UNIVANICH LAMTHAP
POME BIOGAS PROJECT
THAILAND

Prepared by Carbon Bridge Pte Ltd

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

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Title: Univanich Lamthap POME Biogas Project
Version: 006
Date: 08-08-08

A.2. Description of the project activity:

A Biogas project will be undertaken at the Lamthap Factory of Univanich Palm Oil Public Co. Ltd in Krabi Province, Southern Thailand. The project will install a covered inground anaerobic reactor (CIGAR), designed to capture the gases naturally produced from the digestion of organic matter in palm oil mill effluent (POME). This biogas will be used to fuel a 952kW biogas engine to produce electricity to be sold to the Provincial Electricity Authority (PEA) and for use onsite when the existing biomass generator is not operating. Any excess biogas will be consumed in an open flare. Initially one biogas engine will be installed, with an additional two engines installed when the factory and biogas plant is running at higher capacity.

The purpose of the project is to:

- Capture the waste gases and reduce odour currently produced from the factory's deep POME treatment lagoons
- Improve the treatment of the POME
- Use the captured biogas to produce renewable electricity for sale to the national grid and use on-site when the existing biomass generator is not operating
- Sell renewable electricity to the national electricity grid in support of the Thai Government's policy to reduce dependency on fossil fuels
- Reduce greenhouse gas emissions and create Certified Emission Reductions (CERs)

Currently at the factory, all steam needs on site are met from a boiler fired from waste biomass palm fibre and shell. All of the factory electricity needs (around 1MW) are produced from the 1.2 MW biomass steam generator on site. Electricity is purchased from the grid when the onsite biomass generator is not working (for example when the factory is shut down, or if there is a problem with the biomass generator) or if the generator cannot run at full capacity due to a technical problem or the generator cannot supply the full load demand at the factory. The biomass generator will continue to function in the same manner after the biogas plant is installed. Of the remaining waste biomass by products, the empty fruit bunches are disposed in a large deep pit, while the waste shell is disposed, sold and a small amount used as a start up fuel for the biomass boiler. In the future, Univanich is considering technologies for the conversion of the empty fruit bunches to biomass energy.

<u>How the project reduces greenhouse gas emissions</u>
The CIGAR creates an enclosed anaerobic environment which enables bacteria to digest and convert POME organic matter into biogas. The captured biogas will be piped to the first 952kW generator and subsequent generators installed in the future, to produce electricity which will be used onsite and sold to the electricity grid. Any excess biogas will be flared .

The baseline scenario of the project is the continued treatment of POME in deep anaerobic lagoons, which currently emit methane to the atmosphere. The Thai electricity grid currently uses electricity generated from a combination of natural gas, coal, oil, hydro and other sources which combine to be gross emitters of greenhouse gasses.

In the project scenario, methane biogas will be captured and used to fuel an electricity generator, thus reducing emissions of this potent greenhouse gas. The electricity produced from this renewable resource will displace the need for national grid electricity to be produced from fossil fuels like gas, oil and coal.

Contribution to Sustainable Development

Thailand's criteria for sustainable development, as provided by the DNA, focuses on four aspects:

1. Environment and Natural Resources
    - The project will improve the local and global environment, from improving treatment of the factory's POME, to reducing odour and greenhouse gas emissions. The project will not impact on biodiversity and ecosystems (as discussed in Section D), nor will it use additional resources, such as additional water.
2. Social
    - Two thorough consultations have been undertaken with stakeholders, giving full opportunity to ask questions, understand the project and provide feedback on the environmental and social impacts (see Section E). The community was supportive of the project and no objections were raised. The project will comply with Thailand's labour laws. The Univanich company actively supports local community activities.
3. Technology
    - The project will result in technology transfer from overseas. This has been an important feature since the use of CIGAR biogas systems to treat POME in palm oil mills is new to Thailand. Waste Solutions Ltd. a New Zealand firm of consulting engineers which has developed the CIGAR technology, will design, oversee and commission the project, and transfer skills to local workers to operate and maintain the plant.
4. Economic
    - The project will directly create 5 new jobs and thus increase stakeholder incomes. The construction of the project will create employment for local contractors. It will improve human capacity and diversity of employment opportunity, by training project managers, lab technicians and operators.
    - The project will create an indigenous renewable electricity resource and will contribute to the national economy by reducing Thailand's need to import fossil fuels

An Initial Environmental Evaluation (IEA) was carried out and this examines the above issues in more detail.

Table 1 – Sustainable Development Indicators for The Gold Standard

Local/regional/global environment	Score (-2 to 2)
• Water quality and quantity	+1
• Air quality (emissions other than GHGs) Reduction in odour	+1
• Other pollutants (where relevant, toxicity, radioactivity, POPs, ozone depleting gases)	0

• Soil condition (quality and quantity) – use of organic fertilizer of sludge for land application	+1
• Biodiversity (species and habitat conservation)	0
Sub total	+3
Social sustainability and development	
• Employment (including job quality, fulfillment of labour standards)	0
• Livelihood of the poor (including poverty alleviation, distributional equity, and access to essential services)	0
• Access to energy services	0
• Human and institutional capacity (including empowerment, education, involvement, gender)	+1
Sub total	+1
Economic and technological development	
• Employment (numbers)	+1
• Balance of payments (sustainability)	0
• Technological self reliance (including project replicability, hard currency liability, skills development, institutional capacity, technology transfer)	+1
Sub total	+2
TOTAL	+6

A.3. Project participants:

Name of Party involved ((host) indicates a host Party)	Private and/or public entities project participants (as applicable)	Does the Party involved wish to be considered as project participant (Yes/No)
Thailand	• Univanich Palm Oil Public Co. Ltd • Carbon Bridge Pte Ltd	No

Carbon Bridge, who is a project participant, is the contact for this Project Activity.
(See Annex 1 for Contact Details).

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Kingdom of Thailand

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

Krabi Province

A.4.1.3. City/Town/Community etc:

Lamthap District

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

The Project Activity is located at the Univanich Lamthap Factory. The address of the Lamthap factory is 142 Moo 1 Tambol Toongsaitong, Lamthap District, Krabi 81120 Thailand. The following maps give the location of the Factory:

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

Sectoral Scope 13: Waste handling and disposal

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

The Project Activity will employ Waste Solutions Ltd's CIGAR technology, which comprises a uniquely designed lagoon process with mixers, baffles and a thick HDPE cover. The CIGAR contains the organic rich effluent water in an anaerobic lagoon which optimises the contact with anaerobic bacteria to convert the organic matter into biogas. The CIGAR system optimises the mixing process to separate and capture the biogas, which is then collected in pipes, cleaned and stripped of hydrogen sulphide and fed to dedicated biogas engines. In case of any excess build up of biogas the surplus gas will be flared.

The technology and the project process is summarised as follows:

- Effluent collection and reticulation – the POME from the factory will be pumped from the factory, passed through a cooling tower and delivered into a mixing / balancing tank.
- Feed distribution – from the mixing/balancing tank the POME will be pumped into the CIGAR. Waste decanter cake (a fine biomass waste product from the palm oil milling process) will be added, particularly in the low season, to keep the system in balance. This will provide ‘food’ to maintain the bacteria population.
- CIGAR process – the CIGAR is a 46,000 m3 lagoon with a series of inlet pipes, baffles, gas extraction pipes and a thick cover of HDPE sheeting. In the CIGAR the POME follows a series of processes and baffle walls that maximize mixing and contact with the anaerobic bacteria to promote the release of biogas.
- Effluent Discharge or Recycle – the effluent released from the CIGAR is either recycled or sent to a small settling pond where sediment is settled and returned to the CIGAR. The treated waste leaving the treatment system boundary is then pumped to existing water treatment lagoons.
- Sludge, which consists of active bacteria, perished bacteria, and cell debris from the waste water will be collected in the bottom of the CIGAR, and will be either recirculated back to the CIGAR as slurry or removed by pump and used as fertiliser in the company’s nearby oil palm plantations. It is expected to have a good nitrogen content due to the selective nutrient uptake of the bacteria.
- Gas extraction and pumping – the gas will be extracted in a large diameter pipe where it will be stripped of condensation, dust, H_2S and compressed to be sent to the biogas engines.
- Biogas engines – initially one dedicated Guascor biogas engine connected to a generator of 952kW capacity will be imported to produce the electricity. A second genset similar sized genset will be installed in the second year and a third genset around 300kw will be installed in the 6th year when the factory and biogas plant operates at higher capacity.
- An open flare will be installed to consume any excess biogas not used by the gas engine.

The CIGAR biogas technology has been developed by Waste Solutions Ltd (WSL) over 15 years of experience with anaerobic digestion projects. The technology is well proven, having been applied worldwide, and successfully used at some starch and sugar factories in Thailand . The technology has been proven to be safe. In this project the CIGAR will be sited in a sheltered location, and the HDPE cover may be easily drawn down to the liquid surface and covered by water in the event of serious adverse weather. Thus the cover is not at risk to wind conditions and a procedure is in place to manage unusual storm events.

Waste Solutions Ltd., will also oversee the construction and commissioning of the plant. The Univanich management team will co-ordinate the construction, using local suppliers for civil, mechanical, electrical and HDPE works. By constructing the project together with WSL, Univanich’s team will gain an intricate understanding of the plant. After construction, WSL will provide training and operation support and contribute to a SOP (Safe Operating Procedure) manual developed by the Univanich management. Ad hoc review and advice to Univanich operators will be provided by WSL.

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

Year	Annual Estimation of Emission Reductions (t CO_2e)
Year 1 (2008/09)	27,897
Year 2 (2009/10)	30,218
Year 3 (2010/11)	30,245
Year 4 (2011/12)	34,213
Year 5 (2012/13)	45,032
Year 6 (2013/14)	53,668
Year 7 (2014/15)	53,668
Year 8 (2015/16)	53,668
Year 9 (2016/17)	53,944
Year 10 (2017/18)	53,944
Total Estimated Reductions (t CO_2e) **Total Number of Crediting Years**	**436,497** **10**
Annual Average over the Crediting Period of Estimated Reductions (t CO_2e)	**43,650**

A.4.5. Public funding of the project activity:

This project will not receive any public funding from Annex 1 Parties.

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:

Avoided wastewater and on-site energy use emissions in the industrial sector – version04 (AM0022 v4).
Tool to determine project emissions from flaring gases containing methane - version 1.EB28

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

AM0022v4 has been chosen because the proposed project activity consists of the installation of an anaerobic treatment system in an existing open lagoon-based wastewater treatment facility and meets all the applicability conditions. AM0022v4 is the most accurate methodology for wastewater biogas projects, as it includes the actual measured and site specific COD removal rate using a full mass balance approach, rather than applying generic default factors applied in other methodologies.

The project meets the applicability criteria of AM0022v4 as follows:

- The project is implemented in an existing lagoon-based industrial waste water treatment facility for POME with high organic loading;

  There are 10 anaerobic lagoons currently treating the POME. The incoming POME at the Lamthap site has an average COD organic loading of 75,043mg/L.
- The organic wastewater contains organic compounds with a conservative CH_4 emissions factor of 0.21kgCH4/kgCOD;
- The methodology is applied only to the improvement of existing POME treatment facilities. It is not applied to new facilities to be built or new build to extend current site capacity;

  The Lamthap factory was built in 2003/04, with a design capacity of 90 tonnes fruit per hour. The factory has been steadily ramping up processing throughput and will reach full capacity utilisation in 2012.
- The baseline is the continuation of a current lagoon system for managing waste water. In particular, the current lagoon based system is in full compliance with existing rules and regulations;

  The Lamthap Factory is in full compliance with Thai environmental regulations as it does not discharge POME outside the company's property – it is treated in deep anaerobic lagoons and used for irrigation on the company's nearby plantations.
- The depth of the open anaerobic lagoons exceeds 1 metre, in particular loading the waste water is high enough to assure that the lagoon develops an anaerobic bottom layer;

  The depth of the lagoons exceeds 5m.
- The temperature of the POME in the anaerobic lagoons is always at least 15 °C;

  Thailand has a tropical monsoon climate. Monthly temperatures in Krabi Town range between a minimum mean of 23.3 ^oC and a maximum mean of 32.5 ^oC. March is generally the hottest month with a maximum mean of 34.6 ^oC whilst December and January have the coolest temperatures with a minimum mean of 22.2 ^oC.
- The biogas recovered from the anaerobic treatment system is used on-site for power generation, surplus biogas is flared;

  The biogas is used to fuel an initial gas engine with 952kW electricity generator and the surplus biogas will be flared.
- Heat and electricity needs per unit input of the water treatment facility remain largely unchanged before and after the project;

  The balance of energy needs per unit input of the water treatment facility remain largely unchanged. In fact, the project will produce more than sufficient electricity to satisfy the needs of the digester and biogas plant.
- Data requirements as laid out in the related Monitoring Methodology are fulfilled. In particular, organic materials flow into and out of the considered lagoon based treatment system and the contribution of different removal processes can be quantified (measured or estimated).

  The monitoring plan established in AM0022v4 will be implemented onsite, including organic materials flow into and out of the considered lagoon based treatment system and the contribution of different removal processes are quantified.

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

	Source	Gas	Included?	Justification/Explanation
Baseline	CH_4 Emissions from the open lagoon	CO_2	Excluded	Biogenic source, considered carbon-neutral.
		CH_4	Included	Main emission source.
		N_2O	Excluded	Negligible.
	On site CO_2 emissions from fossil fuel displaced by biogas	CO_2	Excluded	Negligible.
		CH_4	Excluded	Negligible.
		N_2O	Excluded	Negligible.
	Grid CO_2 emissions from fossil fuel displaced by biogas	CO_2	Included	Main emission source.
		CH_4	Excluded	Negligible.
		N_2O	Excluded	Negligible.
Project Activity	CH_4 emissions from the open lagoon	CO_2	Excluded	Biogenic source, considered carbon-neutral.
		CH_4	Included	Main emission source.
		N_2O	Excluded	Negligible.
	CH_4 emissions from the new POME treatment facility	CO_2	Excluded	Biogenic source, considered carbon-neutral.
		CH_4	Included	Main emission source.
		N_2O	Excluded	Negligible.
	CH_4 emissions from inefficient combustion and leaks	CO_2	Excluded	Biogenic source, considered carbon-neutral.
		CH_4	Included	Main emission source.
		N_2O	Excluded	Negligible.
	Flare emissions	CO_2	Excluded	Biogenic source, considered carbon-neutral.
		CH_4	Included	Main emission source.
		N_2O	Excluded	Negligible.

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

The most plausible baseline scenario is identified following AM0022v4 methodology, following a procedure which involves several steps, summarized as:

- Step 1 – List a range of potential baseline options
- Step 2 – Select the barriers from the range of potential barriers that can be demonstrated to be significant in the context of the particular project under consideration
- Step 3 – Score the barrier
- Step 4 – Compare, through assessment of the barrier results, which is the most plausible option and determine whether, on balance it can be shown that particular barriers drive a particular baseline option

- Step 5 –Investment Analysis (In situations where more than one baseline option results from the barrier analysis in steps 2 to 4)
- Step 6 – Conclusion – test if the continuation of current practice is the only plausible baseline option.

Step 1: List a range of potential baseline options

The following alternatives are considered as potential baseline scenarios:
Alternative 1: Continuation of the current situation (business as usual)
Alternative 2: The proposed biogas project is undertaken but not as a CDM project activity.
Alternative 3: Installation of new waste water treatment system (aerobic system, activated sludge or filter bed treatment)
Alternative 4: Direct release of POME to a nearby water body

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

The following barriers are expected to be the most significant in the context of the project activity under consideration, and may prevent the implementation of the alternatives considered.

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

Step 3: Score the barriers

Legal barriers

Under Thai regulations, it is illegal to directly discharge waste water into water bodies, as specified in Notification No. 2 of the Thai Ministry of Industry (B.E 2539) which requires effluent discharges into watercourses to have COD not exceeding 120mg/L. The use of open lagoons for the treatment of waste water is allowed, and it is not mandatory to use specific technologies such as biogas digesters or filter beds. Therefore, Alternative 4 cannot be considered the baseline and is now excluded from further barrier assessment. Lamthap Factory is in full compliance under these regulations and therefore faces no barrier for continuation of Alternative 1. To date, there is no existing legislation that enforces anaerobic waste water treatment with coupled biogas collection and utilization. Thus there is no legal barrier to Alternatives 1, 2 or 3.

Technical barriers

Alternative 1, the continuation of the current situation of POME treatment in open anaerobic ponds, is the most common practise of treating palm oil mill effluents in Thailand. This basic technology is available through local equipment suppliers, operated by local staff and presents no uncertainty or perceived risk.

The prevailing practice in Thailand for palm oil mills and around the world, is to dispose and treat the POME in open lagoons. As indicated by a letter from the Chairman of the Palm Oil Crushing Mill Association[1], there are around 33 large palm oil crushing mills in Thailand, and prior to the effective implementation of CDM, it was not common practice for biogas plants to be installed. This is also confirmed from interviews with experts[2] on the Thai palm oil industry, which indicates that palm oil mills

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[1] Chavananand, K. Chairman of Palm Oil Crushing Mill Association, Thailand. July 2007

[2] Interview with Werner Kossmann (Regional Information Service Center for Southeast Asia on Appropriate Technology (RISE-AT), Institute for Science and Technology, Research and Development (IST), Chiang Mai, Thailand), June 5th 2005 (As referenced in the Chumporn PDD, 2007)

in Thailand used open pond systems. There were only 2 small pilot biogas plants in operation, one of which was installed with a government research grant, the other was built because that factory was reported to have a wastewater pollution problem with the existing treatment ponds. Both these projects were based on tank reactors and used modified reconditioned truck engines as generators, a much cheaper alternative to specifically designed (but much more efficient) imported biogas engines.

In contrast, there are technological barriers to the implementation of large biogas and CIGAR electricity projects for POME waste streams. This technology barriers can be characterised as follows:

- Common practice Barrier - CIGAR systems for the recovery of methane from palm oil waste water streams were not available in Thailand. As mentioned on Page 6, the project designers, Waste Solutions Ltd, as international experts on biogas, have used 15 years of international experience to transfer their CIGAR technology to Thailand. They have been involved in CIGAR biogas plants in other agriculture industries in Thailand, however, all of these projects have been implemented with CDM and none of these projects had been in the palm oil industry based on POME.
- Barriers due to lack of skills - Because of the lack of deployment of biogas plants, there is a lack of skilled technicians to build, operate and maintain the technology. Biogas plants require sophisticated operation to manage the complicated biological, gas and electrical components of the project. This requires additional training requirements and it is difficult to find replacement labour from a small pool that have been trained by international experts. This adds to the operating risk of the plant. Already Univanich has had difficulty attracting skilled staff from Bangkok to Southern Thailand.
- Anaerobic Digestion Performance Risks - Biogas and anaerobic digestion plants are not straight 'set and forget' technology – they are biological systems that are 'alive' and require constant monitoring to make sure the system remains in balance. There are multiple variables that affect the performance of the system, such as incoming organic load, temperature, pH/alkalinity and retention time[3]. Changes in these variables can affect the performance of the methanogenic bacteria which in turn can affect the quantity and quality of the biogas necessary for energy production. Problems with biogas plants are often difficult to diagnose, often requiring international experts with understanding of the biological system. It can take significant time to readjust the balance and achieve expected biogas yields.
- POME specific digestion barriers – palm oil mill effluents has specific characteristics that make it more difficult to predict the performance of the systems as POME has high organic COD load and higher concentration of non-biodegradable suspended solids.[4]
- Energy production barriers – the integration of biogas CIGAR systems for commercial energy production is new to Thailand. The first biogas CIGAR system was built at the Khorat Waste to Energy plant as a CDM project and followed by similar plants built by TBEC, all CDM projects. None of these projects were in the palm oil industry or based on POME. As mentioned previously, the first two pilot POME biogas plants, without CDM, used cheap second hand truck engines. Dedicated biogas engines have higher performance but face high upfront costs and must be imported. Dedicated biogas engines are sensitive to the quality of biogas, which is more variable in it's composition than natural gas. This means biogas engines have higher maintenance costs. Biogas engines also have very low tolerance to H2S and require scrubbers which also have performance risks. If the scrubber is not performing well, or has to be decommissioned for service or repair, then the biogas cannot be used to fuel the engines and no electricity revenue can be earned.

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[3] Puetpaiboon, U; Chotwattanasak, J, 2005. *'Anaerobic treatment of palm oil mill wastewater under mesophilic condition'*. Thailand.

[4] Ghazali, A.H, Jusoh,A. and Noor, M.J.M.M; 1989. '*POME treatment utilizing high rate hybrid anaerobic reactor.*' Journal of Islamic Academy of Sciences 2:1, 13-16, Malaysia.

Aerobic treatment systems, activated sludge or filter bed treatment systems are less common in Thailand, and are virtually unknown in the palm oil industry. They are more common in Europe, America, Australia and Japan for other wastewater treatment options and therefore the technology is more likely to be more available than biogas plants in Thailand. They are not commonly deployed on a commercial scale, and are usually used for environmental compliance and municipal systems. Aerobic systems have high energy and operational costs required to operate the aerators. There would be no reason for the Univanich company to replace the existing open anaerobic ponds with a new system of aerobic treatment, activated sludge or filter bed treatment which would all add cost without any financial or compliance improvements.

Financial barriers

Alternative 1, open anaerobic ponds, is already in use and does not require any additional investment and does not face any financial barrier to continued operation. In comparison to this business as usual, more sophisticated anaerobic digesters or aerobic waste water treatment systems are not commonly used for POME treatment and therefore have higher risk. They require high upfront investments, and entail higher operation and maintenance costs. A research paper[5] on the attractiveness of POME biogas systems for energy production pointed out that the benefits of biogas for electricity production 'are very much reduced …due mainly to the considerably higher capital costs of the equipment …resulting in substantially increased capital charges and depreciation cost'.

Biogas plants based on POME face high commercial risk due to the high technical risks, performance risk and lack of local expertise in Thailand, as summarised below:

- The CIGAR technology has not been proven for POME streams. This presents significant commercial risk that the system will not perform and produce the predicted biogas to earn electricity revenue to pay back the high capital investment cost and ongoing operational costs. While the design COD removal efficiency of the CIGAR is predicted as 80%, research papers for removal efficiencies of other biogas plant designs suggest varying and lower removal efficiencies. Of the two pilot POME biogas plants installed in Thailand based on tank systems, research results show lower removal efficiencies of 64% and 75%[6]. Additional revenue stream through the sale of the CERs was seen as crucial to the investors to help alleviate this performance risk.
- Even with the potential to earn electricity revenue alone from biogas plants, a recent palm oil energy report by published UNDP[7] demonstrates the reluctance to invest - 'Whilst the concept of biomass based combined heat and power generation for sale to the grid or other consumers is well accepted, lack of experience and a number of barriers have hindered its development. Key barriers to the development of generation include … a belief that investors view the generation and sale of electricity as marginal to the core business of the industry … and financing of projects based on renewable energy technologies is an unfamiliar investment and perceived as high risk'.
- Univanich had no plans to install a biogas systems at their Factories because the existing wastewater treatment systems fulfill all regulatory requirements. With the high level of interest in CDM projects in Thailand, Univanich was approached by carbon companies seeking to develop biogas projects at the Univanich sites. Thus the idea to develop the biogas plants themselves was established. The most significant barrier in the decision to proceed with the project was the commercial risk, mainly in the performance risk of the system – in delivering the expected biogas quality and quantity to

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[5] Yeoh, B.G, 2004. *'A Technical and Economic Analysis of Heat and Power Generation from Biomethanation of Palm Oil Mill Effluent'*. Electricity Supply Industry in Transition: Issues and Prospects for Asia 14-16 January 2004. Malaysia.

[6] Asian Palm Oil Mill biogas plant was studied to show 64% removals cited in Puetpaiboon, U; Chotwattanasak, J, 2005. *'Anaerobic treatment of palm oil mill wastewater under mesophilic condition'*. P3; Thailand; while removal efficiencies for Thachana biogas plant was studied by Waste Solutions to be 75% (confidential document available to DoE).

[7] United Nations Development Program, '*Generating Renewable Energy from Palm Oil Wastes'*, August 2007, downloaded at http://www.energyandenvironment.undp.org/undp/index.cfm?module=Library&page=Document&DocumentID=6451

generate the returns to pay back the high investment cost of the system and cover the higher operational costs and risk. As mentioned previously, there were very few examples in Thailand of successfully operating biogas to electricity production plants to build confidence in the performance of the system. Of the two pilot POME systems, the efficiencies of the systems were much lower than the design basis expected for the Lamthap CIGAR[8]. This meant it was difficult to have confidence in the viability of the project without CDM support.

- Univanich faced further investment risk by fluctuations in the Thai Baht[9], a significant barrier as equipment necessary for the biogas plant needed to be imported, including the biogas engines, instruments and HDPE liners.

This commercial risk and financial barriers are demonstrated by the fact that biogas plants at palm oil plants and most agriculture plants were very rare in Thailand prior to the introduction of the CDM, despite the fact that these project could earn revenue or make savings from electricity production. It is clear that the CDM has alleviated this commercial risk and tipped the balance to proceed and break from the prevailing practice of open anaerobic lagoons.

Social barriers
Alternative 1 (Open anaerobic ponds) is the common practice in the palm oil industry and does not face any social barrier. The understanding of anaerobic digesters and aerobic waste water treatment systems is comparatively lower in Thailand, however wide social acceptance is being achieved through the CDM public consultative meetings and site visits. The social barriers would arguably be overcome through public awareness raising and demonstration projects.

Business culture barriers
Alternative 1 (open anaerobic ponds) does not face any business culture barriers and is commonly implemented. In contrast, because of the associated technical and financial risks, combined with lower understanding of newer technologies and the absence of legal incentives, shareholders are more reluctant to invest in anaerobic digesters and aerobic waste water treatment systems. For Univanich, at the time of their decision to proceed with the Lamthap project, there was no experience in applying CIGAR POME technology in Thailand, and only 6 CIGAR systems in other industries, such as cassava (built with CDM). This made it difficult for Univanich to have confidence in the starch CIGAR technology in it's performance with POME waste. Univanich Shareholders were only convinced about the viability of the proposed project through the combined estimate of electricity and CDM revenues. The estimate of combined revenue streams helped to mitigate the risk perceived in investing high upfront capital in otherwise unproven and unfamiliar technology.

[8] As cited previously in Footnote 7.
[9] In 2006/07/08 there was significant fluctuation of the Thai Baht due to political instability with the Military Coup in September 2006, an interim government in 2007 and referendum on changing the Constitution in December 2007. This has been compounded by international financial credit crisis In 2007/08 In December 2006, when the project commenced, the Thai Baht was 36.17 to the USD; in August 2006 it was 37.4. In January 2008, when Univanich were ordering their monitoring equipment, the Thai Baht was 31.5 to the USD (downloaded at www.xe.com). This represents 15% swing and significant risk to pricing and budgeting for imported equipment.

Barrier Test Framework

Barrier Tested	**Business as usual**	**Biogas without CDM**	**New sludge or filter bed system**	**Direct release**
Legal				
▪ Does the practice violate any host country laws or regulations or is it not in compliance with them?	N	N	N	Y
Technical				
▪ Is this technology option currently difficult to purchase through local equipment suppliers?	N	Y	Y/N	NA
▪ Are skills and labour to operationalize and maintain this technology in country insufficient?	N	Y	Y/N	NA
▪ Is this technology outside common practice in similar industries in the country?	N	Y	Y/N	NA
▪ Is performance certainty not guaranteed within tolerance limits?	N	Y	Y/N	NA
▪ Is there real, or perceived, technology risk associated with the technology?	N	Y	Y	NA
Financial				
▪ Is the technology intervention financially less attractive in comparison to other technologies (taking into account potential subsidies, soft loans or tax windows available)?	N	Y/N	Y	NA
▪ Is equity participation difficult to find locally?	N	Y/N	Y/N	NA
▪ Is equity participation difficult to find internationally?	N	Y/N	Y/N	NA
▪ Are site owners/ project beneficiaries carrying any risk?	N	Y	Y	NA
▪ Is technology currency (country) denomination a risk?	N	Y	Y	NA
▪ Is the proposed project exposed to commercial risk?	N	Y	Y	NA
Social				
▪ Is the understanding of the technology low in the host country/industry considered?	N	Y/N	Y/N	NA
Business Culture				
▪ Is there a reluctance to change to alternative management practices in the absence of regulation?	N	Y/N	Y/N	NA

Key – Y: barrier exists; N: barrier does not exist; Y/N barrier exists but could be overcome.
NA: question is not relevant.

Step 4: Compare which is the most plausible baseline option

Alternative 1, continuation of the current situation, of open anaerobic ponds, does not face any significant barrier. Alternative 2, the implementation of the proposed CIGAR anaerobic digestion system without CDM faces significant technical, financial and business culture barriers. Alternative 3, the construction of a new system of aerobic waste water treatment, also face technical, financial and business culture barriers and would bring no perceived benefits to the company or the environment and would not be considered by the Univanich shareholders.

For Alternative 2, it can be seen that implementing the biogas plant without CDM is not a plausible baseline as the CDM assistance is fundamental to the successful acceptance and implementation of this project for the following reasons:

- The barrier analysis outlined the significant performance, operational and technology risks associated with biogas projects. It outlined the performance risk of the CIGAR systems' ability to generate the predicted quality and quantity of biogas and showed that the CIGAR design basis are higher than the limited operating pilot POME biogas projects in Thailand. It also outlined the issues associated with the biogas engines, which are sensitive to the quality and quantity of biogas and may not always be able to operate and/or produce the expected output. If the project is unable to operate the biogas engines, or if the CIGAR performance has reduced biogas and hence electricity revenue, the project will at least get some revenue from the emission reduction from destruction of methane. This gave the investors more confidence about investing the high capital cost of the project. The ongoing revenue stream from CDM can help support the higher operational, maintenance costs of the project, particularly when there is reduced electricity revenue. It also helps alleviate the cost of risks employing and keeping trained staff to operate the plant, and to bring in international experts if required to diagnose problems and rehabilitate the process when operational problems occur.
- The lack of evidence supporting the performance of the CIGAR biogas technology, due to it's recent and unproven introduction to the palm oil industry, was one of the largest barriers to acceptance of the project by Univanich management. The electricity revenue generation alone was not perceived to be sufficient to overcome these risks - the separate and additional revenue streams helped mitigate the risk that the investment may suffer loss as a result of lower than predicted performance, or equipment failure in the CIGAR or biogas engines.
- Proof of the need for the CDM to cover these commercial risks are demonstrated by the fact that other than two small pilot plants, there were no biogas investments at palm oil factories in Thailand prior to the introduction of the CDM. It is clear that the CDM has given confidence to investors to develop innovative biogas projects – it has tipped the balance to break from the prevailing practice of open anaerobic lagoons. The international CDM framework whereby details of all biogas projects being developed worldwide is freely available, also gives confidence to the investors that the technology is being adopted in other regions.
- The CDM has created a critical interest in biogas at palm oil and other agricultural plants in Thailand which means that the biogas technology is now more readily available. Now, Thai Suppliers have established relationships with international equipment manufactures to provide the wide range of materials required to build and service the equipment, such as the biogas engines and measurement instruments. With more of the technology deployed, there is also improved experience in installing, servicing and supporting these technologies. Therefore, without CDM in Thailand, this critical mass did not and would not have occurred, and Alternative 2 would have faced insurmountable barriers.

Therefore it is clear that Alternative 2 is not a plausible baseline scenario and Alternative 1, being continuation of the current situation, is considered to be the most plausible baseline scenario.

Step 5: Investment analysis

This step is not required as there is only one baseline option.

Step 6: Conclusion

In summary, the business as usual continuation of the current open lagoon waste water treatment, is the established and least costly solution, which complies with all legal requirements and does not face technical or investment barriers. It therefore constitutes the baseline scenario in the absence of the CDM project activity.

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):

As argued in the previous section and following AM0022, the proposed project is additional as the baseline is the continuation of current practices. In the absence of the project activity, effluent from the palm oil mill would continue to be treated by the existing open lagoon system, resulting in the release of methane into the atmosphere.

In addition, evidence of serious consideration of CDM prior to the start date of the project has been provided to the DoE. The start date 'point of no return' for the project was the start of excavation for the CIGAR on the 6th January 2007. Evidence of this start date has been provided to the DoE, see Section C.1.1. On the 14th December 2006 the Managing Director of Univanich confirmed their intention to appoint Carbon Bridge as CDM consultant to co-ordinate the validation and Registration of the Lamthap Project. This was following a proposal submitted by Carbon Bridge on 8th December 2006 at the request of Univanich. Documentation for this has been provided to the DoE.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

Project Emissions

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

$$E_{project} = E_{CH4\_lagoons} + E_{CH4\_NAWTF} + E_{CH4\_IC+Leaks} \quad \textbf{(1)}$$

Where:
$E_{project}$ are the Total Project Emissions (tCO_2e)
$E_{CH4\_lagoons}$ are the fugitive methane emissions from lagoons from equations 2 (tCO_2e)
E_{CH4_NAWTF} are the fugitive methane emissions from the new anaerobic waste water treatment facility (tCO_2e)
$E_{CH4\_IC+leaks}$ are the methane emissions from inefficient combustion and leaks (tCO_2e)

Fugitive methane emissions from lagoons

$$E_{CH4\_lagoons} = M_{lagoon\_anaerobic} \cdot EF_{CH4} \cdot GWP_{CH4} / 1000 \quad \textbf{(2)}$$

Where:

$E_{CH4\ lagoons}$ is the methane emissions from the lagoons (tCO_2e)

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

EF_{CH4} is the methane emission factor (kg CH_4 / kg COD). A default COD to Methane conversion factor of 0.21kg CH_4/kgCOD is used.

GWP_{CH4} is the Global Warming Potential of methane (GWP_{CH4} = 21)

Amount of organic material removed by anaerobic processes in the lagoon system

$$M_{lagoon\_anaerobic} = M_{lagoon\_total} - M_{lagoon\_aerobic} - M_{lagoon\_chemical\_ox} - M_{lagoon\_deposition} \quad \textbf{(3)}$$

Where:

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

$M_{lagoon\_aerobic}$ is the amount of organic material degraded aerobically in the lagoon system (kg COD). Surface aerobic losses of organic material in pond based systems equal to 254 kg COD per hectare of pond surface area and per day is assumed to be lost through aerobic processes.

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

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

A sensitivity analysis should be carried out for the surface aerobic losses of organic material to assess its applicability under individual project situations.
Deposition, total removal as well as chemical oxidation are project specific factors that must be quantified on a project by project basis. For deposition, Annex 3 outlines one method for determining sedimentation, with the first task to determine whether the pond dynamics are such that sedimentation would occur or if the wastewater contains materials that are likely to sediment. For the Lamthap factory, there do not appear to be significant signs of sedimentation. In the years since the factory started operation, the Univanich team have never needed to desludge any of their lagoons. This is because the Lamthap factory has a decanter which removes sediments from the POME resulting in the waste known as decanter cake. This is currently dumped in an open pit onsite.

In order to assess the amount of COD actually entering the anaerobic system (the lagoons) the amount of COD removed as a result of the new waste water treatment facility must be determined. This is set out in Equation 4
Project Organic Material Entering Lagoon System from New Anaerobic Water Treatment System is:

Amount of organic material removed in the lagoon system

$$M_{lagoon\_input} = M_{input\_total} \cdot (1 - R_{NAWTF}) \quad \textbf{(4)}$$

Where:

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

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

R_{NAWTF} is the total organic material removal efficiency of the new project water treatment facility (-).

Amount of organic material degraded aerobically in the lagoon system

The amount of organic material degraded aerobically in the lagoon system is calculated as the product of the default value for surface aerobic losses of organic material in the pond based system (254 kg COD/ha/day) and of the total surface area of the lagoons.

Following the methodology, a sensitivity analysis is conducted in order to determine the effect of change in the surface aerobic loss of COD on emission reductions. The table below shows that this factor has no material effect on emission reductions (as the changes affect both Baseline emissions and Project emissions). Thus, the risk of inaccuracy in this value is low and the default value of 254 kg COD/ha/day is appropriate.

Sensitivity analysis for surface aerobic losses of organic material

Surface Aerobic Losses	Error Factor Applied	Project Emissions from Lagoon	Sensitivity	Baseline Emissions from Lagoon	Sensitivity	Emission Reductions	Sensitivity
(kg COD/ha/day)	%	(tCO2e)	%	(tCO2e)		(tCO2e)	%
191	-10	7805	-3.6%	35702	-0.8%	27897	0.0%
254	0	7522	0.0%	35419	0.0%	27897	0.0%
279	10	7408	1.5%	35306	-0.8%	27897	0.0%
330	30	7182	4.7%	35079	-0.9%	27897	0.0%
508	100	6390	17.7%	34287	-1.0%	27897	0.0%

Amount of organic material lost through chemical oxidation in the lagoon system

The production process does not use any oxidative chemical compounds. However, low levels of H2S are found in the gases which indicate that there is some natural presence of sulfates in the palm oil residues. The amount of COD removed through the reduction of the sulfates is assumed to be 1% of COD (organic matter) entering the system. This assumption will be monitored and verified exposte.

Total material removed in the lagoon system

$$M_{lagoon\_total} = M_{lagoon\_input} \cdot R_{lagoon} \qquad \textbf{(5)}$$

Where:

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

R_{lagoon} is the total organic material removal ratio of the lagoon (-) and is equal to the proportion of organic material removed (through all routes) within the boundaries of the lagoon system under consideration.

Amount of organic material lost through deposition in the lagoon system

Material deposition in the lagoon system is:

$$M_{lagoon\_deposition} = M_{lagoon\_input} \cdot R_{deposition} \qquad \textbf{(6)}$$

Where:

$R_{deposition}$ is the organic material deposition ratio of the lagoon. It is equal to the proportion of organic material physically sedimented in lagoons within the project boundaries.

Methane emissions from new anaerobic waste water treatment facility

Methane emissions from the specific anaerobic waste water treatment facility that is implemented with the project, are assessed and estimated based on measurements, technology supplier data and expert estimates. They may be neglected if documented evidence for their insignificance is given.

Methane emissions from inefficient combustion emissions

Methane emissions from inefficient combustion from biogas flaring and biogas use for on site electricity generation are quantified through equation 7.

$$E_{CH4\_IC+Leaks} = (\sum_{r} V_r \cdot C_{CH4\_r} \cdot (1 - f_r) \cdot GWP_{CH4}) + PE_{flare} \qquad \textbf{(7)}$$

Where:

the sum is made over two routes *r* for methane destruction (heating and power generation), of which only power generation is relevant for the project activity

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

C_{CH4} is the methane concentration in biogas (tCH_4/Nm^3) to be measured on wet basis.

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

PE_{flare} are the project emissions from flaring of the residual gas stream (tCO_2e) calculated following the procedures described in the *“Tool to determine project emissions from flaring gases containing Methane”*. PE_{flare} can be calculated on an annual basis or for the required period of time using this tool.

Methane emissions from leaks in biogas system

Leaks in the biogas system include leaks from any anaerobic digester and leaks from the biogas pipeline delivery system. In addition, the amount of biogas leaking from the biogas delivery system (pipeline) will be calculated. Since these pipelines are short (i.e, less than 2km, and for on site delivery only) there will be limited leakage where high quality materials are utilised in construction. Tests will be carried out annually to determine how much biogas (and finally methane) leaks.

<u>Baseline Emissions</u>

Total estimated baseline emissions are the sum of fugitive methane emissions from the existing lagoon-based water treatment system and CO_2 emissions from the generation of heat on site and/or of power on and off site.

$$E_{BL} = E_{CH4\_lagoons\_BL} + E_{CO2\_heat\_BL} + E_{CO2\_power\_BL} \quad \textbf{(8)}$$

Where:
E_{BL} are the Total Baseline Emissions (tCO_2e)
$E_{CH4\_lagoons\_BL}$ are the fugitive methane emissions from lagoons in the baseline case (tCO_2e). They are calculated with baseline data based on equation 2 in the section on project emissions.
$E_{CO2\_heat+powers\_BL}$ are the CO_2 emissions from on site fossil heat and/or power generation in the baseline case (tCO_2) that are displaced by generation based on biogas collected in the anaerobic treatment facility.
$E_{CO2\_grid\_BL}$ are the CO_2 emissions related to electricity supplied by the grid in the baseline case (tCO_2) that are displaced by generation based on biogas collected in the anaerobic treatment facility.

On site heat generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility

The proposed project does not generate any heat for on or off site use.

On site and/or off site grid power generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility

For displaced electricity generated off site different quantification processes for carbon emission factors (CEF) may be applied. Since the project will have sub 15MW of installed capacity the small scale procedures for sub 15MW electricity generation for export to a grid, as set out by the CDM Executive Board, may be applied (under 1D, Renewable Energy Projects for a Grid). Under AMS I.D, Option a) is chosen and the CEF is calculated as per ACM0002 version 06, and the OM and BM are calculated ex-ante.

$$E_{CO2\_power} = EL \cdot CEF \quad \textbf{(10)}$$

Where:
EL is the amount of electricity displaced by the electricity generated from the biogas collected from the anaerobic treatment facility.
CEF is the carbon emission factor for the electricity displaced by the electricity generated from the biogas. If in the baseline situation only one source of power is used (onsite production or grid), then the corresponding carbon emission factor is applied. If the two sources are used in the baseline situation, the lowest among (i) carbon emission factor of the grid as discussed above (tCO2e/MWh) and (ii) carbon emission factor of the on site electricity generation equipment displaced (tCO2e/MWh) is used. In the case of the proposed project, the carbon emission factor of the Thai national grid is lower than that of the on site diesel and is thus applied.

Fugitive methane emissions from lagoons

In the baseline case, without the new anaerobic treatment facility, no material is degraded from the waste water before entering the lagoon system and all the organic material to be treated enters the lagoon system. Equation (4) in the project case has to be changed for the baseline into:

$$M_{lagoon\_input\_BL} = M_{input\_total} \quad (11)$$

Where:

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

M_{input_total} is the total amount of organic material fed into the baseline water treatment facility (kg COD). It is the same amount as fed into the project water treatment facility.

All emission factors, surface aerobic losses of organic material, aerobic degradation, deposition or removal as well as chemical oxidation are determined in the same way as described for the project scenario in the section on project emissions above.

Leakage

According to the methodology, leakage is considered to be negligible.

Emission Reductions

Emission reductions, ER (t CO2e) are calculated as the difference between baseline (equation 8) and project (equation 1) emissions (see equation 12 below). Leakage is considered to be negligible.

$$ER = E_{BL} - E_{project} \quad \textbf{(12)}$$

Following the methodology, it will be verified that this equation delivers a conservative estimate of emission reductions i.e. that the emissions of CH_4 from the lagoons in the baseline situation are not higher than the total emissions of biogas from the digester and the lagoons in the project situation. Therefore calculate:

$$E_{CH4\_lagoon\_BL} - \left(E_{CH4\,lagoon} + E_{CH4\_nawtf} + E_{CH4\_coll}\right) \quad \textbf{(13)}$$

Where:

*E*CH4_coll is the amount of methane expressed in (tCO_2e) contained in the biogas collected from the anaerobic treatment facility (i.e. the biogas sent to the generators and the biogas sent to the flare).

A positive difference is to be deducted from the result obtained through equation (12) in order to obtain the final estimation of the emissions reductions.

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

Data / Parameter:	**EFCH4**
Data unit:	kg CH4/ kg COD
Description:	Methane emission factor
Source of data used:	AM 0022v4

Value applied:	0.21
Justification of the choice of data or description of measurement methods and procedures actually applied :	Based on research conducted on palm oil mill effluent for one year (Yacob et al, 2005) which showed the average removals to be 0.232 kg CH_4/kg POME COD loaded. However to be conservative, the lowest documented value for EF_{CH4} was used, and 1 standard deviation was subtracted from the average, which gives 0.21 kg CH_4/kg COD.
Any comment:	

Data / Parameter:	**R_{lagoon}**
Data unit:	%
Description:	Total organic material removal ratio of the lagoon
Source of data used:	Measured by the project developer, with COD samples taken over 2006/2007, included peak and low production seasons.
Value applied:	97% in Years 1-3; 86% in Years 4-10.
Justification of the choice of data or description of measurement methods and procedures actually applied :	Estimated by the project developer using historical COD for POME entering and leaving the open lagoon treatment system. R_{lagoon} for Years 4.-10 is adjusted by an uncertainty factor of 0.89 to account for higher POME throughput in the lagoon systems for these years.
Any comment:	Please refer to Request for Deviation and EB Guidance http://cdm.unfccc.int/UserManagement/FileStorage/AM_CLAR_2FIOGWB9Y1PPWE6MO8CMQWJBGOR9X6

Data / Parameter:	**Rdeposition**
Data unit:	%
Description:	Organic material deposition ratio
Source of data used:	Yacob et al, 2006
Value applied	5% of measured incoming COD
Justification of the choice of data or description of measurement methods and procedures actually applied :	The Sedimentation Appendix 3 in AM22v4 states 'The first task will be to determine whether the waste water contains material that is likely to sediment, and assess whether the pond dynamics are such that such sedimentation will occur': 1. At the Lamthap Mill, the waste water does not contain material likely to sediment – this is because the Lamthap milling process includes a decanter (not centrifuge) which removes 'decanter cake' that is the material in POME that usually sediments. At Lamthap, the decanter cake (which looks like ground coffee) is separated and disposed in a large deep pit. 2. The team then checked the pond dynamics to confirm this and held discussions with the Site Managers - the lagoons (especially the first lagoon) has never once been desludged or filled with sediment, demonstrating that sedimentation is unlikely. This is different to the Univanich TOPI Mill which did not have a decanter and has been desludged over time.

	Therefore, the team did not proceed to onsite sedimentation test, as the first step of the sedimentation methodology was cleared. (Note ACM14v2 which has replaced AM22, now makes this sedimentation tests mandatory). However, because this is a Gold Standard project which asks to follow conservative factors, we still applied a deposition ratio of COD, based on literature research of removals in other POME lagoons in Malaysia. Research conducted (Yacob et al, 2006) and published in reputable journal, showed sedimentation would be low at around 4-5% in the POME project that was tested for 1 year.
Any comment:	

Data / Parameter:	Surface Oxidation Rate
Data unit:	kg COD/hectare
Description:	the amount of organic material degraded aerobically in the lagoon system (kg COD)
Source of data used:	AM0022v4
Value applied:	254
Justification of the choice of data or description of measurement methods and procedures actually applied :	Further details of this figure are explained extensively in Appendix 1 of AM0022v4.
Any comment:	Refer to Sensitivity Analysis in B.6.1

Data / Parameter:	**CEF**
Data unit:	tCO_2/MWh
Description:	Carbon emission factor for the electricity displaced by the electricity generated using biogas
Source of data used:	See Appendix 3.
Value applied:	0.5098
Justification of the choice of data or description of measurement methods and procedures actually applied :	The electricity produced by the project will offset electricity from the Thailand National electricity grid.
Any comment:	Explanation of the CEF calculation is outlined in Appendix 3.

Data / Parameter:	**Flare combustion efficiency** $\eta_{flare,h}$
Data unit:	%
Description:	Default factor to determine flare emissions
Source of data to be used:	*"Tool to determine project emissions from flaring gases containing Methane" December 2006*

Value applied:	50
Justification of the choice of data or description of measurement methods and procedures actually applied :	This is the default factor for an open flare as per the "*Tool to determine project emissions from flaring gases containing Methane*"
Any comment:	The mass flowrate and mass fraction of methane of the biogas entering the flare will be monitored and using the default factor, the project emissions from the flare will be calculated. • The flare efficiency in the hour *h* ($\eta flare,h$) is 0% if the flame is not detected for more than 20 minutes during the hour *h.* • 50%, if the flare is detected for more than 20 minutes during the hour *h*.

Data / Parameter:	*Methane density at standard conditions*
Data unit:	Kg CH4 / Nm3 biogas
Description:	Density of methane at standard temperature and pressure
Source of data to be used:	*"Tool to determine project emissions from flaring gases containing Methane" December 2006*
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.716 kgCH4/Nm3
Description of measurement methods and procedures to be applied:	N/A
QA/QC procedures to be applied:	N/A
Any comment:	

B.6.3 Ex-ante calculation of emission reductions:

Project Emissions

$$E_{project} = E_{CH4\_lagoons} + E_{CH4\_NAWTF} + E_{CH4\_IC+Leaks} \quad \textbf{(1)}$$

= 5775 + 0 + 1747
= 7522 tCO_2

Fugitive methane emissions from lagoons

$$E_{CH4\_lagoons} = M_{lagoon\_anaerobic} \cdot EF_{CH4} \cdot GWP_{CH4} / 1000 \quad \textbf{(2)}$$

= 1309537* 0.21 * 21 /1000

= 5775 tCO_2

Amount of organic material removed by anaerobic processes in the lagoon system

$$M_{lagoon\_anaerobic} = M_{lagoon\_total} - M_{lagoon\_aerobic} - M_{lagoon\_chemical\_ox} - M_{lagoon\_deposition} \quad \textbf{(3)}$$

= 1669421– 256621 – 17211 – 86053
= 1309537 kg COD

Amount of organic material removed in the lagoon system

$$M_{lagoon\_input} = M_{input\_total} \cdot (1 - R_{NAWTF}) \quad \textbf{(4)}$$

= 8605263* (1-0.80)
= 1721053 kgCOD

Amount of organic material degraded aerobically in the lagoon system

M lagoon aerobic
= 254 * 2.76* 365
=256621kgCOD

Amount of organic material lost through chemical oxidation in the lagoon system

Mlagoon_chemical_ox = M_{lagoon_input} x $R_{oxidation}$

= 1% x 1721053 kgCOD
= 17211 kg COD

Total material removed in the lagoon system

$$M_{lagoon\_total} = M_{lagoon\_input} \cdot R_{lagoon} \quad \textbf{(5)}$$

= 1721053 * 0.97
= 1669421 kgCOD

Material deposition in the lagoon system

$$M_{lagoon\_deposition} = M_{lagoon\_input} \cdot R_{deposition} \quad \textbf{(6)}$$

= 1721053 * 0.05
= 86053 kgCOD

Methane emissions from new anaerobic waste water treatment facility

Methane emissions from the CIGAR are expected to be zero for this project, as the CIGAR will be operating under sub atmospheric pressure. Therefore it is likely that air would be drawn in as opposed to biogas escaping out. Leaks in the biogas pipeline system are also expected to be zero for this project, however this will be monitored as per AM0022v4. At Lamthap, all the pipes will be new and high quality materials and significantly less than 2km (around 200m).

Methane emissions from inefficient combustion emissions

$$E_{CH4\_IC+Leaks} = (\sum_r V_r \cdot C_{CH4\_r} \cdot (1-f_r) \cdot GWP_{CH4}) + PE_{flare} \quad \textbf{(7)}$$

= 3635724 * 0.6 * 0.000716 * (1-0.98) * 21 + 1090
= 1747 tCO_2

<u>Baseline Emissions</u>

$$E_{BL} = E_{CH4\_lagoons\_BL} + E_{C02\_heat\_BL} + E_{CO2\_power\_BL} \quad \textbf{(8)}$$

= 32892 + 0 + 2527
= 35419 tCO_2

Fugitive methane emissions from lagoons

$$E_{CH4\_lagoons\_BL} = M_{lagoon\_anaerobic\_BL} \cdot EF_{CH4} \cdot GWP_{CH4} / 1000$$

= 7458475* 0.21 * 21 /1000
= 32892 tCO_2

Amount of organic material removed by anaerobic processes in the lagoon system

$$M_{lagoon\_anaerobic\_BL} = M_{lagoon\_tatal\_BL} - M_{lagoon\_aerobic\_BL} - M_{lagoon\_chemical\_ox\_BL} - M_{lagoon\_deposition\_BL}$$

= 8223784 – 256621 – 84781– 423906
= 7458475 tCO_2

Amount of organic material removed in the lagoon system

$$M_{lagoon\_total\_BL} = M_{lagoon\_input\_BL} \times R_{lagoon}$$

= 8478127* 0.97
= 8223784kgCOD

Amount of organic material lost through chemical oxidation in the lagoon system

Mlagoon_chemical_ox = $M_{lagoon\_input\_BL}$ x $R_{oxidation}$
= 1% x 8478127 kgCOD
= 84781kgCOD

Material deposition in the lagoon system

$$M_{lagoon\_depositionl\_BL} = M_{lagoon\_input\_BL} \cdot R_{deposition}$$

= 8478127 * 0.05
= 423906 kgCOD

Amount of organic material degraded aerobically in the lagoon system

M lagoon aerobic
= 254 * 2.77 * 365
= 256621 kgCOD

On site and/or off site grid power generation emissions displaced by generation based on biogas collected in the anaerobic treatment facility

$$E_{CO2\_power} = EL \cdot CEF \quad \textbf{(10)}$$

= 4957 * 0.5098
= 2527 tCO_2

Leakage

According to the methodology, leakage is considered to be negligible.

Emission Reductions

$$ER = E_{BL} - E_{project} \quad \textbf{(12)}$$

=35419 - 7522= 27897 tCO_2

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

Year	Baseline Emissions (t CO_2e)	Project Emissions (t CO_2e)	Annual Estimation of Emission Reductions (t CO_2e)
Year 1 (2008/09)	35,419	7,522	27,897
Year 2 (2009/10)	36,730	6,512	30,218
Year 3 (2010/11)	36,764	6,519	30,245
Year 4 (2011/12)	41,716	7,503	34,213
Year 5 (2012/13)	55,249	10,218	45,032
Year 6 (2013/14)	66,422	12,754	53,668
Year 7 (2014/15)	66,422	12,754	53,668
Year 8 (2015/16)	66,422	12,754	53,668

Year 9 (2016/17)	66,422	12,478	53,944
Year 10 (2017/18)	66,422	12,478	53,944
Total Estimated Reductions (t CO2e)			**436,497**
Total Number of Crediting Years			**10**
Annual Average over the Crediting Period of Estimated Reductions (t CO_2e)			**43,650**

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

B.7.1 Data and parameters monitored:

1.Data / Parameter:	POME flows entering system boundary
Data unit:	m^3 / year
Description:	POME flows entering system boundary
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	110,350
Description of measurement methods and procedures to be applied:	Flow rates will be measured continuously with magnetic flow meters and the cumulative flow rate logged in the meter. A weekly backup reading will be logged on paper and transferred to spreadsheet. Kobold, a German brand has been selected, which has a stated accuracy of +/-0.3% of measured reading.
QA/QC procedures to be applied:	Flow meters will factory calibrated and a calibration certificate issued. The meter will be serviced and checked annually by the Supplier, including verification that the meter is reading correctly. The meters will be checked monthly to ensure they are operating, with random audit checks by the Audit manager.
Any comment:	POME wastewater volume will increase as the factory reaches full production – annual wastewater volumes are contained in Annex 3.

2a. Data / Parameter:	POME flows leaving project treatment facility
Data unit:	m^3 / year
Description:	POME flows leaving project treatment facility
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	110,350
Description of	Flow rates will be measured continuously with magnetic flow meters. A German

measurement methods and procedures to be applied:	brand, Kobold, has been selected, which has a stated accuracy of +/-0.3% of measured reading. The final pipe leading to the existing lagoons is gravity fed and not under pressure. As flow rate accuracy for non-pressurised pipes is much lower, the flow meter will be located in the section of the pipe under pressure. As such, the volume of wastewater recycled back to the CIGAR will also be measured with a magnetic flow meter, and this volume will be subtracted, as per 2b below.
QA/QC procedures to be applied:	Flow meters will factory calibrated and a calibration certificate issued. The meter will be serviced and checked annually by the Supplier, including verification that the meter is reading correctly. The meters will be checked monthly to ensure they are operating, with random audit checks by the Audit manager.
Any comment:	

2b. Data / Parameter:	POME flows leaving project treatment facility, and being recycled back to CIGAR
Data unit:	m^3 / year
Description:	POME flows leaving project treatment facility and being recycle back to CIGAR.
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	Some of the wastewater will be recycled back to the CIGAR. As this will be accounted for in the flow rate leaving the project treatment facility, this must be subtracted from the total flows leaving the project treatment facility. Flow rates will be measured continuously with magnetic flow meters. A German brand, Kobold, has been selected, which has a stated accuracy of +/-0.3% of measured reading.
QA/QC procedures to be applied:	Flow meters will factory calibrated and a calibration certificate issued. The meter will be serviced and checked annually by the Supplier, including verification that the meter is reading correctly. The meters will be checked monthly to ensure they are operating, with random audit checks by the Audit manager.
Any comment:	

3. Data / Parameter:	POME organic material concentration entering the project boundary
Data unit:	kg COD/m^3
Description:	POME organic material concentration entering the project boundary
Source of data to be used:	Sampled by project developer
Value of data applied for the purpose of calculating expected emission reductions in	75.043

section B.5	
Description of measurement methods and procedures to be applied:	Daily sampling of the untreated process effluent will be conducted on site. Initially, the daily samples will be sent to an accredited laboratory until the equipment and training for operating COD testing equipment is fully operational and sufficient level of accuracy can be maintained with the on site testing procedure.
QA/QC procedures to be applied:	COD concentration will be analysed by an accredited laboratory on a weekly basis.
Any comment:	

4. Data / Parameter:	POME organic material concentration leaving the treatment facility
Data unit:	kg COD/m^3
Description:	POME organic material concentration leaving the treatment facility
Source of data to be used:	Sampled by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	15
Description of measurement methods and procedures to be applied:	Daily sampling of the treated POME will be conducted on site. Initially, the daily samples will be sent to an accredited laboratory until the equipment and training for operating COD testing equipment is fully operational and sufficient level of accuracy can be maintained with the on site testing procedure.
QA/QC procedures to be applied:	COD concentration will be analysed by an accredited laboratory.
Any comment:	

5. Data / Parameter:	Electricity generated from the biogas collected in the anaerobic treatment facility and consumed on site or sent the grid, less any electricity consumed by the biogas plant (5.b)
Data unit:	MWh
Description:	Electricity generated from the biogas collected in the anaerobic treatment facility and consumed on site or sent the grid
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	4957 MWh/year (5,325MWh output–368MWh from biogas plant use see 5b.)
Description of measurement methods and procedures to be	Measured continuously using electricity meters The Biogas Technician will log the meter reading on paper every month and transfer the amount to the electronic spreadsheet.

applied:	
QA/QC procedures to be applied:	Meters will undergo maintenance and calibration according to appropriate industry standards.
Any comment:	The amount of electricity that will displace electricity from the grid is minimal. Therefore, rather than using 3 years historical data, a reasonable estimate of the amount of electricity produced by the renewable electricity generator was used, deducting the amount of electricity consumed by the CIGAR and assuming a conservative capacity factor of 85%.

5b. Data / Parameter:	Electricity used to operate the biogas plant
Data unit:	MWh
Description:	Electricity used to operate the biogas plant.
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	368 MWh/year
Description of measurement methods and procedures to be applied:	Measured continuously using electricity meters, The Biogas Technician will log the meter readings on paper every month and transfer the amount to the electronic spreadsheet.
QA/QC procedures to be applied:	Meters will undergo maintenance and calibration according to appropriate industry standards.
Any comment:	Based on a load of 70kW (the load to operate the plant is expected to be 35kW, however it has been doubled to be conservative), however the actual load will be monitored as above. This MWh amount will be deducted from the total electricity produced by the biogas plant.

6a. Data / Parameter:	Surplus biogas sent to flare
Data unit:	Nm^3 biogas
Description:	Surplus biogas sent to flare
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	242382
Description of measurement methods and procedures to be applied:	Flow rates will be measured continuously with German technology (Kobold) Oscillator flow meters. These meters are more sturdy and reliable for biogas, which tends to be less clean and higher moisture levels than natural gas, for which most gas flow meters are designed to measure. The flow rate readings will be adjusted for temperature and pressure, which will be monitored at the same point. These oscillator meters have an accuracy of 1.5% of measured volume.

QA/QC procedures to be applied:	Flow meters will factory calibrated and a calibration certificate issued. The meter will be serviced and checked annually by the Supplier, including verification that the meter is reading correctly. The meters will be checked monthly to ensure they are operating, with random audit checks by the Audit manager.
Any comment:	

6b. Data / Parameter: (repeated for flare tool)	FVRG,h. Volumetric flow rate of the residual gas in dry basis at normal (NTP) conditions in the hour *h*
Data unit:	m 3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h . Normalised to take into account pressure and temperature. To calculate project emissions from flare.
Source of data:	Measurements by project participants using a flow meter
Measurement procedures:	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 (fvi,h) when the residual gas temperature exceeds 60 ºC
Monitoring frequency:	Flow rates will be measured continuously with German technology (Kobold) Oscillator flow meters. These meters are more sturdy and reliable for biogas, which tends to be less clean and higher moisture levels than natural gas, for which most gas flow meters are designed to measure. The flow rate readings will be adjusted for temperature and pressure, which will be monitored at the same point. These oscillator meters have an accuracy of 1.5% of measured volume.
QA/QC procedures	The flow meter will undergo maintenance according to the manufacturers standards. Flow meters will calibrated at the time of installation and will undergo maintenance and calibration at least once per year, co-ordinated by the Biogas Supervisor, and audited every 6 months by the Internal Audit Manager.
Any comment:	Also used to monitor flowrate according to Manufacturers Specification where biogas flowrate should be below 650m3/hour.

7. Data / Parameter:	Biogas sent to generator sets and used for electricity generation
Data unit:	Nm^3 biogas
Description:	Biogas sent to generator sets and used for electricity generation
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	3635724
Description of measurement methods and procedures to be applied:	Flow rates will be measured continuously with German technology (Kobold) Oscillator flow meters. These meters are more sturdy and reliable for biogas, which tends to be less clean and higher moisture levels than natural gas, for which most gas flow meters are designed to measure. The flow rate readings will be adjusted for temperature and pressure, which will be monitored at the same

	point. These oscillator meters have an accuracy of 1.5% of measured volume.
QA/QC procedures to be applied:	Flow meters will factory calibrated and a calibration certificate issued. The meter will be serviced and checked annually by the Supplier, including verification that the meter is reading correctly. The meters will be checked monthly to ensure they are operating, with random audit checks by the Audit manager.
Any comment:	

8. Data / Parameter:	Biogas methane concentration
Data unit:	%
Description:	Biogas methane concentration
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	60
Description of measurement methods and procedures to be applied:	Measured continuously on wet basis by near infrared spectrometry. Most gas analyzer brands have an accuracy of 2-3%.
QA/QC procedures to be applied:	The spectrometer will undergo maintenance according to the manufacturers standards. It will be calibrated at the time of installation. Quarterly calibration of methane concentration will be conducted, checking against a reference bottle of known methane concentration or other appropriate way to cross check the result. Calibration checks will be conducted every six months.
Any comment:	

9. Data / Parameter:	Project emissions from flaring of the residual gas stream
Data unit:	tCO_2
Description:	Project emissions from flaring of the residual gas stream
Source of data to be used:	Measured/Calculated
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1090
Description of measurement methods and procedures to be applied:	The parameters used for determining the project emissions from flaring of the residual gas stream (PEflare) should be monitored as per the “Tool to determine project emissions from flaring gases containing Methane”.
QA/QC procedures to be applied:	
Any comment:	

10. Data / Parameter:	Amount of chemical oxidising agents entering system boundary

Data unit:	mg/L
Description:	Measurement of the presence of sulfates in the POME
Source of data to be used:	Sampled by project developer and sent to the laboratory for testing
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1% of incoming COD
Description of measurement methods and procedures to be applied:	Quarterly samples of POME will be tested for the volume of sulphates.
QA/QC procedures to be applied:	An accredited laboratory will be used for testing, as in the test of the COD.
Any comment:	The production process does not use any oxidative chemical compounds. However, low levels of H2S are found in the gases which indicate that there is some natural presence of sulfur in the palm oil residues, which may occur from sulfates, or from proteins which are not oxidative and would not result in removal of COD. The amount of COD removed through the reduction of the sulfates is assumed to be 1% of COD (organic matter) entering the system. This assumption will be monitored and verified exposte, by testing the amount of sulfates in the wastewater and using the stochiometric equation to determine the volume of COD lost.

11. Data / Parameter:	Gen set combustion efficiency
Data unit:	%
Description:	Gen set combustion efficiency
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	98
Description of measurement methods and procedures to be applied:	Generation set combustion efficiency will be determined and tested annually as part of regular maintenance.
QA/QC procedures to be applied:	The Biogas supervisor is responsible for co-ordinating this process. This test will be conducted through an independent service to determine combustion efficiency.
Any comment:	

12.Data / Parameter:	Flow of POME directly to the current water treatment system, and bypassing the new POME treatment facility
Data unit:	m^3
Description:	Flow of POME directly to the current water treatment system, and bypassing the

	new POME treatment facility
Source of data to be used:	Measured by developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	Bypass flow is measured by an electromagnetic flow meter. A flow meter is the same or more accurate than a level sensor, and therefore has been proposed. The bypass is not expected to be used except in emergency situations. Therefore volumes of wastewater measured are expected to be low or zero. A German brand, Kobold, has been selected, which has a stated accuracy of +/-0.3% of measured reading.
QA/QC procedures to be applied:	The flow meter will calibrated at the time of installation and will undergo maintenance and calibration at least once per year, co-ordinated by the Biogas Supervisor, and audited every 6 months by the Internal Audit Manager.
Any comment:	

13. Data / Parameter:	Loss of biogas from pipeline
Data unit:	%
Description:	Loss of biogas from pipeline
Source of data to be used:	
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	Integrity of biogas pipeline for losses of biogas methane will be tested annually through a process of pressurizing the system and establishing pressure drops through leakage.
QA/QC procedures to be applied:	The process will be conducted annually by the Biogas Supervisor and overseen by the Factories Manager.
Any comment:	

14. Data / Parameter:	Organic material removed from POME facility
Data unit:	tCOD
Description:	Organic material removed from POME facility
Source of data to be used:	Measured by project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of	Removals of COD after monitoring and prior to entry to the lagoon system will

measurement methods and procedures to be applied:	recorded to ensure CH_4 emissions are not overestimated. This may be material screened out after the POME concentration is recorded.
QA/QC procedures to be applied:	The Biogas Supervisor is responsible for ensuring that the COD measure has been taken by the Biogas Plant Technicians at the correct location and after any screenings have been removed. The Internal Audit manager will be responsible for random checks on the whole process.
Any comment:	COD test will be carried out after any screening of the POME, therefore this value is expected to be zero.

15.Data / Parameter:	Other flare operation parameters – Flame detector
Data unit:	
Description:	Detection unit
Source of data:	Measured by project developer
Measurement procedures:	The data logger will be linked up to an alarm. If the flame goes out, the Biogas Powerplant Technicians will immediately attend and re-ignite the flame. If the flame is not re-ignited within 20mins, then the emission from that hour will not be included.
Monitoring frequency:	Continuously.
QA/QC procedures	The detector will be checked on a quarterly basis to ensure that it is operational and functioning correctly.
Any comment:	As per *Tool to determine project emissions from flaring gases containing Methane*". Used to demonstrate that the flare is operational (e.g. through a flame detection system reporting electronically on continuous basis)). If the flare is not operational for more than 20mins the default value to be adopted for flare efficiency is 0%.

16.Data / Parameter:	Other flare operation parameters – pressure of biogas sent to flares
Data unit:	mBar
Description:	Pressure gauge
Source of data:	Measured by project developer
Measurement procedures:	The pressure of the system is expected to be well between 10mBar - 100mBar, which is the operational conditions of the flare specified by the manufacturer. This will be tested and confirmed quarterly.
Monitoring frequency:	Quarterly.
QA/QC procedures	The gauge will be calibrated before use.

Any comment:	As per Tool to determine project emissions from flaring gases containing Methane". Used to demonstrate that the flare complies with manufactures specification of pressure supplied between 10-100 mBar

17.Data / Parameter:	**Proportion of methane emitted from covered lagoon**
Data unit:	m^3 biogas leaked / m^3 biogas produced
Description:	Proportion of methane emitted from covered lagoon
Source of data:	Measured by project developer
Measurement procedures:	Using portable gas meter around perimeter of covered lagoon to identify any leaks.
Monitoring frequency:	Daily
QA/QC procedures	Portable gas meter will be calibrated monthly. Daily recordings will be logged and maintenance engineer notified immediately to rectify any leaks. Date and time repair will be logged.
Any comment:	

B.7.2 Description of the monitoring plan:

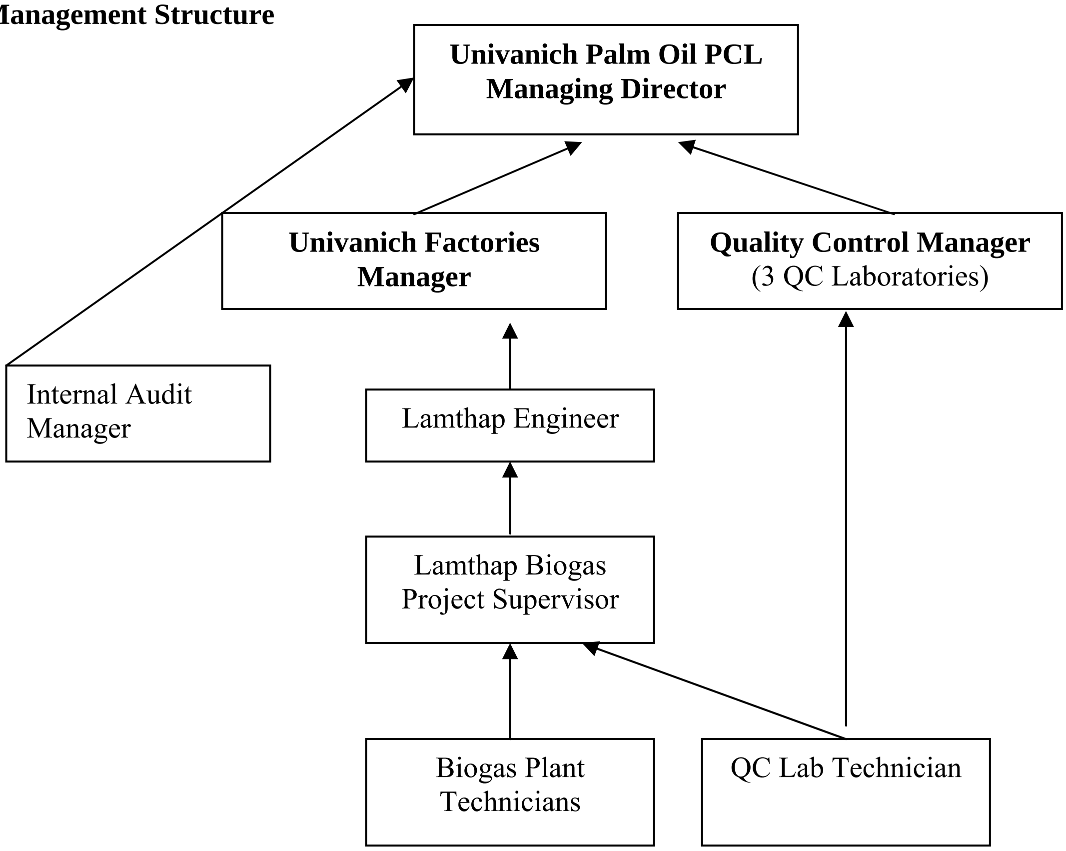
The Monitoring Plan ensures that parameters for both project and baseline scenario emissions are monitored. The main elements, to be monitored as per AM0022v4[10], include:

- Fugitive methane, through the assessment of organic material flows through the project and the baseline system;
- Electricity generated from the biogas collected in the anaerobic treatment facility and consumed on site or sent to the grid;
- On-site heat generated from the biogas collected in the anaerobic treatment facility;
- Inefficient biogas combustion emissions in project: emissions arising though inefficient destruction of biogas in electricity generation sets will be quantified through assessing the efficiency of biogas destruction during equipment O&M cycles; the parameters used for determining the project emissions from flaring of the residual gas stream (PE_{flare}) will be monitored as per the "Tool to determine project emissions from flaring gases containing Methane".
- Biogas leakage in project: through leaks in the pipeline during transportation of biogas, or its production in anaerobic digesters.

[10] Note, AM 0022 specifically stresses the importance to quantify (measured or estimated) the organic material flowing into and out of anaerobic systems; and contribution of different removal processes – in this case, this can include the sludge removed from the CIGAR and dried aerobically and sent for land application as an organic fertilizer high in nitrogen.

In the Appendices, Table 1 outlines the parameters, recording frequency, type of equipment and how the data will be archived and who will be responsible. Figure 1 outlines the location of each of the monitoring points.

Management Structure



The Lamthap Biogas Project Supervisor is responsible for:

- Overseeing the whole Biogas operation, guiding decision making on process management and changes, liaising with WSL for guidance and resolving equipment, operational and monitoring issues;
- Managing all monitoring data from data logger and entering manual records reported from Biogas Plant engineers; including sending backups of data to Univanich HQ.
- Preparing monthly Operational, Maintenance and Monitoring Report (OMM Report) for Lamthap Biogas Project and submitting to Univanich Factories Manager and Lamthap Engineer.
- Arranging quality control checks with Quality Control Manager, and checking daily on the agreed quality control data collection and filing.
- Co-ordinating and Overseeing annual calibration checks of equipment with equipment suppliers, and recording any biogas losses throughout the project system.

The Lamthap Engineer is responsible for:

- Providing support and guidance to the Biogas Project Supervisor
- Ensuring smooth co-operation between Factory and Biogas operations and staff.
- Ensuring smooth cooperation between the biogas plant and the Provincial Electricity Authority (PEA)

The Biogas Plant Technicians are responsible for

- Maintaining smooth operation of the biogas digester, generator and flares, and ensuring the effective operation of all associated equipment, including the pumps, blowers, valves, pipes and meters.
- Collecting all manual data relating to the CIGAR process, gensets, flares and any biogas pipe losses on daily basis, and maintaining records in a daily log.
- Maintaining daily Operational and Maintenance (O&M) logs. These logs are to provide detailed information on site concerning the operation of the plant. Any event of significance will be reported and recorded in a special incident log.

The QC lab technician is responsible for :

- All laboratory testing to international standards, including COD and oxidation substances.
- Other tests specified by Waste Solutions Ltd for identifying the 'health' of the CIGAR.
- Entering laboratory test data into the daily log, in compliance with electronic filing procedures
- Reporting to the Biogas Project Supervisor on any significant fluctuations and variations identified in the POME.

The Univanich Factories Manager will be responsible for :

- Any external communication – including submitting monthly reports to Carbon Partners and any liaison with Verifying Auditors.
- Negotiating technical issues relating to the connection and supply of electricity from the biogas project to the national grid and PEA.
- Reporting to the Managing Director on the performance of the Lamthap Biogas Project against design parameters for certified reduction of greenhouse gasses, generation of electricity and compliance with statutory environmental protection standards
- Co-ordinating internal audit of data collected and the procedures to ensure they are conducted correctly. Initially, this will be conducted weekly and then on a regular basis, depending on the quality and outcomes of the audit.
- Co-ordinating independent Univanich Audit Staff to conduct an annual audit of the monitoring procedures and data collection.

The Quality Control Manager is responsible for :

- Managing the factory's QC Laboratory to ensure that agreed Quality Control procedures are carried-out on site and reported to the Biogas Project Supervisor and to the Factories Manager.

The Internal Audit Manager is responsible for :

- arranging random checks of the monitoring and reporting system according to the following frequency.
  (i) On receipt of the first OMM Report, and not less than six weeks after commissioning of the project.
  (ii) At six monthly intervals
- Reporting any problems with the monitoring system or with the OMM Report to the Managing Director,

All OMM personnel will be trained technicians, and any additional training required to ensure accurate and effective monitoring will be provided by WSL and Carbon Bridge prior to project commissioning. This training will include CIGAR plant operation, equipment operation, data monitoring and recording (including how to reconcile any adjustments and/or data uncertainties), reporting, calibration, maintenance, emergency procedures, project performance review, and corrective actions. The Biogas Project Supervisor will be trained on the intricacies of the biological and flow process, to be able to remedy operational problems before they seriously affect the performance of the project.

All data will be stored on spreadsheets and backed up electronically on a separate computer. Copies of the collated data will be printed monthly as part of the monthly OMM report. All data will be kept for at least 2 years following the end of the crediting period. Any lost data due to equipment failure will be reconstructed from former and subsequent series measurements up to 6 months after the equipment failed. This is considered reasonable as despite a quality control, maintenance and auditing system in place, instrument failure and delays in replacement may still occur. During this period, additional evidence will be used to demonstrate the continuing of factory operations to avoid suspicion that the data is indeed missing due to instrument failure and not cessation of the production process.

The Biogas Project Supervisor will oversee the annual calibration and/or process to verify the meter reading is accurate in co-operation with the equipment suppliers. Calibration of equipment to required international standards will be performed by the technology provider or by their approved representative prior to sale of equipment. Annual calibration and or service and verification will be part of procurement contracts.

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)

05/03/07

Carbon Bridge Pte Ltd. Carbon Bridge is a Project Participant for the project.

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:

06/01/07.

This is the date excavation started on the CIGAR and is considered the 'point of no return' for the project. The contract with the Civil Earthworks contractor was signed on 4th January 2007. The contract for the Earthworks has been submitted to the DoE, as well as an email from the Managing Director of Univanich to Carbon Bridge informing that excavation started on the 6th January 2007.

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

N/A

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

C.2.1.2. Length of the first crediting period:

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

31/10/08 or date of Registration.

C.2.2.2. Length:

10 years 0 months

SECTION D. Environmental impacts

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

An Initial Environmental Evaluation (IEE) was conducted for the project, considering direct and indirect impacts on the environment, human use and quality of life values. No significant direct or indirect environmental impacts were identified compared to the business as usual operation of the factory.

Of particular biodiversity importance in Southern Thailand is the Andaman Sea coastal lowland forests and the Krabi River estuary which has many surrounding national parks, protected areas, endangered bird species and important tourism locations. Two main potential biodiversity impacts were identified but not considered significant in the Initial Environmental Evaluation. These were: –

1. Accidental spill of POME into the nearby Sinpoon stream.
   The Lamthap Factory is not located in the Krabi River Estuary Catchment. It is 40km west of the Andaman Sea coast and part of the Tapi River catchment, which drains north to the Gulf of Thailand. The Nong Thung Thong National Bird Park and declared non-hunting area receive waters draining from the Sinpoon river – however this National Park is 120km away from the Lamthap Factory and the effect of any accidental release of POME with high organic COD and BOD loading would have been significantly reduced over this distance and time due to aeration mixing and dilution. Nevertheless a spill would have significant biodiversity and livelihood impact on the immediate Sinpoon Stream and River and therefore, as discussed in Sections D.2 & E.3, there are systems in place to avoid such an spill.
2. The clearing of land for palm oil plantations:

   The Lamthap factory was built in 2003/04, with a design processing capacity of 90 tonnes fruit per hour. The factory has been steadily ramping up processing throughput and will reach full capacity utilisation in 2012. Univanich will continue to buy the majority of it's fruit bunch supply from local farmers, who currently sell to Univanich and other Palm Oil Mills in the area. Expansion of land for these small holder farms is either from conversion of land from rubber, or disused rice paddy areas where it is largely no longer economic to farm in southern Thailand.

   This planned expansion is part of the baseline case and the biogas plant will have no impact on the expansion plans of Univanich. The factory has been operating profitably and not marginal – therefore it could not be claimed that the biogas plant and any profits indirectly contributes to the factory expansion plans. Univanich is a publicly listed company and all financial statements are publicly available.

Environmental benefits of the project were highlighted, including:

- Improved air quality through the reduction in biogas production and fugitive emissions of biogas from the existing waste water treatment system
- Improved water quality through the decrease of COD of waste water from the new treatment system
- Reduction in the demand for fossil fuel based grid electricity
- Reduction of greenhouse gas emissions.

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:

The proposed project does not require an Environmental Impact Assessment (EIA) under Thai Law.

No significant environmental concerns were raised during the initial stakeholder consultation, although the importance of ensuring no release of POME to the local Sinpoon Stream was stressed. In the baseline case, Univanich does not release POME outside the company's land, and this will remain in the project case. All POME is held in a series of deep open anaerobic lagoons, where 97% of the COD is removed. The final treated POME is used for irrigation on the company's adjacent oil palm nurseries and plantations. In the project case, the CIGAR will be added in addition to these anaerobic lagoons – therefore the treatment process will be improved. In addition, the CIGAR significantly reduces the time and space required to treat the POME, reducing the spatial impact should an accidental release to the local stream occur. The risk of discharge of POME to the stream is no different under the baseline and project case, except during the construction process of diverting the POME to the new CIGAR. In the unlikely event that this should happen, Univanich have a stormwater management system in place, with perimeter drains that would collect and divert any spilled POME to the stormwater storage system – the stormwater is collected in a sump and pumped to the POME treatment lagoons. Procedures have been developed to ensure that no accidental risk would occur.

The process to assess the project against the Gold Standard EIA Pre-screen checklist did not trigger a need for an EIA to be performed:

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

N/A – no significant impact was identified therefore these do not apply.

SECTION E. Stakeholders' comments

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

The initial stakeholder consultation for the Univanich Lamthap POME Biogas Project was held at the Local Council Building (Or Bor Tor Thong-sai-thong) Lamthap District, Krabi Thailand at 10am on 2nd February 2007.

The Consultation session was structured in a way that stakeholders directly affected by the project as well as the public and non-government representatives were able to provide their input. As an initial consultation, it was designed to occur prior to the development of the CDM project, so that any input and concerns could be factored into the project design. The summary of the consultation report (in Thai) was made available within 15 days for local participants, authorities and other interested parties to read and make any comments. No comments were received.
The process to invite stakeholders was as follows:

- A total of 55 people and organisations were directly invited by letter, including direct neighbours of the factory, policy makers, local government officials, key members of the community and staff working at the factory.
- Public notices were placed in Thai language in the 2 local Newspapers – Krabi Baan Rou and Krabi News. It ran for 1 week. All policy makers, NGOs and interested stakeholders were invited and welcomed to attend or to comment directly.
- A notice was posted at the Univanich Lamthap Factory for staff and the local farmers who enter the factory to sell their fresh fruit bunches.
- A notice was posted at 2 public places – at the Local Council Building (Or Bor Tor Thong-sia-thong) in Lamthap and in Downtown Lamthap. The notices had the same content as the advertisement in the paper.
- The Gold Standard NGO Supporters in Thailand: Director of WWF Thailand and ATA (Alternate Technology Association) were directly invited and asked to comment.
- The Gold Standard Team was invited to attend.

Overall, 56 people attended the initial stakeholder consultation.

A second consultation was held on 3 July 2007 with around 50 people attending. The second meeting had lively discussion and a more relaxed and open atmosphere than the first meeting. Participants seemed to listen more closely, perhaps as the concept seemed less foreign than at the initial consultation. This was helped by including a visit to see the site under construction – as stakeholders could visualise what the project would be like and see the existing unsightly ponds. There were many good questions reflecting an interest to see information about the concept of climate change and biogas spread across the community. No objections were raised about the project, although again, the importance of safety was highlighted. There was an eagerness to see the project successfully completed and replicated across the industry in the region.

E.2. Summary of the comments received:

A range of local policy makers, officials, factory staff, local community members and farmers attended the consultation session. Participants were given full opportunity to ask questions, understand the project and provide feedback on the environmental and social impacts of the projects. Those who did not attend were given full opportunity to comment.

As with other biogas projects, two key priorities arose from stakeholder comments:
- The benefit of reduction in odour and improving POME pollution treatment
- Ensure the safety of the biogas system, particularly to make sure there are no explosions or fire.

No objections were raised about the project, and in fact people were asking when the project would start. Most were supportive of the positive environmental impact it would have in the area, particularly relating to odour.

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

Overall the stakeholder consultation was positive and there was a high level of interest to see the project go ahead successfully. As outlined above, the key factors to take into account were:

1. Ensure the safety of the biogas system, particularly to make sure there are no explosions or fire.
   In the design of the biogas plant, enclosed spaces have specifically been avoided:
   - All pump and blower rooms are open – with only a roof and concrete slab floor which avoids any spaces for concentration of gases.
   - All necessary electric motors (pumps and blowers) will be explosion rated ie they are enclosed to avoid sparking.
   - The risk of explosion at the CIGAR is negligible, as it is open to the atmosphere and methane gas would diffuse.
   - The generator room is equipped with forced ventilation. As per the biogas engine manufacturers safety specifications, the building has brick walls and concrete ceiling.
   - Adequate fire and safety equipment are available onsite. Fire hazard at the CIGAR is considered low, but possible if, for example, there is gas leaking and it is exposed to a flame, such as a worker smoking. The fire would smoulder and put itself out as there is insufficient oxygen to continue burning. This has happened before at another site in Thailand and little damage occurred.

2. Ensuring no POME enters the local stream

As mentioned above, Univanich do not release POME outside the company's land, and this will remain in the project case. The CIGAR significantly reduces the time and space required to treat the POME, reducing the spatial impact should an accidental release to the local stream occur. As mentioned in Section D2, the risk of discharge of POME to the stream is no different under the baseline and project case, except during the construction process of diverting the POME to the new CIGAR. Procedures have been devised to ensure that no accidental risk would occur. Nevertheless, Univanich have a stormwater management system in place, with perimeter drains that would collect and divert any spilled POME to the stormwater storage system – the stormwater is collected in a sump and pumped to the POME treatment lagoons.

Annex 1
CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

This project will not receive any public funding from Annex 1 Parties.

Annex 3

BASELINE INFORMATION

Baseline Characteristics of Anaerobic Open Lagoons

Surface Area of Anaerobic Ponds		
Ponds 1-6	86x25	m2
Ponds 7-9	150x30	m2
Equalisation pond 1	(16x91)/2	m2
Equalisation pond 2	(16x69)/2	m2
Total Surface Area	27,680	m2
Average CODin to lagoons	76,829	mg/L
Average CODout from lagoons	2,103	mg/L
Average COD removal ratio	97.26%	%

Factory Production	tonne FFB/year	m3 POME /year
Production Year 1	220700	110350
Production Year 2	226100	113050
Production Year 3	226300	113150
Production Year 4	286500	143250
Production Year 5	376600	188300
Production Year 6	451600	225800
Production Year 7	451600	225800
Production Year 8	451600	225800
Production Year 9	451600	225800
Production Year 10	451600	225800

Carbon Emission Factor Calculation

The baseline carbon emission factor (CEF) is calculated as the combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors according to the following three steps:

- Step1: Calculate Operating Margin emission factor (EF_{OM})
- Step2: Calculate Build Margin emission factor (EF_{BM})
- Step3: Calculate Combined Margin and the baseline emission factor CEF

Step1: Operating Margin emission factor (EF_{OM})

The Simple OM method is used because dispatch data is not publicly available in Thailand so the Dispatch Data Analysis based OM method cannot be selected and low-cost/must-run resources (LCMR) in Thailand constitute less than 50% of total grid generation in average of the five most recent years. This can be shown in the following table, which indicates that natural gas, a non-LCMR, constitutes around 70% of the total grid generation, indicating that LCMR constitutes less than 50%.

Natural gas proportion of total grid generation as a non-LCMR based on generation

	2001[1]	2002[1]	2003[1]	2004[1]	2005[2]
Natural Gas (MW/h)	72,168,000	78,819,000	85,533,838	89,939,772	94,584,580
Total Generation (MWh)	102,057,000	109,039,000	116,862,000	125,641,000	132,009,000
Percentage	70.71%	72.29%	73.19%	71.58%	71.65%

1 Study on Electricity Sector Baselines in Thailand, ERM-Siam Co Ltd, December 2005

2 Electrical Power in Thailand 2005, Thailand DEDE, 2005 - http://www.dede.go.th/dede/index.php?id=128

The Simple OM emission factor ($EF_{OM,simple,y}$) is calculated as the generation-weighted average emissions per electricity unit (tCO2/MWh) of all generating sources serving the system, not including low-operating cost and must-run power plants:

$$EF\_OM_y = \frac{\sum_{i,j} F_{i,j,y} * COEF_{i,j}}{\sum_j GEN_{j,y}}$$

Where: $F_{i,j,y}$ is the amount of fuel i (in a mass or volume unit) consumed by relevant power sources j in year(s) y,

j refers to the power sources delivering electricity to the grid, not including low-operating cost and must-run power plants, and including imports to the grid,

$COEFi,j\ y$ is the CO_2 emission coefficient of fuel i (tCO_2 / mass or volume unit of the fuel), taking into account the carbon content of the fuels used by relevant power sources j and the percent oxidation of the fuel in year(s) y, and

$GENj,y$ is the electricity (MWh) delivered to the grid by source j.

The CO_2 emission coefficient $COEFi$ is obtained as

$$COEF_i = NCV_i * EF_{CO2,i} * OXID_i$$

Where: $NCVi$ is the net calorific value (energy content) per mass or volume unit of a fuel i,

$OXIDi$ is the oxidation factor of the fuel

$EF_{CO2,i}$ is the CO_2 emission factor per unit of energy of the fuel i.

(Ex-ante) the full generation-weighted average for the most recent 3 years for which data are available at the time of PDD submission is used to calculate the Simple OM emission factor. 2005 is the most recently available data – as the required data to calculate the CEF is published in the Electrical Power in Thailand reports, produced by the Thailand Department of Alternative Energy Development and Efficiency, of which the most recent publication is for the 2005. Although the Thailand Power Development Plan for 2007 has been published, it does not contain sufficient data on historical power generation and fuel use. In addition, award of contracts to Independent Power Producers (IPPs) and SPPs is available for the year 2007. However, it does not contain all the necessary data to calculate the CEF.

Operating Margin (OM)				
Fuel Type	Generation - MWh	Fuel Consumption	Units	CO_2 Emissions - tCO_2
2003				
Fuel Oil	2,941,000	696	10^6 litres	2,141,503
Diesel Oil	180,000	51	10^6 litres	137,573
Coal & Lignite	16,807,000	15,406	10^3 tonnes	16,323,643
Natural gas	76,332,000	698,132	MMscf	39,948,509
SPP Fuel Oil	57,348			41,758
SPP Imported Coal	1,237,107			1,201,529
SPP Natural Gas	9,201,838			4,815,801
Electricity Imported	2,479,000			0
Total	109,235,293			64,610,316
			$EF_{OM,Simple,2004}$ =	**0.5915**
2004				
Fuel Oil	7,138,000	1,697	10^6 litres	5,221,452
Diesel Oil	551,000	120	10^6 litres	323,701
Coal & Lignite	17,993,000	16,537	10^3 tonnes	17,522,010
Natural gas	80,489,000	724,560	MMscf	41,460,772
SPP Fuel Oil	57,148			41,804
SPP Imported Coal	1,219,464			1,187,543
SPP Natural Gas	9,450,772			4,868,197
Electricity Imported	3,388,000			0
Total	120,286,384			70,625,479
			$EF_{OM,Simple,2005}$ =	**0.5871**
2005				
Fuel Oil	8,244,000	1,996	10^6 litres	6,141,437
Diesel Oil	414,000	83	10^6 litres	223,893
Coal & Lignite	18,334,000	16,537	10^3 tonnes	17,522,010
Natural gas	85,703,000	764,118	MMscf	43,724,360
SPP Fuel Oil	52,581			39,171
SPP Imported Coal	1,339,073			1,279,767
SPP Natural Gas	8,881,580			4,531,246
Electricity Imported	4,419,000			0
Total	127,387,234			73,461,884
			$EF_{OM,Simple,2005}$ =	**0.5767**
Generation-Weighted 3 year average emissions factor for 2003-2005 =				**0.5847**

Step2: Build Margin emission factor (EF_{BM})

The Build margin emissions factor ($EF_{BM,y}$) is calculated as the generation-weighted emissions factor (tCO2/MWh) of a sample of plants, *m,* being the five most recently built or the plants which constitute 20% of the system generation, whichever is the largest annual generation.

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} * COEF_{i,m}}{\sum_{m} GEN_{m,y}}$$

The five most recently built plants in the Thailand power system produce a very small portion of the annual generation, therefore the plants which comprise 20% of the system generation have been sampled. Total grid generation for 2005 was 132,009 GWh and 20% of this system generation is 26,402 GWh. Forty five plants comprise the most recently installed 20%, with the Ratchaburi Thermal Unit 2 being the marginal power plant, and therefore included in the calculation.

The build margin is as follows:

Company	Com Date	Fuel Type	Generation	Efficiency[5]	Fuel	Emissions
			MWh	10^3 Btu/MWh	10^6 units	tCO_2
Combined Cycle Natural Gas						
Ratchaburi Combine Cycle[1]	1/04/2002	Natural Gas	10,102,097	7540	78526	4,493,390
Glow IPP[2]	31/01/2003	Natural Gas	4,646,000	6900	33049	1,891,122
Eastern Power & Electric[2]	25/03/2003	Natural Gas	2,627,000	7003	18966	1,085,264
Bang Pakong	1/01/2005	Natural Gas	728,297	8480	6367	364,331
Thermal Natural Gas						
Ratchaburi Thermal[1]	1/11/2000	Natural Gas	4,312,000	9587	42618	2,438,669
Thermal Fuel Oil						
Karabi Themal[3]	1/01/2004	Fuel Oil	1,145,000	8917	271	833,283
Hydro						
Lamtakhong[3]	1/01/2004	Hydro	484,000	-	-	0
Huai Yamo (Tak)[3]	1/01/2004	Hydro	2,000	-	-	0
SPP						
Various SPP Natural Gas[4]	2001-2005	Natural Gas	1,239,752	-	-	632,503
Various SPP Biomass[4]	2001-2005	Biomass	1,709,479	-	-	0
Total			**26,995,625**			**11,738,561**
Build Margin						**0.4348**

1 Electricity Supply Industry Reform and Thailand Power Pool, EPPO, November 2000 - http://www.eppo.go.th/power/FF-E/pw-reform-1-main-E.html Table 3 (for commissioning dates), and Electrical Power in Thailand 2005, Thailand DEDE, 2005 (for the 2005 electricity generation, separated by date of comissioning and prorated based on installed capacity)
2 Thai IPP, EPPO, May 2007 - http://www.eppo.go.th/power/data/
3 Electrical Power in Thailand 2005, Thailand DEDE, 2005 - http://www.dede.go.th/dede/index.php?id=128
4 Thai SPP, EPPO, May 2007 - http://www.eppo.go.th/power/data/A20:N37
5 Electrical Power in Thailand 2005, Thailand DEDE, 2005 - http://www.dede.go.th/dede/index.php?id=128

Step3: Calculate the combined margin and the baseline emission factor CEF

The baseline emission factor *EF* is calculated as the weighted average of the Operating Margin emission factor (EF_{OM}) and the Build Margin emission factor (EF_{BM}):

$$EF = w_{OM}*EF_{OM} + w_{BM}*EF_{BM}$$

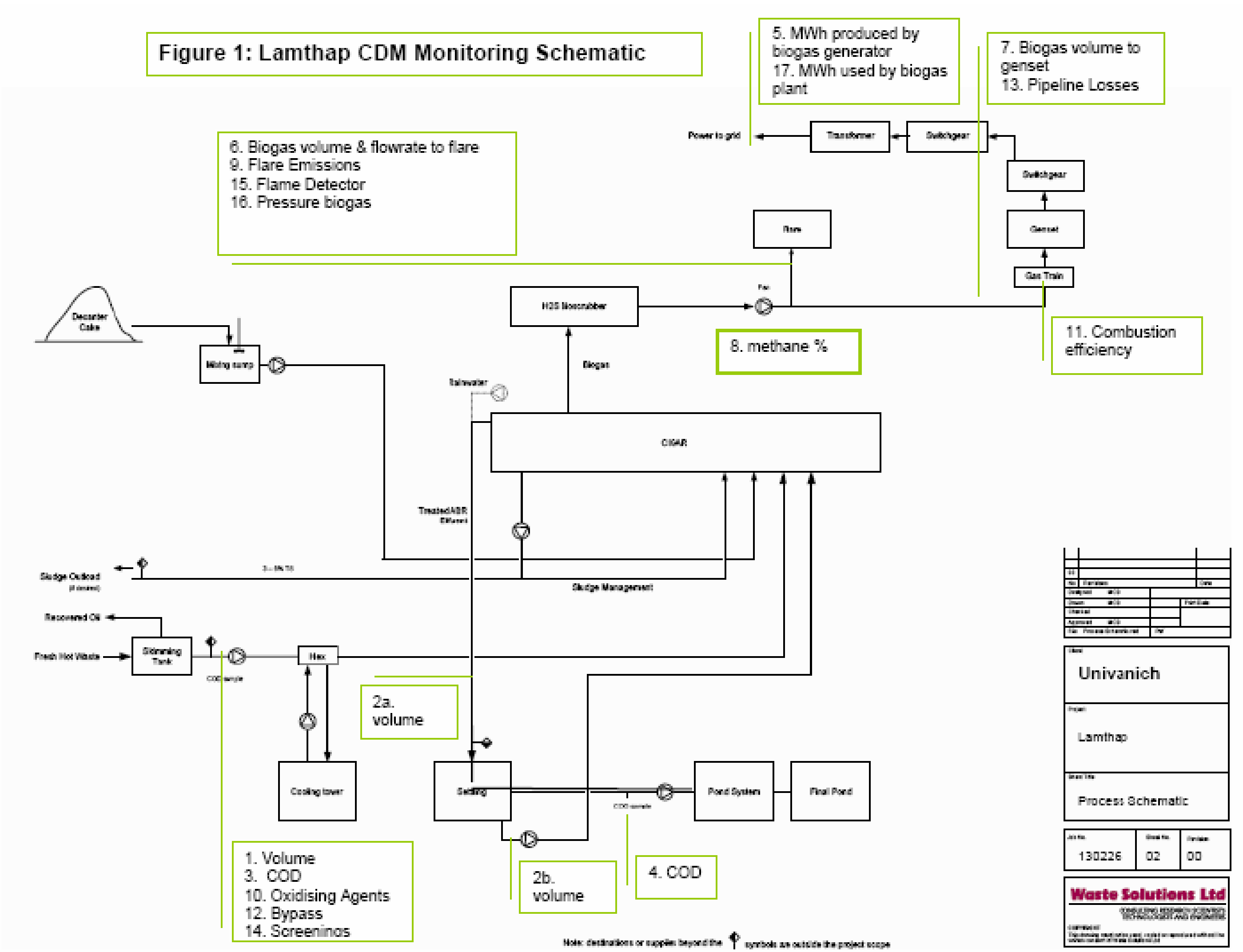
Where the weights w_{OM} and w_{BM}, by default, are 50%

Operating Margin	0.5	0.5847
Build Margin	0.5	0.4348
Baseline Combined Margin Emissions Factor		**0.5098**

All other baseline information is outlined in Section B.6.2.

Annex 4

Figure 1: Lamthap CDM Monitoring Schematic



MONITORING POINTS & INFORMATION TABLE

ID	Data type	Data variable	Data unit	M, C, E*	Recording Frequency	Archiving of data	Comment	Responsibility
1	volume	POME flows entering system boundary.	m3	M	Continuously. With a weekly manual log of the meter reading to back up and transferred to spreadsheet.	Electronic.	Flow meters will be calibrated at least once per year.	Biogas Technicians
2a	volume	POME flows leaving project treatment facility.	m3	M	Continuously, With a weekly manual log of the meter reading to back up and transferred to spreadsheet.	Electronic	The final flow rate will subtract the volume of POME sent back for recycling to calculate the net total volume leaving the treatment facility.	Biogas Technicians
2b	Volume	POME flows sent back for recycling	M3	M	Continuously. With a weekly manual log of the meter reading to back up and transferred to spreadsheet.	Electronic	This will be subtracted from 2a above, to account for the POME recycled back to the CIGAR.	Biogas Technicians
3	concentration	POME organic material concentration entering the project boundary.	kg COD/ m3	M	Daily	Paper and transferred to electronic	Indicator of baseline POME methane emissions. Organic material concentration will be sampled on site daily, but off-site analysis by an accredited lab will be conducted weekly.	QC Lab Technician

4	concentration	POME organic material concentration leaving the treatment facility.	kg COD/ m3	M	Daily	Paper and transferred to electronic	Indicator of project POME methane emissions. Organic material concentration will be sampled on site daily, but off-site analysis by an accredited lab will be conducted weekly.	QC Lab Technician
5	energy content	Electricity generated from the biogas collected in the anaerobic treatment facility and consumed on site or sent the grid	MWh	M	Continuously. With a weekly manual log of the meter reading to back up and transferred to spreadsheet.	Electronic	Indicates grid electricity displaced. Meter is located at point after electricity is taken off for use in the CIGAR to ensure the auxiliary load is not included in the electricity monitored from this meter.	Biogas Technicians
6a	volume	Biogas sent to flares	Nm3	M	Continuously. Logged and stored on data logger. The data will be copied off the logger weekly and transferred to spreadsheet.	Electronic	Volume in Nm3, normalised to take into account pressure and temperature. To calculate project emissions from flare. 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 when the residual gas temperature exceeds 60 ºC	Biogas Technicians
6b	flowrate	Biogas flowrate sent to flares	m3/h	M	Continuously. Logged and stored on data logger. The data will be copied off the logger weekly and transferred to spreadsheet.	Electronic	Volume in Nm3, normalised to take into account pressure and temperature. To calculate project emissions from flare. Ensure that the same basis (dry or wet) is considered for this measurement and the measurement of volumetric	Biogas Technicians

							fraction of all components in the residual gas when the residual gas temperature exceeds 60 ºC	
7	volume	Biogas sent to gen sets	Nm3	M	Continuously . Logged and stored on data logger. The data will be copied off the logger weekly and transferred to spreadsheet.	Electronic	Volume in Nm3, normalised to take into account pressure and temperature.	Biogas Technicians
8	concentration	Biogas methane concentration	%	M	Continuously. Logged and stored on data logger. The data will be copied off the logger weekly and transferred to spreadsheet.	Electronic	Quarterly calibration of gas meter reading, checked against a reference bottle. Initially monthly calibration checks and if readings consistent switch to quarterly. Measured by infrared spectrometry. To be measured on wet basis. To calculate project emissions from flare. 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 when the residual gas temperature exceeds 60 ºC. Using simplified approach, only measuring CH4	Biogas Technicians
9	mass	Project emissions from flaring of the residual gas stream.	T CO2e	C	Monthly	Electronic	Calculated from ID numbers 6,8 & 15	Biogas Technicians

10	concentration	Amount of chemical oxidising agents entering system boundary.	Tonnes /m3	M	quarterly	Electronic	Samples will be tested for sulfate concentration by accredited lab. Volume is expected to be low.	QC Lab Technician
11	percentage	Gen set combustion efficiency	%	M	During regular O&M cycle (minimum of annually)	Electronic		Equipment Supplier/ Biogas Technicians
12	volume	Flow of POME directly to the current water treatment system, and bypassing the new POME treatment facility	m3	M	Continuously. With a weekly manual log of the meter reading to back up and transferred to spreadsheet.	Electronic	Bypass flow measured by magnetic flow meter	Biogas Technicians
13	percentage	Loss of biogas from pipeline	%	M	Annually	Electronic	Integrity of biogas pipeline for losses of biogas methane will be tested annually through pressurizing the system and establishing pressure drops through leakage.	Biogas Technicians
14	mass	Organic material removed from POME facility	t COD	M	Annually, with monthly confirmation that COD tests are carried out after removals	Electronic	Removals/screenings of COD after monitoring and prior to entry to the lagoon system should be recorded to ensure CH4emissions are not overestimated. This maybe material screened out after the POME concentration is recorded. Ensure COD testing is after screenings.	Biogas Technicians
15	Signal	Flame detector	C	M	Continuously. Monthly integrity checks of the flame detector.	Electronic	Measured to demonstrate that the flare is operational to use 50% default	Biogas Technicians

							efficiency. Measured through a flame detection system (it is specified that this should be electronic, reporting continuously, but we will try for manual). If the flare is not operational the default value to be adopted for flare efficiency is 0%.	
16	Pressure	Pressure Gauge	mBar	M	Continuously. Logged and stored on data logger. The data will be copied off the logger weekly and transferred to spreadsheet.	Electronic	Used to ensure the biogas flare is operating according to the manufacturers specifications range of between 10-100mBar.	Biogas Technicians
17	Energy Content	Electricity used by biogas plant	MWh	M	Logged manually from electricity meter	Electronic	Used to estimate project emissions from electricity use to operate the biogas plant	Biogas Technicians

*** MEASURED (M), CALCULATED (C) OR ESTIMATED (E)**