{COD_{c,dig\_out}}$
Data unit:	kg/m^3
Description:	COD concentrations in effluent from the digester-dewatering system discharged to the open lagoons to estimate CH_4 emissions in the project case.
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	2.00 kg/m^3. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Measurements will be carried out monthly by MS ISO/IEC 17025 accredited laboratory using approved standard methods of testing. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing will be carried out adhering to internationally recognised procedures.
Any comment:	

Data #12:	
Data / Parameter:	**$EL_{Pr,y}$**
Data unit:	MWh/yr
Description:	Amount of electricity in the year y that is consumed at the project site for the project activity.
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	1,576.8 MWh/yr. Electricity supply for the project activity will be exclusively from renewable energy source.
Description of measurement methods and procedures to be applied:	The electricity consumed due to the project activity will be recorded continuously by the electricity meter at the electrical switchboard panel in the control room. Data will be archived electronically, minimum for two years, after last issuance of CERs. (Electricity supply for the project activity will be exclusively from renewable energy source.)
QA/QC procedures to be applied:	Electricity meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company. Uncertainty of the meters to be obtained from the manufacturers. This uncertainty will be included in a conservative manner while calculating CERs.
Any comment:	

Data #14:	
Data / Parameter:	**F_{la}**
Data unit:	m^3/yr
Description:	Flow rate of sludge used for land application after dewatering (for residual sludge from the anaerobic digester after treatment only).
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	11,988 m^3/yr (Dry sludge content: 2,397.6 t/yr). During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	The sludge from the anaerobic digester after dewatering will have a dry solid content of about 20%. Flow rate of sludge is measured in terms of the weight of sludge collected daily. Monitoring will be conducted continuously. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data will be low. Measurement equipment will undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	

Data #15:	
Data / Parameter:	**$COD_{c,la}$**
Data unit:	kg/m^3
Description:	COD concentrations of the sludge after dewatering for land application (for residual sludge from the anaerobic digester after treatment only).
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	**6.0 kg/m^3 sludge COD in effluent** (Concentration of sludge COD in the effluent from the anaerobic digester after treatment but before dewatering.) **0.2 t/m^3 as dry sludge after dewatering** (Assuming a concentration factor of 0.2/0.006 = 33.3 on dewatering). During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Measurements will be carried out monthly by MS ISO/IEC 17025 accredited laboratory. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing will be carried out adhering to internationally recognised procedures.
Any comment:	

Data #16:	
Data / Parameter:	**$F_{c,dw}$**
Data unit:	m^3/yr
Description:	Flow rate of organic wastewater from the dewatering process to the open lagoon
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	1,200 m^3/d (a conservative estimate; since the sludge will take away a small volume of the total organic wastewater flow). During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	A flow meter will be installed to measure the flow rate of the wastewater from the dewatering process to the lagoon. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data will be low. Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	Parameter monitored continuously but aggregated annually for calculations.

Data #17:	
Data / Parameter:	**$COD_{c,dw}$**
Data unit:	kg/m^3
Description:	COD concentration of the wastewater from the dewatering process to the open lagoon.
Source of data to be	Measurements

used:	
Value of data applied for the purpose of calculating expected emission reductions in section B.6	2.0 kg/m^3. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Measurements will be carried out monthly by MS ISO/IEC 17025 accredited laboratory. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing will be carried out adhering to internationally recognised procedures.
Any comment:	

Data #18:	
Data / Parameter:	**FR_{bio}**
Data unit:	m^3/yr
Description:	Amount of biogas collected in the outlet of the Bio-digester measured using a continuous flow meter.
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	4,670 t CH_4/yr (6,550,000 Nm^3/yr, density of CH_4: 0.713 kh/Nm^3). During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Measured with a pre-calibrated gas flow meter incorporated into the main gas outlet pipe. Flow rate will be monitored continuously. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data will be low. Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	Parameter monitored continuously but aggregated annually for calculations.

Data #19:	
Data / Parameter:	**$P_{CH4,bio}$**
Data unit:	%
Description:	Percentage of biogas that is methane in the outlet of the bio-digester
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	62.5. During implementation of the project activity, the actual monitored data will be applied.
Description of	Measurement will be conducted quarterly and at 95% confidence level using a

measurement methods and procedures to be applied:	calibrated portable gas meter by taking statistically valid number of sample measurements. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing will be carried out adhering to internationally recognised procedures.
Any comment:	To be measured at wet basis.

Data #20:	
Data / Parameter:	**$FR_{f, inlet}$**
Data unit:	m^3/yr
Description:	Flow rate of biogas entering the flare
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	10% (conservative assumption). During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Measured with a pre-calibrated vortex gas flow meter incorporated into the flare gas pipe before flaring. Data will be obtained continuously. A one-year cumulative flow will be used for calculations. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data will be low. Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	Parameter monitored continuously but aggregated annually for calculations.

Data #22:	
Data / Parameter:	**$PE_{flare,y}$**
Data unit:	tCO_2e
Description:	Project emissions from flaring of the residual gas stream in year y (**$PE_{flare,y}$**)
Source of data to be used:	The parameters used for determining the project emissions from flaring of the residual gas stream in year y (**$PE_{flare,y}$**) shall be monitored as per the "*Tool to determine project emissions from flaring gases containing methane*".
Value of data applied for the purpose of calculating expected emission reductions in section B.6	980.7. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Calculation.
QA/QC procedures to be applied:	
Any comment:	

Data #22a:	
Data / Parameter:	$fv_{i,h}$
Data unit:	--
Description:	Volumetric fraction of component *i* in the residual gas in the hour *h* where i = CH_4, CO, CO_2, O_2, H_2, N_2.
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	0.625
Description of measurement methods and procedures to be applied:	Measurement using a gas analyser continuously. Ensure that the same basis (dry or wet) is considered for this measurement and the measurement of the volumetric flow rate of the residual gas ($FV_{RG,h}$) when the residual gas temperature exceeds 60 °C. Values to be averaged hourly or at a shorter time interval. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Analysers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard certified gas.
Any comment:	As a simplified approach, project participant may only measure the methane content of the residual gas and consider the remaining part as CO_2.

Data #22b:	
Data / Parameter:	$FV_{RG,h}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*.
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	
Description of measurement methods and procedures to be applied:	Measurements continuously using a flow meter. Ensure that the same basis (dry or wet) is considered for this measurement and the measurement of volumetric fraction of all components in the residual gas ($fv_{i,h}$) when the residual gas temperature exceeds 60 °C. Values to be averaged hourly or at a shorter time interval. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Flow meters are to be periodically calibrated according to the manufacturer's recommendation.
Any comment:	

Data #22c:	
Data / Parameter:	**Operation parameters of the flare**
Data unit:	--
Description:	This should include all data and parameters that are required to monitor whether the flare operates within the range of operating conditions according to the manufacturer's specifications.
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	
Description of measurement methods and procedures to be applied:	Monitor continuously all data and parameters indicating the operating conditions of the flare according to the manufacturer's specifications. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Engineer-in-charge to verify regularly the monitoring records of the operators.
Any comment:	

Data #24:	
Data / Parameter:	**$FR_{e, inlet}$**
Data unit:	m^3/yr
Description:	Flow rate of the biogas entering the electricity generation equipment
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	90% of 4,670 t CH_4/yr (6,550,000 Nm^3/yr, density of CH_4: 0.713 kh/Nm^3). During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Measured with a gas flow meter incorporated into the biogas fuel pipe line before combustion. Data will be measured continuously. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data will be low. Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	Parameter monitored continuously but aggregated annually for calculations.

Data #25:	
Data / Parameter:	**$FR_{e, s}$**
Data unit:	m^3/hr
Description:	Flow rate of the electricity generation equipment stack gases
Source of data to be	Measurements

used:	
Value of data applied for the purpose of calculating expected emission reductions in section B.6	--
Description of measurement methods and procedures to be applied:	Monitoring continuously following standard procedures and equipment manufacturer's specifications. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data will be low. Flow meters will undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	Parameter monitored continuously but aggregated annually for calculations.

Data #26:	
Data / Parameter:	$\mathbf{P_{CH4, e, s}}$
Data unit:	%
Description:	Methane content in stack gas of electricity generation equipment
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	--
Description of measurement methods and procedures to be applied:	At least quarterly and to ensure a 95% confidence level using a calibrated portable gas meter and taking statistically valid number of samples. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing will be carried out adhering to internationally recognised procedures.
Any comment:	

Data #27:	
Data / Parameter:	$\mathbf{T_{comb, e}}$
Data unit:	Fraction/ratio
Description:	Fraction of time gas is combusted in the electricity generation equipment
Source of data to be used:	Calculation from the gas flow rate and the manufacturer's specification for the electricity generation equipment.
Value of data applied for the purpose of calculating expected emission reductions in section B.6	--
Description of measurement methods	Measured using a run time meter connected to a flame detector or flame continuous temperature controller. Data will be archived electronically, minimum

and procedures to be applied:	for two years, after last issuance of CERs.
QA/QC procedures to be applied:	The manufacturer's operation and maintenance procedures for the electricity generation equipment will be followed.
Any comment:	

Data #32:	
Data / Parameter:	$\mathbf{S_a}$
Data unit:	kg/yr
Description:	Amount of sludge applied to land
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	2,397,600. During implementation of the project activity, the actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	Sludge solids (as TSS) will be measured monthly following recognised standard method by in-house laboratory. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing will be carried out adhering to internationally recognised procedures.
Any comment:	

Data #33:	
Data / Parameter:	**NC**
Data unit:	kg N / kg sludge
Description:	Nitrogen content in the sludge used for land application, for estimating N_2O emission in project emission.
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.0365. During implementation of the project activity, actual monitored data will be applied.
Description of measurement methods and procedures to be applied:	NC (as total nitrogen) of sludge solids will be measured monthly following international recognised standard method by MS-ISO 17025 accredited laboratory. Data will be archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Uncertainty level of data is low. Sampling and testing will be carried out adhering to internationally recognised procedures.
Any comment:	

Data #34:	
Data / Parameter:	Regulations and incentives relevant to effluent
Data unit:	--
Description:	
Source of data to be used:	Malaysian Government publications
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Publication of Malaysian Environmental Quality Act & Regulations as of April 2006.
Description of measurement methods and procedures to be applied:	Data will be monitored 100% and archived electronically, minimum for two years, after last issuance of CERs.
QA/QC procedures to be applied:	Quality control for the existence and enforcement of relevant regulations and incentives is beyond bounds of the project activity. Instead, the DOE will verify the evidence collected.
Any comment:	

Data #35:	
Data / Parameter:	Physical leakage of digester tanks
Data unit:	Yes/no
Description:	Detection of physical leakage of digester tanks.
Source of data to be used:	Measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.6	No. During implementation of project activity, any leakage detected during any month will be recorded and the leaks will be sealed with the appropriate sealing material immediately. As a conservative measure, the default physical leakage of 15% will be applied during the month when a leakage is detected.
Description of measurement methods and procedures to be applied:	The upper gas-containing sections of the tank will be monitored monthly by applying standard techniques for leak monitoring to ensure that no leakage takes place in the welding joints. Leakage if detected will be rectified immediately to ensure that the leaked amount will be minimal, and limited to affect not more than one month.
QA/QC procedures to be applied:	Data uncertainty level will be low. The monitoring work will be verified by supervisors-in-charge.
Any comment:	

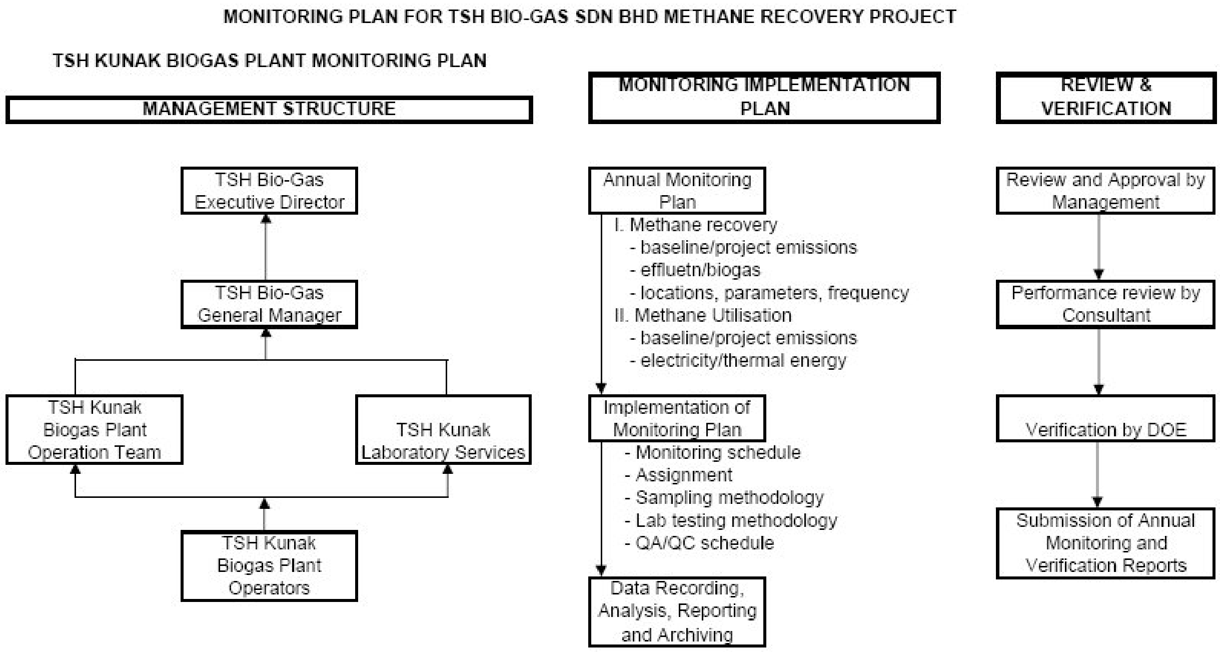
B.7.2 Description of the monitoring plan:

The project developer, TSH Bio-Gas Sdn Bhd, will adopt the monitoring plan as shown in the following figure, for the monitoring of the emission reductions and any leakage effects generated by the project activity.

TSH Bio-Gas Sdn Bhd will form an operational and management team which will be responsible to operate and maintain the biogas plant and implement the monitoring plan. Samples and data are collected by the Operators and submit daily to the Head of Operation Team and the Laboratory. Operational and monitoring data will be submitted weekly to the General Manager of TSH Bio-Gas Sdn Bhd responsible for overseeing the Biogas Plant. Compile data and monthly reports will be submitted to the Executive Director of TSH Bio-Gas Sdn Bhd.

The sampling and data collection activities of the operators, supervised by the Head of the Operation Team and the Laboratory, are guided by Monitoring Implementation Plan established on a annual basis. The plan will specify the scope of monitoring and the planning of implementation, including monitoring schedules, assignment, methodology and QA/QC schedule. The requirements of data recording, analysis, reporting and archiving are identified.

The data and reports from the monitoring team will reviewed and approved by the management on monthly basis. The management may call in regular review of the performance of the monitoring output by external consultant. The monitoring data and reports will be subject to verification by the appointed DOE, according to the schedule as required for the registered CDM project activity. The annual Monitoring Reports and the Verification Reports of the will be submitted as scheduled.



The monitoring implementation plan is targeted to lower the project uncertainties and enhance the confidence of results generated. Detailed procedures covering the following aspects are found in **Annex 4.**

1. Procedures for handling of emergency situations.

2. Procedures for monitoring, measurement and reporting.
3. Procedures for maintenance of biogas plant.
4. Procedures for handling of day-to-day records.
5. Procedures for handling of monitoring data adjustments and data uncertainties.
6. Procedures for review of reported results/data.
7. Procedures for internal audit of GHG project based on operational requirements.
8. Procedures for project performance review.
9. Procedures for corrective actions in order to provide more accurate future monitoring and reporting.

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)

Date of Completion: 19 March 2007 (Version 5)

Persons responsible:

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SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

October 2007 (starting operation).

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

25 years

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

C.2.1. Renewable crediting period

The project entity has chosen the renewable 3 x 7 years crediting period.
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C.2.1.1.Starting date of the first crediting period:

1st October, 2007 or the date of project being registered.

C.2.1.2.Length of the first crediting period:

7 years

C.2.2. Fixed crediting period:

C.2.2.1.Starting date:

n/a

C.2.2.2.Length:

n/a

SECTION D. Environmental impacts

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

The project activity basically involves the replacement of the existing open lagoons for palm oil mill effluent (POME) treatment by the installation of closed tank anaerobic digesters. The biogas produced will be captured and utilised for electricity generation using gas engines. The project activity will contribute to the following environmental improvements:

- Reducing the emissions of methane, a potent greenhouse gas.
- Avoiding the odour in the emissions of biogas from the open lagoons.
- Land area required will be smaller. Some of the open lagoons can be reclaimed.
- The project contributes to renewable energy development is Malaysia. The biogas-generated electricity will displace electricity from the use of fossil fuel generator.

Minor and localised environmental impacts may be expected during project construction. These include increase of a few transport vehicles required to bring in steel plates and beams, cranes for construction, some dust and noise pollution which may arise within the work site from the construction activities. No impact is expected to the vicinity environment and residential area since the project is located at the existing palm oil mill within the oil palm plantation area.

During operational phase of the project activity, environmental impacts are expected to be primarily positive in view of the improvement measures anticipated as an outcome of the project activity which are described above. These include improvement in effluent discharge quality, reductions of air pollutant emissions and saving in land area. The project activity contributes to the various aspects of environmental, socio and economical of sustainability to the community and the country as discussed in this document.

The recovery and utilisation of the biogas contributes to the development of a significant renewable energy source for the country. The biogas is generated through the anaerobic digestion which may be controlled readily. The gas pressure is relatively low and in totally air-free condition (no risk of explosion). The system and the associated power generation equipment pose no risks at any significant level.

No transboundary pollution impacts are expected.

No environmental impact study (EIA) is required by the Malaysian Department of Environment for this project in accordance with the EIA Order 1988 under the Environmental Quality Act 1976 of Malaysia.

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:

Not applicable

SECTION E. Stakeholders' comments

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

The project involves the capture of methane from palm oil mill effluent treatment to be used as renewable fuel for power generation at TSH Oil Palm Mill in Kunak, Tawau, Sabah. A stakeholder's meeting has been conducted to meet the local stakeholders and explain about the project activity and to receive comments, thus fulfilling the application process for the CDM project. The project does not require public participation or stakeholder meetings under existing laws.

The Local Stakeholder's Consultation Meeting was held on 21 November 2006 involving TSH management and staff members and 23 local stakeholders. The stakeholders represented local residents, planters, Tawau Town Board Representatives, the Department of Environment (DoE) official and a non-governmental organisation called Partners of Community Organisations (PACOS). Invitation letters with a description of the project were sent out two weeks earlier to a total of 27 recipients representative of the local community of Kunak and Tawau at various levels, including government agencies and non-governmental organisations. A follow up was done to confirm attendance.

The following is a list of the participants:

No.	*Department/Organisation*	*Representatives*

No.	*Department/Organisation*	*Representatives*
1.	Department of Environment Official	1
2.	Local Town/Village Representatives	18
3.	Partners of Community Organisations (PACOS)	1
4.	Planter Representatives	2
5.	Tawau Town Board Representative	1
	TOTAL	23

The meeting commenced as scheduled at 10.30 am at the TSH Kunak Oil Palm Mill premises in Kunak, Tawau, Sabah. The representative of the project participant, TSH Biogas Sdn Bhd, welcomed the local stakeholders and gave a brief introduction on the project to be implemented at TSH Kunak Oil Palm Mill as a measure to improve on the wastewater management and contribution to sustainable development.

The project consultant followed up by explaining to the stakeholders about the Kyoto Protocol, Annex I countries and their commitment, Article 12 Clean Development Mechanism (CDM), and how it is good for the environment, socially, economically and to the country. Participants were informed of the project descriptions and activities and how the project meets the National CDM Criteria. The following project benefits were high-lighted:

1. Mitigation of the uncontrolled release of methane to the atmosphere from the existing open lagoons for palm oil mill effluent (POME) treatment.
2. Recovery methane and utilized as a renewable fuel of power generation, thus displacing fossil fuel usage.
3. CDM support contributes to feasibility of the project.
4. The project would contribute to improvement in the quality of the treated effluent discharge from the palm oil mill.

E.2. Summary of the comments received:

Listed below is a summary of the comments received from the stakeholders who attended the meeting. The questions/comments were mainly posed on the environmental impacts of the project and how the project could help to create job opportunities in the local area.

No.	*Question*	*From*
1.	Where is the effluent currently stored or treated?	Tawau DoE
2.	How can biogas be used as energy and will there be any emissions of dangerous gases?	Tawau DoE
3.	You said that the project will create employment opportunities. How many skilled and unskilled workers do you need?	PACOS

No.	Question	From
4.	Are there plans to develop a similar project in other areas?	PACOS
5.	Can the anaerobic digester biogas-capture technology be applied to treat municipal solid wastes?	Planter
6.	If so, can this be developed into a CDM project and claimed for the emission reduction credits?	Planter

The participants did not raise any objections to the project and showed general appreciation of the positive environmental and social contributions.

The meeting was adjourned at 11.30am and participants were informed that they could also submit questions and comments on the project to TSH within a week from date of the meeting.

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

The project participant and consultant's response to the comments received from the stakeholders are as follows.

No.	TSH's Response
1.	The effluent is kept in the open ponds for treatment to meet DOE standards for effluent discharge.
2.	Similar to natural gas, the biogas (the main component methane) captured can be used to generate energy. CO2 that is emitted in this process is carbon neutral and does not contribute towards GHG. In this process, the traces of hydrogen sulphide present are also destroyed. There will be no emission of poisonous gases.
3.	During the construction phase, there will be a need for skilled and general workers. We estimate the demand to be between 10 and 15 skilled workers and 20 to 25 unskilled workers. We will also need 15 to 20 skilled and unskilled workers to run the plant. It will be easier to hire locals and we will also provide training for them.
4.	We are considering the same for other TSH plants. But we recognise that the investment is rather high. We hope this project will be a success and that CDM is a proven and sustainable approach, then it could also encourage others to follow suit.
5.	Yes, anaerobic digester for solid waste can be designed for biogas capture. A pre-separation to isolate the organic component of the solid wastes for anaerobic digestion is required to make the process more efficient.
6.	Yes, the project activity which will contribute to significant emission reductions can be claimed under the CDM.

Since there were no adverse comments or objections, there was no need for any change to the project or the project implementation.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funding is provided the project activity.

Annex 3

BASELINE INFORMATION

The following table summarises the data used in the *ex-ante* calculations of baseline emissions:

Table: Baseline information

Parameter	**Data source (*ex ante* figures)**	**Monitoring after project implementation**	**Value used for *ex ante* baseline calculation**
Production capacity palm oil plant	Plant operator	YES	320,000 t/y (2007) 499,500 t/y (2008 – onwards)
Production days	Plant operator	YES	333 days/year
Flow rate of effluent (as generated by production process)	Plant operator, Measurement	YES	294,122 m^3/y (2007) 401,822 m^3/y (2008 – onwards)
COD concentration of influent (digester inlet)	Plant operator, Measurement	YES	55.0 kg/ m^3
COD concentration of effluent discharged to open lagoon after digester and sludge removal	Plant operator, Measurement	YES	2.0 kg/ m^3
Reduction of COD in tank digester	Measurement	YES	85%
Biogas producing capacity (B_o)	Default value as specified in AM0013, based on IPCC default values[10]	--	0.21 kg CH_4/kg COD
Methane conversion factor ($MCF_{baseline,m}$)	Calculated using AM0013 Version 4 formula	--	0.4682 (depth > 5 m) 0.3344 (depth 1-5 m)
Fraction of anaerobic degradation due to lagoon depth (f_d)	AM0013 Version 4	--	0.70 (depth > 5 m) 0.50 (depth 1-5 m)
Average ambient temperature near project site	Department of Malaysian Meteorological Services	--	26.8 °C
CO_2 emission factor for the East Coast Grid of Sabah, Malaysia	Malaysian Energy Centre (Pusat Tenaga Malaysia, PTM)	--	0.80 tCO_2/MWh[11]
Amount of electricity that	Measurement and	YES	16,000 MWh/y

[10] Lowest value provided by IPCC Good Practice guidance, 2000, Page 5.19 was adopted in AM0013, Version 4. However, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 6.21 recommended that: "If no country specific data are available, it is *good practice* to use the IPCC COD-default factor for B_o (0.25 kg CH_4/kg COD)." Pending further guidance, the lagoon baseline emissions will be modified accordingly.

[11] PTM/DANIDA, April 2006. Study on grid connected electricity sector baselines in Malaysia

would be consumed annually at the project site in the absence of the project activity using fossil fuel	calculation		
Global warming potential: CH_4 N_2O	UNFCCC	--	 21 310
Regulations on discharge limits (COD)	Environmental Quality Act, 1974, Malaysia	YES	No regulations controlling on COD in effluent discharge

Annex 4

Monitoring Information

MONITORING IMPLEMENTATION PLAN

1. Introduction

The purpose of the Monitoring Implementation Plan is to provide a documented procedure by which monitoring and verification activity can be conducted on the project activity. The plan will be adhered to for the duration of the project activity. The monitoring implementation plan ensures that accurate and valid monitoring data are obtained for determination of Project's Certified Emission Reductions (CERs), which will be used for periodic verification purpose.

2. Operational and Monitoring Obligations

TSH Bio-Gas Sdn Bhd will fulfil the required operational and data collection obligations so that CERs are calculated in a transparent manner. All data required for baseline and emission reduction emission reduction determination shall be monitored as directed in this PDD.

3. Management and Operational Systems

The following roles and responsibilities, inline with stipulated management structure, will be assigned for ensuring a successful operation of the project:

- Executive Director – financial and policy matters
- General Manager – overall management of the CDM project
- Operation Team to be headed by an Operations Manager – design, training, system establishment and implementation of monitoring plan
- Laboratory services – monitoring and analysis of key parameters with QA/QC built in
- Operators – daily operations including sampling, recording of readings and filing of records.

Internal training will be provided for operational staff to enable them to undertake the tasks required by the Monitoring Implementation Plan. Initial staff training will be provided before project starts operating and generating CERs. Specifically, training will be provided for:

- Operation Team – aspects for overall implementation of monitoring plan including operation and maintenance of the biogas plant.
- Laboratory staff – analysis of key parameters complete with QA/QC protocols
- Operators – daily operations including sampling, recording of readings and filing of records.

Re-training of operational staff and in new areas of operation and monitoring will be provided where necessary.

4. Monitoring and Operational Procedures

The monitoring and operational procedures for the Monitoring Implementation Plan to ensure credibility and verifiability of the CERs achieved are described in the following sections.

4.1 Procedures for handling of emergency situations

The biogas plant has been designed to run continuously for biogas capture and utilisation with minimum chance of emergency situations. However, if emergency situations do occur which can result in biogas supply interruptions, the following procedures will be observed:

- Identify the problem.
- Mobilise the emergency team to tackle the situation on an urgent basis.
- Evaluate all practical alternative solutions.
- Implement the action plan that will alleviate the emergency situation.
- Review of effectiveness of plan.
- Review effects on CERs.
- Implement preventive actions that will prevent similar emergency situations in future.

4.2 Procedures for monitoring, measurement and reporting

The Operations Manager shall ensure that monitoring, measurement and reporting are carried out as required in this PDD. The requirements for data recording, reporting and achieving are identified. The procedures below will be observed:

- All parameters as listed in section B.7 of this PDD will be monitored. The annual monitoring plan shall cover:
  - Methane recovery:
    - Baseline/project emissions
    - Effluent/biogas
    - Locations, parameters and frequency
  - Methane utilisation:
    - Baseline/project emissions
    - Electricity/thermal energy
- The monitoring implementation plan will address the following aspects:
  - Monitoring schedule
  - Assignment of responsibilities
  - Sampling methodology
  - Laboratory analysis methodology

  - QA/QC schedule
- Plant operators are responsible for carrying out day-to-day monitoring and recording of instrument readings as required in this PDD. Specific forms have been designed for this recording.
- Plant operators shall carry out sampling of effluents and laboratory staff shall carry out analysis of parameters required in this PDD. Specific forms have been designed for sampling and analysis records.
- Laboratory personnel shall carry out biogas composition analysis as required. Specific form has been designed for this recording.
- Measures to be implemented for ensuring data quality of all parameters to be monitored are:
  - Use of standard methods of analysis;
  - Frequent calibration of monitoring and analytical equipment;
  - Incorporation of QA/QC protocols in routine analysis;
  - Regular crosscheck of internally monitored parameters with external MS ISO/IEC accredited laboratories; and
  - Regular maintenance of monitoring equipment.

4.3 Procedures for maintenance of biogas plant

The Operations Manager shall ensure that the biogas plant will be maintained in tip-top conditions for continuous operations. Reference shall be made to Biogas Plant Operations Manual and equipment manuals. Specifically, the following procedures will be observed:

- Regular checking and maintenance of all equipment and treatment units. Specific forms for recording of plant status have been incorporated.
- Provide standby equipment wherever appropriate for reducing downtime.
- Close monitoring of required parameters to ensure optimum treatment efficiency is achieved. Specific forms for sampling and monitoring records have been incorporated.

4.4 Procedures for handling of day-to-day records.

The specific procedures for handling day-to-day records are:

- The plant operators shall submit day-to-day records for biogas monitoring to Operations Manager for review so that any unusual conditions can be identified and remedied promptly.
- The monitoring records will be kept secure at the Biogas plant site.
- The Operations Manager shall input monitoring records as electronic achieve on monthly basis while keeping raw data for verification in accordance with CDM requirement.

4.5 Procedures for handling of monitoring data adjustments and data uncertainties.

The specific procedures for handling of monitoring data adjustments and data uncertainties are:

- The monitoring plan shall incorporate QA/QC protocols so as to enhance the confidence of results generated and to reduce the data uncertainties.
- When uncertainties emerge (such as unusual data), the monitoring data shall be subject to immediate checks such as repeat testing or verification with external parties.
- Any departure of monitoring data from those normally observed or previously estimated should be verified. Once verified, the data should be reflected in the reported CERs.
- The Operations Manager will immediately report any CERs data adjustment to the General Manager will in turn report to the Executive Director.

- The monitoring data shall be subject to internal and third party verification.

4.6 Procedures for review of reported results.

The specific procedures for review of reported results are:

- The Operations Manager shall submit the monitoring records to the General Manager for review weekly.
- Based on the monitoring records, the General Manager shall provide the direction for plant operation and monitoring in keeping up with obligations under the project activity.
- The top management shall review and approve reported results on a quarterly basis.

4.7 Procedures for internal audit of GHG project based on operational requirements.

TSH Bio-Gas Sdn Bhd shall, in accordance with a predetermined schedule and procedure, conduct yearly internal audits of the project activities to verify that its operations continue to fulfil the requirements of the PDD. The procedures below are observed:

- The internal audit programme shall address all monitoring and operational requirements.
- The General Manager shall plan and organise audits as required by the schedule and requested by management from time to time.
- Audits shall be carried out by trained and qualified personnel who are independent of the operations and monitoring.
- Audits shall be guided by an audit checklist.
- The internal auditor will report the audit findings to the General Manager.

4.8 Procedures for project performance review

In accordance with a predetermined schedule and procedure, the top management of TSH Bio-Gas Sdn Bhd shall conduct a yearly performance review of the biogas plant operations and monitoring to ensure their continuing suitability and effectiveness, and to introduce necessary changes and improvements in meeting with the obligations under the PDD. The review shall take account of, among others:

- Recent monitoring data.
- Validation and verification reports from DOE.
- Suitability of monitoring procedures and schedule.
- Reports from managerial and operation staff.
- Outcome from recent internal audits.
- Recommendation for improvement in monitoring and operations.

4.9 Procedures for corrective actions in order to provide more accurate future monitoring and reporting.

TSH Bio-Gas Sdn Bhd has established a procedure and designate personnel for implementing corrective actions to provide more accurate future monitoring and reporting. The procedures below are observed.

- Identification of doubtful monitoring data.
- Investigation to determine the root cause(s) of the problem (cause analysis).
- Identification of potential correction actions.
- Selection and implementation of actions that most likely to eliminate the problem and to prevent recurrence.
- Monitor the results to ensure that corrective actions taken have been effective.