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:

>>
Chao Khun Agro Biogas Energy Project
19/02/09
Version 04

A.2. Description of the project activity:

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The Chao Khun Agro Biogas Energy Project (hereafter, the Project) developed by Thai Biogas Energy Company Ltd (hereafter referred to as "TBEC, "or the Project Developer) is an anaerobic digestion project, which treats wastewater from the cassava processing factory owned by Chao Khun Agro Products (hereafter referred to as the Facility) in Saraburi, Thailand.

The Covered In-Ground Anaerobic Reactor (CIGAR) will remove the organic material in the wastewater, thus reducing the Chemical Oxygen Demand (COD) and subsequent fugitive CH_4 emissions. Biogas produced in the CIGAR will be used in the Chao Khun Agro Products factory to dry the wet starch cake to the final dry starch product, thereby displacing the fuel oil currently employed to dry the starch product. Surplus biogas, where produced, will be flared rather than released to the atmosphere.

	Baseline Scenario	Project activity
Wastewater Treatment	Wastewater, high in COD, is treated via a lagoon system, producing methane-rich biogas	An Covered In-Ground Anaerobic Reactor-CIGAR- will be used to treat this wastewater, reducing the water's COD prior to release to the current pond system
Industrial Activities	Use of fuel oil to dry wet tapioca starch cake	Use of renewable, sustainably produced biogas in dual fuel burner system to ensure heating energy self-sufficiency

The project is helping the Host Country fulfil its goals of promoting sustainable development. Specifically:

- The project will act as a clean technology demonstration project, which could be replicated across Thailand and the region;
- It will act as an important capacity building project, nationally and locally, especially demonstrating the use of a new financial mechanism for funding of the renewable energy and waste management sector via the CDM;
- It increases diversity and security of energy supplied through energy self-sufficiency, reducing the import of energy from overseas - with a positive effect on Thailand's balance of payment;
- The project creates temporary employment opportunities during construction and permanent employment opportunities during operation;
- It provides additional value for cassava production through energy production;

- The project will make use of material currently considered a waste material that gives rise to a considerable hazard i.e. the flammable methane rich biogas emitted;
- Technology will be sourced locally where possible, or transferred from overseas where required.

A.3. Project participants:

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Project participants

Name of party involved (*) ((host) indicates a host party)	Private and/or public entity(ies) Project participants (*) (as applicable)	Kindly indicate if the party involved wishes to be considered as project participant (Yes/No)
Kingdom of Thailand	Thai Biogas Energy Company	No
United Kingdom of Great Britain and Northern Ireland	EcoSecurities Group plc.	No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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A.4.1.1. Host Party(ies):

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Thailand (the “Host Country”)

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

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Saraburi Province

A.4.1.3. City/Town/Community etc:

>>

Amphur Kangkoy

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

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Chao Khun Agro Products Project, 44 Moo 2, Songkorn, Kaengkoi, Saraburi, 18110, Thailand. The GPS coordinates are: 14°35'59.28"N 101°00'41.30"E.

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

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

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

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The project will involve three important components, each requiring the transfer of technology, each at different stages of characterisation in the region and worldwide.

1. **Fugitive Methane Mitigation:** The primary emissions reduction component stems from capturing fugitive methane emissions through a Covered In-Ground Anaerobic Reactor, a type of anaerobic digester, which consists of a series of baffled reactors connected only by overflow weirs. The CIGAR may include a final settling unit. The CIGAR was first developed by Waste Solutions Ltd. in New Zealand. In addition to the anaerobic digester itself, the CIGAR consists of a piping system that moves the biogas from the digester to the flare and dual fuel burner, as well as a state-of-the-art monitoring system.
2. **Fuel Switching to use Biogas:** In the project activity, heat will be generated in a Loos boiler with capacity 15 ton steam per hour at 195°C and 13 bar. The burner is a WKGMS70/2-A Weishaupt burner. Both the boiler and burner will be sourced from Germany.

Any excess biogas will be sent to a flare. The flare is an Organics Ltd flare with a capacity of 2000 Nm^3 per hour. The flame is detected by a UV sensor.

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

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The table below sets out the emissions profile of the project over the ten-year crediting period.

Total Emissions Reductions throughout the Crediting Period (tCO_2e)

Years	Annual estimation of emissions reductions (tonnes of CO_2e)
2009	48,167
2010	48,167
2011	48,167
2012	48,167
2013	48,167
2014	48,167
2015	48,167
2016	48,167
2017	48,167
2018	48,167
Total Estimated Reductions (tonnes of CO_2e)	481,672
Total Number of Crediting Years	10
Annual average of the crediting period of emissions reductions (tonnes of CO_2e)	48,167

A.4.5. Public funding of the project activity:

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The project will not receive any public funding from Parties included in Annex I of the UNFCCC.

SECTION B. Application of a baseline and monitoring methodology

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

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AM0022 Avoided Wastewater and On-site Energy Use Emissions in the Industrial Sector, Version 04 (EB 28).

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

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AM0022 specifically focuses on wastewater fugitive methane abatement through anaerobic digestion in an industrial context. AM0022 sets out the following applicability criteria, and evidence for the Project meeting those criteria is listed below:

Methodology Conditionality

Condition	Applicable?	Justification / Project Condition
Project is implemented based upon a baseline of existing lagoon-based industrial wastewater treatment facilities for wastewater with high organic loading;	Yes	Chao Khun Agro Biogas Energy Project currently uses an anaerobic lagoon system to manage the high organic load of the wastewater.
The methodology is applicable only to the improvement of existing wastewater treatment facilities. It is not applicable for new facilities to be built, or new build to extend current site capacity;	Yes	The lagoon system at Chao Khun Agro Biogas Energy Project has been in operation for several years, since the factory began operation. The project activity will not lead to an increase in production capacity.
The organic wastewater contains simple organic compounds (monosaccharides);	Yes	The facility processes cassava which by nature contains simple organic compounds[1].
It can be shown that the baseline is the continuation of a current lagoon system for managing wastewater. In particular, the current lagoon-based system is in full compliance with existing rules and regulations	Yes	The existing lagoon system is in full compliance with all current regulations in Thailand[2].
The depth of the anaerobic lagoon should be at least 1 m	Yes	The depth of the anaerobic lagoon is greater than 1 m (approximately 4-5m).
The temperature of the wastewater in the anaerobic lagoons is always at least 15 °C	Yes	The average ambient temperature in the region is 25 °C[3]; the wastewater temperature is at least this as it is not cooled in any manner.
In the project, the biogas recovered from the anaerobic treatment system is flared and/or used onsite for heat and/or power generation, surplus biogas is flared	Yes	Biogas is used onsite in the facilities' heaters. Surplus biogas is flared.
Heat and electricity needs per unit input of the water treatment facility remain largely unchanged before and after the project;	Yes	The project will not require any significant increase in heat or electricity needs. The energy requirements for the project activity are minimal.
Data requirements as laid out in the related Monitoring Methodology are fulfilled. In particular, organic	Yes	The monitoring plan based on the Monitoring Methodology has been implemented onsite. All data - including the

[1] Reducing sugar testing was completed to demonstrate that the wastewater contains simple organic compounds.

[2] Certificates certifying that COD levels were below the regulated level were made available to the validator.

[3] www.weather.co.uk

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).		monitoring of wastewater volume, organic content at the inlet and outlet of the digestor, and contribution of removal processes - required to be tested is accurately measured or estimated, in accordance with AM0022, version 04. For further details, refer to section B.7.

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

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According to AM0022, project boundaries should be drawn encompassing:

- Methane emissions from the existing lagoon-based waste water treatment system up to, and including, the point at which organic material flows can be quantified or estimated into and out of the wastewater treatment facility;
- Potential methane emissions from the newly introduced anaerobic waste water treatment facility;
- CO_2 emissions from displaced fuel oil historically used for on site heat generation at Chao Khun Agro Products;
- Methane emissions from incomplete combustion of biogas in heat and/or power generation or in flare systems, or from leakage in piping.

In accordance with AM0022, ignored emissions include: nitrous oxide from the waste treatment system, and nitrous oxide from biogas combustion and/or destruction.

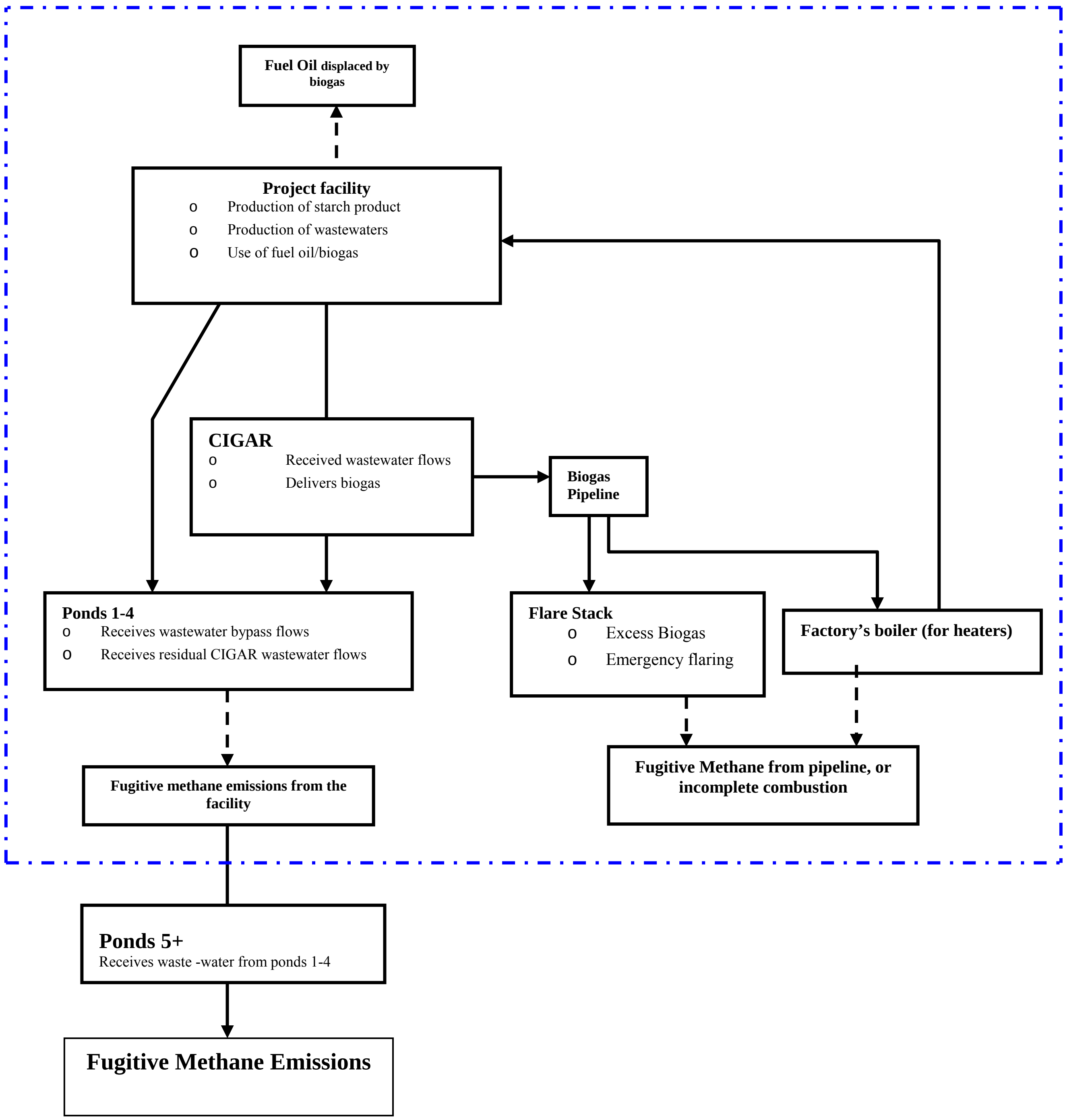
The following project activities and emission sources are considered within the project boundaries:

Sources and gases included in the project boundary

	Source	Gas	Included?	Justification/Explanation
Baseline	Existing lagoon-based waste water treatment system	CO_2	No	CO_2 is not considered in the lagoon-based wastewater treatment.
		CH_4	Yes	In accordance with AM0022, only CH_4 is considered in the lagoon-based wastewater treatment.
		N_2O	No	Not applicable
	Emissions from displaced fossil fuel use for onsite heat generation	CO_2	Yes	In accordance with AM0022, only CO_2 is considered in the emissions from displaced fuel oil.
		CH_4	No.	CH_4 is not considered in the emissions from displaced fossil fuel.
		N_2O	No	Not applicable
Proje ct Activi ty	Existing lagoon-based waste water treatment	CO_2	No	CO_2 from the lagoons is not a source of project emissions.
		CH_4	Yes	In accordance with AM0022, CH_4

	system			from the lagoons is the only gas considerate as a source of project emissions from the sxisting wastewater system.
		N_2O	No	Not applicable
	Emissions from leakage in piping	CO_2	No	Not applicable
		CH_4	Yes	CH_4 emissions from leakage in piping will be considered as according to AM0022.
		N_2O	No	Not applicable
	Fugitive Emissions from the Flare	CO_2	No	CO_2 from combustion is not accounted for in Project Emissions.
		CH_4	Yes	In accordance with AM0022, methane emissions due to incomplete combustion are accounted for in Project Emissions.
		N_2O	No	Not Applicable
	Fugitive Emissions from the Gen Set	CO_2	No	CO_2 from combustion is not accounted for in Project Emissions.
		CH_4	Yes	Methane emissions due to incomplete combustion are accounted for in Project Emissions.
		N_2O	No	Not Applicable
	Fugitive Emissions from the Dual Fuel Burner	CO_2	No	CO_2 from combustion is not accounted for in Project Emissions.
		CH_4	Yes	Methane emissions due to incomplete combustion are accounted for in Project Emissions, as according to AM0022.
		N_2O	No	Not Applicable

Chao Khun Agro Biogas Energy Project



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

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As according to AM0022, a six step process was used in order to define the baseline and to demonstrate that the continuation of current practices (existing lagoon based waste water treatment system without biogas use or flaring of the biogas).

Step 1: List a range of potential baseline option:

1. Continuation of current practices (BAU);
2. Direct release of wastewaters to an offsite water way;
3. Anaerobic digestion of wastewater streams;
4. Aerobic treatment of wastewaters (activated sludge or filter bed type treatment).

Step 2: Identify significant potential barrier:

- Legal;
- Technical;
- Financial;
- Social;
- Business culture;

Step 3: Score the barrier:

Legal

- Is this practice regulated by Host Nation law or regulation and therefore legally allowed?

Are there legal barriers to alternative baseline practices?

- Current practice: **No.**
  - This activity is not regulated by national law, and is therefore legal.
- Direct Discharge to water bodies: **Yes.**
  - This option is not allowed under Thai Law. There will be no further discussion of this option in the barriers analysis.
- Anaerobic digestion: **No.**
  - No law exists to drive an alternative waste management practice. This activity is not regulated by national law, and is therefore legal.
- Aerobic treatment**: No.**
  - No law exists to drive an alternative waste management practice. This activity is not regulated by national law, and is therefore legal.

There are no laws or regulations regulating the use of pond systems, the current practice (BAU), anaerobic digestion of wastewater streams or aerobic treatment of wastewaters in Thailand. However, the Enhancement and Conservation of National Environmental Quality Act of 1992 prohibits direct release into water bodies (rivers, lakes etc). As an option that contravenes the law cannot be considered realistic, the regulation for the purposes of this project can be considered an

absolute barrier. Hence, the option of directly releasing wastewaters to an offsite water way is not discussed further throughout the barriers analysis.

In the case of the Project, there is an extensive lagoon system that functions in COD removal and, ultimately, evaporation of the wastewater flow. Therefore, under the BAU scenario, there is no need for discharge to the environment. No permit is required for this system (as there is no discharge). Furthermore, Thailand does not require the monitoring of CO_2, CH_4, or any other GHG emissions and thus fugitive methane emissions from the lagoon system are not held to any standard of compliance.

Current practice, anaerobic and aerobic treatment of wastewaters would represent legal management options and would not be subject to additional regulation, apart from that they need to achieve the same effluent release standards as in the current pond systems.

As any options that are illegal – such as direct release into water bodies - are not considered plausible, legal issues are therefore not considered a barrier to any of the scenarios.

Technical

- Is this technology option currently available through local equipment suppliers?
- Are there sufficient skills and labour to operate and maintain this technology in country?
- Is this technology a regional or global standard, or technology of choice?
- Can performance certainty be guaranteed within tolerance limits?
- Can real or perceived technology risk associated with this technology be discounted?

Are there technical barriers to alternative baseline practices?

- Current practice: **No.**
  - This technology is the technology of choice in Thailand and the region.
- Anaerobic digestion: **Yes.**
  - This is perceived as a risky, novel and locally unavailable technology. Few AD plants existed in Thailand prior to the implementation of the Project.
- Aerobic treatment: **Yes.**
  - In the industrial sector regionally, little aerobic treatment is employed on a commercial scale.

Pond based wastewater cleansing systems have low capital and O&M costs and are a low maintenance solution. These types of systems are used extensively both in Thailand and world wide (Parr, Smith and Shaw 2000). Ponds are the technology of choice in tropical situations and any other area where regulation does not require more engineered solutions. They are seen as very low risk, and utilise low-tech pond redundancy to ensure that final releases of wastewater effluents are within regulated tolerances.

Anaerobic systems are novel, not only in Thailand, but the wider region and globally. Neither the technology, nor the requisite skills to build and operate such systems are generally available locally. The majority of the equipment used in the Project activity had to be purchased from overseas as it was not available in Thailand. Additionally, due to the lack of utilization of anaerobic digestion

technology in Thailand, there is a lack of skilled labourers to operate and maintain this technology. Furthermore, it is hard to attract interest to work in the field (Prasertsan, Sajjakulnukit 2005). Skilled labourers must be trained on the O&M procedures of digesters, especially CIGARs. This training was conducted by Waste Solutions Limited, a New Zealand based company [4].

Furthermore, at the time of writing, there are only 5MW of electricity being generated in Thailand from biogas and the additional generation capacity is a proposed CDM activity (Biopact 2007).

AD systems are perceived as relatively high risk, being based upon the function of a biological system that is neither 100% characterised, nor performance guaranteed. The biological system is at constant risk of changes in the chemical composition that can harm the anaerobic bacteria and biological activity and subsequently the waste management and energy production regimes. These harmful changes can be caused by a host of problems such as mismanagement of the CIGAR or mixing pond, improper recycling of the wastewater or the introduction of chemical agents into the system. AD systems require constant and ongoing precise management of a variety of elements, water flows, pH etc. Overall they are perceived as a risky solution.

Aerobic management systems are similarly a novel choice in Thailand; the majority of wastewater treatment systems are anaerobic lagoons, as demonstrated above. Aerobic treatment systems are not very common. They are complicated to control and costly due to the high energy requirement (oxygen needs to be supplied) and a large volume of sludge is produced (Parr, Smith and Shaw 2000). Oxygen is supplied to the system through a mechanical process; the necessary operating and maintenance of this mechanical system is much greater than that of the use of anaerobic lagoons. Furthermore, the significant amount of sludge generated by aerobic systems must be disposed of.

In addition to this, a third party report from 2007 by the Energy Conservation and Renewable Energy Division and Energy Policy and Planning Office of Thailand[5] (hereafter referred to as 'the EPPO report') clearly confirms that open ponds are the prevailing practice for the treatment of wastewater at tapioca (also called cassava) starch plants in Thailand. The report also states that insufficient knowledge and confidence in the technology is preventing the use of more advanced water treatment technology, i.e. that this is operating as a preventative technology barrier for anaerobic reactors.

At the time of decision making for the project activity the Ministry of Energy in Thailand had started a pilot scheme to study and demonstrate biogas technology at tapioca/cassava starch processing facilities. The projects involved in the scheme received financial support from The Energy Conservation Fund (ENCON) and technical support from the Ministry of Energy. Nine factories were selected for this pilot scheme, but the project activity was not included in this scheme so it did not receive this kind of financial support. The existence of this support scheme demonstrates that these projects face significant barriers and would not be developed in the absence of external support.

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[4] Please refer to Annex 6 for proof of training by Waste Solutions Ltd

[5] Seminar Document: The Promotion of Biogas from Wastewater as An Alternative Energy and for Environmental Improvement, published by the Energy Conservation and Renewable Energy Division and Energy Policy and Planning Office (EPPO), 2007

In addition to the projects receiving financial support under the ENCON scheme, there are 17 similar projects that have applied for CDM financing in Thailand[6], suggesting that CDM incentives are necessary for these projects to take place, this was further justified by a published article from the Thai Tapioca Starch Association (TTSA)[7]. No similar projects have been identified outside of the CDM or ENCON scheme, therefore it can be considered that there are no similar operational projects in Thailand that do not have financial support either from the Government or from CDM revenues.

The technology for the proposed project was not available in the host country, and the equipment had to be imported. The technology adopted is an advanced covered in-ground anaerobic reactor (CIGAR)®, a technology developed by a New Zealand company, Waste Solutions Ltd. The CIGAR® system consists of a series of baffled reactors covered by thick HDPE covers, connected by overflow weirs, plus gas blowers, as well as a state-of-the-art monitoring system. Besides, major equipments such as dual fuel burner and gas blowers have been imported from Germany and New Zealand, respectively. Furthermore, no other projects using this CIGAR® technology were developed in the host country prior to the start date of this project, with the exception of the Korat Waste To Energy project (KWTE), a registered CDM project (UNFCCC #1040)[8]. Therefore there are no similar projects in the host country using this technology (in the absence of CDM).

Technology issues are therefore considered a major barrier to the anaerobic scenario and mid-range barrier to the aerobic alternative and no barrier to the current pond based management system.

Financial

- Is this technology intervention financially attractive in comparison to other technologies?
- Is this the most financially viable option?
- Is equity participation easy to find internationally?
- Is equity participation easy to find locally?
- Are site owners/ project beneficiaries carrying any risk?
- Is technology currency (country) denomination a risk?
- Is the proposed project subject to commercial risks?

Are there financial barriers to alternative baseline practices?

- **Current practice:** No.
  - o This technology, where currently installed, requires no further financing.
- **Anaerobic digestion:** Yes.
  - o This is perceived as a high risk, novel project. No successful commercial AD plants exist in Thailand at present that have not been developed outside the CDM. In this project, no risk is being taken by Thai nationals or the facility management, the risk being left to niche foreign investors.

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[6] Website of the Thailand Designated National Authority

[7] Advance Energy Plus Co., Ltd. presented the pilot project of CDM development program in "bundle" pattern among medium size starch manufacturers and small size starch manufacturers. http://www.thaitapiocastarch.org/co-operation_detail.asp?id=5

[8] As evidenced by the sales list from the technology provider, Waste Solutions

- **Aerobic treatment:** Yes.
    - Similar risks (although perhaps lower) may be observed for aerobic treatment.

In discussing financial analysis of any project that involves – or could involve - multiple parties with distinct roles, a key variable to consider is the relative division of risk and reward between those parties.

For the facility, the current system is financially attractive, given that it complies with current regulation and requires virtually no management input to achieve the key parameter.
For the facility, ponds represent the lowest cost of all three scenarios i.e. making it the most financially viable option since even the most productive land in developing countries is reasonably priced, which ensures the feasibility of waste stabilization ponds as a sustainable alternative for wastewater treatment (Peña Varón 2003). The current system requires no further costs while the implementation of the project activity incurs significant costs[9]. Under this scenario, the facility's unit energy costs would remain on par with the rest of the industry, leaving it at no relative competitive disadvantage.

Commercial risk is a very significant barrier to adopting waste to energy AD technology. The commercial risks include 1) complete non-performance or dissatisfactory biogas yield insufficient to offset the high Operation &Maintenance costs and depreciation[10] 2) cost overruns to already high capex budgets 3) biological shocks that harm or kill the bacteria interrupting cash flows 3) business risk of host company that can't be controlled by project developer, directly affect the CIGAR 4) lack of control of the starch produced by Host Company as even small changes in the starch product may affect the biogas yield significantly. This is exemplified by the comparison of the overall risks associated with maintaining the business as usual scenario (no risk) against the risks associated with project implementation even if the risk, which is high, is borne by a number of different entities. There is further investment risk due to the risk associated with the vulnerability of the Thai Baht, the local currency. Sentiment towards the baht is undermined by domestic political instability and signs of slower economic growth (Economist Intelligence Unit 2006).

Furthermore, the equipment was paid for in US Dollars, whilst in the absence of the CDM the project would have no income in US Dollars, only in Thai Baht. This would mean that there would be a significant exchange rate risk, which exacerbated the low rate of return and made the project even more unattractive for investors. Exchange rate fluctuations can be seen in figure 1, which shows the Thai Baht exchange rate for the 10 years prior to decision making. This figure clearly shows that there have been large fluctuations in the exchange rate, particularly following the 1997 Asian financial crisis, that significantly increase the risk of financing such a project for potential investors. Carbon credit sales are paid for in US Dollars, so the CDM effectively mitigates the exchange rate risk.

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[9] A study was conducted comparing the Net Present Value of alternative wastewater treatment systems. It was demonstrated that the NPV of anaerobic lagoons is 45% lower than that of aerobic systems (Arthur 1983). One of the key aspects about anaerobic ponds is that that their main capital (land) is recoverable (Peña Varón 2003).

[10] e.g. Another project by the same Project Developer replaced an old failed biogas reactor for this reason

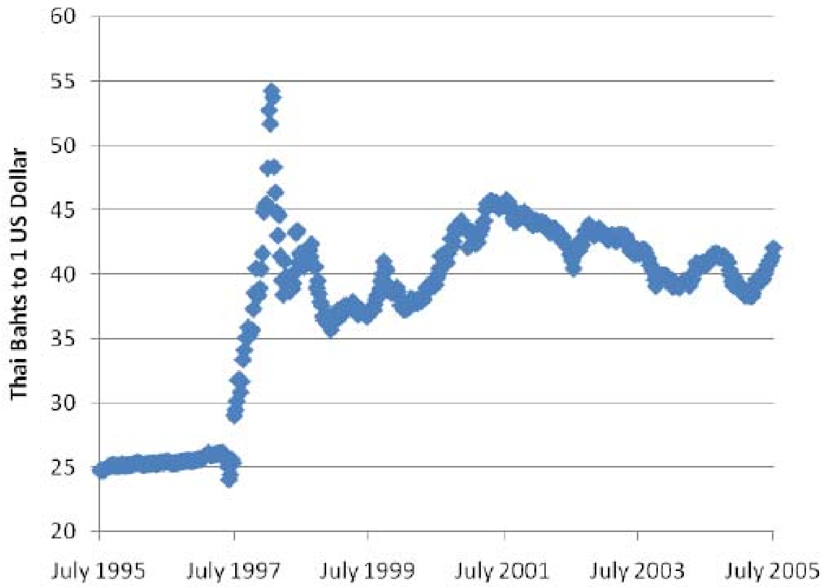

Figure 1: Thai Baht to US Dollar exchange rates from July 1995 – July 2005 (Source: Bloomberg Finance LP)

The project activity was not able to get funding from any Thai sources; it is only able to proceed due to being financed exclusively by equity from foreign investors specializing in high-risk projects. For example, Al Tayyar Energy is a private equity investor with several years experience working on high-risk energy investments in developing countries. Local investors, including even the management of the facility, are unwilling to take on the risks of such a novel project when the business-as-usual pond-based system satisfies the wastewater management needs. Hence, bioenergy project developers face more difficulty in getting finance. Without the subsidies, it is almost impossible to produce a bankable document for the loan proposal (Prasertsan, Sajjakulnukit 2005). In order to be incentivized to invest in the project with a technology unknown in Thailand, the foreign investors looked towards the added benefits from CDM[11]. The benefits from the CDM were an integral part of the investors' decision to proceed; benefits from CDM were considered with the other benefits from the project from the very start. Had carbon credits not been one of the benefits associated with the project, the investors would have been in a similar situation as local investors; they would have lacked the encouragement to invest. The benefits from carbon credits provide even further encouraged the investors to invest as revenue from carbon credits is in stable US dollars while all other revenues associated with the project activity are in the fluctuating Thai baht.

The EPPO report mentioned in the technical barrier section, clearly states that anaerobic reactors come with "high investment cost and high operating costs", and that consequently most facilities chose to retain their wastewater in open ponds.

Although the project activity has secured funding and this funding has been provided by a foreign investor, it should be noted that those investors were specialized in renewable energy, with a very

[11] Proof of this was provided to the validator.

good understanding of the CDM. In fact it was never an option for the investors to develop the project as anything other than a CDM project, as evidenced by the TBEC Investment Memorandum presented to the DOE. The funding was only secured because of the CDM and the additional incentives and investor confidence it brings to the project. The project is being funded by TBEC, a company created in 2003 and invested in by CleanTHAI, Al Tayyar Energy Ltd (ATE) and Private Energy Market Fund LP (PEMFUND) as an investment vehicle for CDM biogas projects in Thailand. The company was specifically created to help facilities in Thailand develop clean technology biogas projects through the CDM process, and the profitability of each of the projects being developed relies on income from the CDM. [12]It is also demonstrated in the TBEC Shareholder Agreement signed in April 2004 that specifically states the company (TBEC) will engage in the generation and sale of Emission Reduction Certificates.

In the Investment Memorandum it was clearly demonstrated that the financial rates of return of the project activity, and the other similar projects, was not sufficiently high to make them an attractive investment without income from the CDM. This memorandum is specific evidence to support the barrier due to lack of financing in the absence of CDM.

Given the poor financial state of the host company (Chao Khun Agro) it was not able to make additional investments outside of the core business and it was not easy to find investors willing to invest in the business. The investors in TBEC commissioned a Legal Due Diligence Report on CKA while they were considering whether to go ahead with the investment. The Legal Due Diligence Report was prepared by Bamrung Suvicha Apisakdi Law Associates Bangkok, Thailand in March 2004; it includes an assessment of the CKA’s audited accounts. The accounts show that at the end of 2002 the liabilities of CKA exceeded the available assets to meet these liabilities. In its report for fiscal year 2002 the auditor notes that CKA had gone through debt restructuring and failed to make repayments. The Legal Due Diligence Report concludes that the auditor of CKA’s most recent accounts had significant concerns over the financial prospects of the Company. This demonstrates that CKA did not have funds available for making new investments and it would have been very difficult for them to raise additional debt in order to pay for the project activity. The poor financial state of CKA would also mean that there was significant risk for a third party (like TBEC) to invest in the project activity, because income for the third party relies on CKA’s continued operation (i.e. TBEC‟s main non-CDM income is from the sale of heat to CKA). This would make equity participation difficult to find locally and internationally. Therefore the Legal Due Diligence Report is specific evidence to support the financial barrier.

In addition to the risk from the project activity, there was the very significant risk associated with the operation of the factory which produces the wastewater in the project activity. One example of this is, in 2005, there was a prolonged droughts that crushed cassava crop output (Partos 2005), harming the Thai cassava industry. Further demonstrated this risk is the fact that a number of cassava starch producing companies have experienced severe financial turmoil and bankruptcy[13].

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[12] This is clearly demonstrated in the TBEC Investment Memorandum that was presented to the DOE.

[13] As demonstrated to the validator.

The commercial risks associated with anaerobic technology also apply to aerobic treatment systems as they are an unknown, risky and costly technology. There have high upfront costs associated and the O&M is costly and complicated due to the necessity of constant mechanical aeration (Parr, Smith and Shaw 2000). Additional costs are incurred by the need for electricity for the aeration and removal of the production of large amounts of sludge.

Financial barriers are perceived to be major barriers to the project scenario of adopting AD technology and major barriers to the aerobic waste management alternative. Conversely, they do not pose barriers to the continued prevailing practice of pond systems.

Social

- Is this considered a well understood and accepted technology in the Host Nation and among local constituencies?

Are there Social barriers to alternative baseline practices?

- Current practice: This technology is an accepted technology, and continued operation of existing facilities presents no real social barriers. **No.**
- Anaerobic digestion: There is the risk of social perception being against a novel technology, however none have been observed in relation to this project, as a result of public engagement and the support of the facility management. **Yes.**
- Aerobic treatment: There is the risk of social perception being against novel technologies. **Yes.**

Where ponds are currently employed, few social barriers may be observed. They are accepted within the local environment and are the most popular operating practice in Thailand (FAO 2001). Anaerobic, and even aerobic facilities, present social barriers of perceived risk (explosion from biogas collection, smell etc), even where not merited, as the local community does not have knowledge of or experience with the anaerobic digestion technology. Although there still exists the potential for some perceived social risks, public engagement with regard to the Project activity have decreased this risk for the Project.

Social issues are therefore considered a minor barrier to the latter two scenarios and no barrier to the current pond based management system.

Business Culture

- Is there a willingness to change to alternative management practice in the absence of regulation?
- Is this technology considered 'standard practice' in the industry?
- Is there experience of applying the technologies?
- Is this technology considered a high management priority, as a result of its familiarity?

Are there business culture or other barriers to alternative baseline practices?

- Current practice: This technology is an accepted technology, and continued operation of existing facilities presents no real barriers. **No.**

- Anaerobic digestion: There is no experience of implementing such technologies in a Thai context and no strong drivers to become energy self-sufficient. **Yes.**
- Aerobic treatment: There is no experience of implementing such technologies in a Thai context. **Yes.**

As discussed in previous sections, the current pond based treatment is considered standard operating practise in Thailand and the region for wastewater treatment. The project activity, on the other hand, is not the standard operating practise. There is little experience of utilising aerobic or anaerobic technologies in a Thai context, and therefore these are not considered a high management priority. Additionally, there is a low level willingness to change from the current practice as it is efficient, low cost and in compliance with regulation.

The highest priority for most in the cassava sector is the management of waste discharges by simply maintaining compliance with local regulation at the lowest cost possible. Energy production, which is capital intensive and requires even greater management resources than the simple digestion process, is not a priority as electricity prices in Thailand are reasonable due to the government charging a uniform retail price throughout the country, with residential and industrial customers paying similar prices. Subsequently, this results in significant cross-subsidies between the industrial and residential sectors (World Energy Council 2005).

Business culture issues are therefore considered a barrier to the latter two scenarios and no barrier to the current pond based management system.

Step 4: Compare which is the most plausible baseline option:
The barriers analysis above has clearly shown that the most plausible baseline scenario is the prevailing practice of pond systems. In the situation where both anaerobic and aerobic wastewater treatment are considered, the most significant barriers are technology familiarity, perceived risks and the relative lack of investment interest among the key business constituency. The lack of experience with AD in the cassava industry in Thailand leaves most potential participants perceiving a very high risk.

In addition to the technical and social barriers of the Project activity, there are also associated financial barriers. As the Project activity is risky while the baseline scenario is safe, well known and inexpensive, there is little motivation to invest in the Project activity. This is demonstrated by the necessity of investment by foreign investors specializing in high risk projects.

Therefore, the context of the historical and future circumstances of the underlying asset, there are no barriers to current pond system wastewater treatment and significant financial and technical barriers to the alternatives, including Anaerobic Digestion.

Timeline of events

Event	Date
Contract signed with carbon advisor[14]	09/12/2004
Start of project activity[15]	28/07/2005

[14] Contract between EcoSecurities and project developed has been shown to the DOE

Approval of AM0022, version 1	13/05/2005
Start of validation[16]	29/10/2005
Start of commissioning[17]	16/12/2006

Barriers Analysis Results Summary

Barrier Tested / **Plausible Baseline Alternative**	**Direct Discharge to water bodies**	**Continuation of current practices**	**Anaerobic digestion**	**Aerobic treatment**
Legal				
• Does the practice violate any host country laws or regulations or is it not in compliance with them?	**Y**	**N**	**N**	**N**
Technical				
• Is this option currently difficult to purchase through local equipment suppliers?	**N/A**	**N**	**Y**	**Y**
• Are skills and labour to operationalize and maintain this technology in country insufficient?	**N/A**	**N**	**Y**	**Y**
• Is this technology outside common practice in similar industries in the country?	**N/A**	**N**	**Y**	**Y**
• Is performance certainty not guaranteed within tolerance limits?	**N/A**	**N**	**Y**	**Y**
• Is there real, or perceived, technology risk associated with the technology?	**N/A**	**N**	**Y**	**Y**
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/A**	**N**	**Y**	**Y**
• Is equity participation difficult to find locally?	**N/A**	**N**	**Y**	**Y**
• Is equity participation difficult to find internationally?	**N/A**	**N**	**Y**	**Y**
• Are site owners/project beneficiaries carrying any risk?	**N/A**	**N**	**Y**	**Y**
• Is technology currency (country) denomination a risk?	**N/A**	**N**	**Y**	**Y**
• Is the proposed project exposed to commercial risk?	**N/A**	**N**	**Y**	**Y**
Social				
• Is the understanding of the technology low in the host country/industry considered	**N/A**	**N**	**Y**	**Y**
Business Culture				
• Is there a reluctance to change to alternative management practices in the absence regulation?	**N/A**	**N**	**Y**	**Y**

Step 5: Investment analysis
As specified in AM0022, this step is not necessary as there is only one baseline option result.

Step 6: Conclusion

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[15] Final budget was provided by the technology provider and so, decision to proceed with the project activity could be made. Evidence has been shown to the DOE.

[16] http://cdm.unfccc.int/Projects/Validation/DB/BUXKLPCSLMR8WGDLXOGYU2UMAP5H8A/view.html

[17] Proof of the start of commissioning has been shown to the DOE

The baseline determination demonstrates that the current and historic practices (and emissions), the use of the pond treatment, would continue in the absence of the CDM project activity. No other alternative baseline option is more likely therefore AM0022 is applicable.

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 according to the additionality procedures in AM0022, version 04, given that the baseline determination in this project (see section B.4.) demonstrates that the baseline is different from the proposed project activity not undertaken as a CDM project activity, it is concluded that the project is additional

B.6. Emissions reductions

B.6.1. Explanation of methodological choices:

>>

As per methodology AM0022, Version 4, emission reductions of the project activity are equal to baseline emission minus project emissions. Leakage is considered to be negligible.

Total 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, biogas leaks.

(1)

where:

- $\mathbf{E_{project}}$ are the Total Project Emissions (tCO2e)
- $\mathbf{E_{CH4\_lagoons}}$ are the fugitive methane emissions from lagoons from Equation (2) (tCO_2e)
- $\mathbf{E_{CH4\_NAWTF}}$ are the fugitive methane emissions from the new anaerobic wastewater treatment facility (tCO_2e)
- $\mathbf{E_{CH4\_IC+leaks}}$ are the methane emissions from inefficient combustion and leaks (tCO_2e)

To calculate methane emissions from inefficient combustion and leaks, the “Tool to determine project emissions from flaring gases containing methane” was used for the flaring component. As the project activity utilises an open flare, the default flare efficiency – as stated by the tool – is 50%.

Total Baseline Emissions

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 (through the combustion of fuel oil).

$$E_{BL} = E_{CH4\_lagoons\_BL} + E_{C02\_heat\_BL} + E_{CO2\_grid\_BL} \quad (2)$$

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.
- **$E_{CO2\_heat\_BL}$** 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.

R_{lagoon} was determined through a series of biochemical tests prior to project implementation, as in accordance with AM0022.

As stated above, baseline emissions include the CO_2 emissions from onsite heat generation and electricity from the grid. As no electricity will be generated from biomass, **$E_{CO2\_grid\_BL}$** will not be included.

Total Emissions Reductions

$$ER = E_{BL} - E_{project} \quad (3)$$

Where:

***ER*:** Emission reduction ($t\ CO_2e$)
***E_{BL}*:** Baseline emissions ($t\ CO_2e$)
***$E_{project}$*:** Project Emissions ($t\ CO_2e$)

It must be verified the 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.

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

(Copy this table for each data and parameter)

Data / Parameter:	EF_{CH4}
Data unit:	kg CH_4/kg COD
Description:	Methane emission factor
Source of data used:	AM0022
Value applied:	0.21

Justification of the choice of data or description of measurement methods and procedures actually applied :	The 2006 IPCC default of 0.25 kg CH_4/kg COD has been corrected to 0.21 kg CH_4/kg COD to account for uncertainties. This is also the value applied in AM0022.
Any comment:	
Data / Parameter:	GWP_{CH4}
Data unit:	
Description:	Global Warming Potential of methane
Source of data used:	AM0022
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC default, as set in the Kyoto Protocol
Any comment:	
Data / Parameter:	$M_{lagoon\_aerobic}$
Data unit:	kg COD/ha/day
Description:	Amount of organic material degraded aerobically in the lagoon system
Source of data used:	AM0022
Value applied:	254
Justification of the choice of data or description of measurement methods and procedures actually applied :	As provided by the Methodology and tested by the sensitivity analysis
Any comment:	
Data / Parameter:	R_{lagoon}
Data unit:	%
Description:	Total organic material removal ratio of the lagoon
Source of data used:	Project developer
Value applied:	96
Justification of the choice of data or description of measurement methods and procedures actually applied :	Determined in accordance with AM0022 prior to the start of the project activity through on-site biochemical testing in the lagoon system.
Any comment:	

Data / Parameter:	$R_{deposition}$
Data unit:	%
Description:	Organic material deposition ratio of the lagoon
Source of data used:	Project developer
Value applied:	1.78
Justification of the choice of data or description of measurement methods and procedures actually applied :	In accordance with AM0022, testing was done prior to the start of the project activity which determined the rate of deposition.
Any comment:	
Data / Parameter:	$NCV_{fuel\ oil}$
Data unit:	TJ/dm^3
Description:	Net calorific value of fuel oil
Source of data used:	IPCC 2006 and density from Engineer's Edge
Value applied:	39.996×10^{-6}
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC default value from Table 1.2 of Chapter 1 of Vol.2 used for the NCV of fuel oil expressed in TJ/t. This value is multiplied by the density value of 0.99Kg/l from Engineer's Edge (http://www.engineersedge.com/fluid_flow/fluid_data.htm).
Any comment:	
Data / Parameter:	$EF_{fuel\ oil}$
Data unit:	tCO_2/TJ
Description:	Carbon emission factor of the fuel oil
Source of data used:	IPCC 2006
Value applied:	77.367
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC default value from Table 1.3 of Chapter 1 of Vol.2 gives an EF for residual fuel oil of $21.1kg_{carbon}/GJ_{fuel\ oil}$. Applying the coefficient 44 g of CO_2/12 g of Carbon gives 77.367 t_{CO2}/TJ.
Any comment:	
Data / Parameter:	Lagoon surface area
Data unit:	ha
Description:	Total lagoon area
Source of data used:	Project developer
Value applied:	2.09
Justification of the choice of data or description of	

measurement methods and procedures actually applied :	
Any comment:	
Data / Parameter:	Flare efficiency
Data unit:	%
Description:	Flare efficiency for open flare
Source of data used:	Tool to determine project emissions from flaring gases containing methane
Value applied:	50
Justification of the choice of data or description of measurement methods and procedures actually applied :	This is calculated according to the "Tool to determine project emissions from flaring gases containing methane" for open flares which consists of using a 50% default if a flame is detected for at least 20min in the hour and ensuring that flare is operated properly.
Any comment:	

Data / Parameter:	Rso_4^{2-}
Data unit:	Kg/tonne (kg_{COD}/tSO_4^{2-})
Description:	Reduction factor for SO_4^{2-} oxidative substance
Source of data used:	AM0022 v4
Value applied:	651
Justification of the choice of data or description of measurement methods and procedures actually applied :	AM0022 v4 states in p.32 under the section Determining losses of Chemical Oxygen Demand through chemical oxidation: "where the concentration of sulphate is observed to be 1 kg/m^3 of waste water, 0.651kg/m^3 of Chemical Oxygen Demand will be removed through chemical reaction with the sulphate" hence the reduction factor is 0.651 $kg_{COD}/kgSO_4^{2-}$ => 651 kg_{COD}/tSO_4^{2-}.
Any comment:	

B.6.3 Ex-ante calculation of emission reductions:

>>

As per the equation set out in AM 0022, the following equations are used to estimate project emissions.

Total 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, the new anaerobic wastewater treatment facility, incomplete biogas combustion, and biogas leaks

(1)

where:

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

- **$E_{CH4\_lagoons}$** are the fugitive methane emissions from lagoons (tCO_2e)
- **E_{CH4_NAWTF}** are the fugitive methane emissions from the new anaerobic wastewater treatment facility (tCO_2e)
- **$E_{CH4\_IC+leaks}$** are the methane emissions from inefficient combustion and leaks (tCO_2e)

Total Project Emissions (TCO_2e)

Year	$E_{CH4\_lagoons}$ (tCO2)	E_{CH4_NAWTF} (tCO2)	$E_{CH4\_IC+leaks}$ (tCO2)	$E_{project}$ (tCO2)
2009	14,800	-	5,503	20,304
2010	14,800	-	5,503	20,304
2011	14,800	-	5,503	20,304
2012	14,800	-	5,503	20,304
2013	14,800	-	5,503	20,304
2014	14,800	-	5,503	20,304
2015	14,800	-	5,503	20,304
2016	14,800	-	5,503	20,304
2017	14,800	-	5,503	20,304
2018	14,800	-	5,503	20,304
2018	14,800	-	5,503	20,304
Total	162,803	-	60,537	223,340
Average	14,800	-	5,503	20,304

Fugitive Methane Emissions from Lagoons

Fugitive Methane Emissions from Lagoons are:

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

where:

- **$M_{lagoon\_anaerobic}$** 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[18].
- **GWP_{CH4}** is the Global Warming Potential of methane (GWP CH_4 = 21)

The total removal of COD from individual lagoons is a function of:

- Aerobic surface oxidation of COD;
- Chemical oxidation in lagoons (where oxidative species such as sulphate are present);
- Sedimentation of material that microbes are unable to degrade before they form a bottom sediment; and,
- COD degradation as a result of anaerobic micro bacterial activity.

[18] The IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories default of 0.25 kg CH_4/kg COD has been corrected to 0.21 kg CH_4/kg COD to account for uncertainties, as described in AM022.

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

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

where:

- **M_{lagoon_total}** is the total amount of organic material removed in the lagoon system (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 and 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 (kg COD).

COD Degraded Anaerobically in Lagoon System in Baseline Scenario

Year	M_{input_total} (kgCOD)	M_{lagoon_input} (kgCOD)	R_{lagoon}	M_{lagoon_total} (kgCOD)	$M_{lagoon\_aerobic}$ (kgCOD)	$M_{lagoon\_chemical\_ox}$ (kgCOD)	$M_{lagoon\_deposition}$ (kgCOD)	$M_{lagoon\_anaerobic}$ (kgCOD)
2009	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
2010	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
2011	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
2012	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
2013	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
2014	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
2015	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
2016	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
2017	15,014,233	15,014,233	96%	14,413,663	180,492	128		13,965,790
2018	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
2018	15,014,233	15,014,233	96%	14,413,663	180,492	128	267,253	13,965,790
Total	165,156,560	165,156,560	96%	158,550,298	1,985,416	128		153,623,689
Average	15,014,233	15,014,233	1	14,413,663	180,492	128	267,253	13,965,790

As prescribed by the methodology, a sensitivity analysis has been carried out to determine the suitability of the surface oxidation factor utilised in this project analysis. This is presented in Annex 5.

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 wastewater treatment facility must be determined.

Project Organic Material Entering Lagoon System from New Anaerobic Water Treatment System is:

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

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 (-). It is a project specific factor used to estimate how much COD will be removed from the system.

Total Material Removed In Lagoon System is:

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

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. A project specific factor, and is equal to the proportion of organic material removed (through all routes) within the boundaries of the lagoon system under consideration. This factor has been determined by carrying out a series of biochemical tests prior to project implementation. This value has been determined to be 96% for this project.

Material Deposition In 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. It is a project specific factor derived by from pre-project analysis.

COD Degraded Anaerobically in Lagoon System in Project Scenario

Year	M_{input_total} (kgCOD)	R_{NAWTF} (%)	M_{lagoon_input} (kgCOD)	R_{lagoon}	M_{lagoon_total} (kgCOD)	$M_{lagoon\_aerobic}$ (kgCOD)	$M_{lagoon\_chemical\_ox}$ (kgCOD)	$M_{lagoon\_deposition}$ (kgCOD)	$M_{lagoon\_anaerobic}$ (kgCOD)
2009	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2010	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2011	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2012	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2013	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2014	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2015	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2016	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2017	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2018	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
2018	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069
Total	165,156,560	75%	41,289,140	96%	39,637,574	1,985,416	408	668,133	36,916,763
Average	15,014,233	75%	3,753,558	96%	3,603,416	180,492	41	66,813	3,356,069

Methane emissions from new anaerobic waste water treatment facility

In accordance with AM0022, methane emissions from the CIGAR should be assessed and estimated based on measurements, technology supplier data and expert estimates. They may be disregarded if documented evidence for their insignificance is given.

Methane emissions from Inefficient Combustion Emissions

The combustion of biogas methane may give rise to significant methane emissions as a result of incomplete, or inefficient combustion. The two predominant potential routes for the destruction of methane are:

- Biogas flaring;
- Biogas use in heating systems.

This methane should be quantified through Equation (7).

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

Where:
r for methane destruction (heating);
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 expressed on wet basis. It is the product of the methane concentration in the biogas in Nm^3_{CH4}/Nm^3_{Biogas} and the methane density at normal conditions.
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.

$$E_{CH4\_IC\_heat} = V_{heat} \cdot C_{CH4\_r} \cdot (1 - f_{heat}) \cdot GWP_{CH4}$$

$E_{CH4\_IC\_heat}$ = 13,601 * 340 * 61.5% * 0.0007168 * (100-90.6%) * 21
$E_{CH4\_IC\_heat}$ = 4,024 tCO_2/yr

$E_{CH4\_IC\_flaring}$ = 1,479 tCO_2/yr

In the project activity, biogas will be flared only during equipment maintenance periods at the project site or during times where biogas production exceeds the capacity of the dual fuel burner. Such occasions will be rare, however, and flare use will in fact be sporadic. Project emissions from the flare will be calculated using the *"Tool to determine project emissions from flaring gases containing Methane"*. Since no continuous monitoring takes place, the default flare efficiency prescribed by the tool is utilized. The calculation steps for project emissions are as follows:

Step 1. Determination of the mass flow rate of the residual gas that is flared

This step calculates the residual gas mass flow rate in each hour *h*, based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$$FM_{RG,h} = p_{RGn,h} \, x \, FV_{RG,h} \qquad \textbf{(Flare: 1)}$$

Where:
$FM_{RG,h}$: Mass flow rate of the residual gas in hour h (kg/h)
$p_{RG,n,h}$: Density of the residual gas at normal conditions in hour h (kg/Nm3)
$FV_{RG,h}$: Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h (Nm3/h)

As stated in the*"Tool to determine project emissions from flaring gases containing Methane"*, a simplified approach may be taken, in which only the volumetric fraction of methane is measured and the difference to 100% is considered as nitrogen (N_2). Hence step 2 is not applicable to the chosen methodological application of the tool and it is not included here for clarity purposes. As the methane combustion efficiency of the flare will not be continuously monitored as a default value for open flares will be used, steps 3-4 are also not applicable and will not be included.

Step 5: Determination of methane mass flow rate in the residual gas on a dry basis
The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane ($\_{CH4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis).

$$TM_{RG,h} = FV_{RG,h} \, x \, fv_{CH4,RG,h} \, x \, p_{CH4,n} \qquad \textbf{(Flare: 13)}$$

Where:
$FV_{RG,h}$: Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (Nm^3/h)
$Fv_{CH4,RG,h}$: Volumetric fraction of methane in the residual gas on dry basis in hour h
$\rho_{CH4,n}$: Density of methane at normal conditions (kg/m)

$TM_{RG,h}$ = 39.208 * 61.5% * 0.7168
$TM_{RG,h}$ = 17.265 kg/hr

Step 6: Determination of the hourly flare efficiency
The determination of the hourly flare efficiency depends on the operation of flare (e.g. temperature), the type of flare used (open or enclosed) and, in case of enclosed flares, the approach selected by project participants to determine the flare efficiency (default value or continuous monitoring).

In case of open flares and use of the default value for the flare efficiency, the flare efficiency in the hour *h* ($\eta_{flare,h}$) is:

- 0% if the flame is not detected for more than 20 minutes during the hour h.
- 50%, if the flame is detected for more than 20 minutes during the hour h

Step 7: Calculation of annual project emissions from flaring
Project emissions from flaring are calculated as the sum of emissions from each hour *h*, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour *h* ($\eta_{flare,h}$), as follows:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} x(1 - n_{flare,h}) x \frac{GWP_{CH4}}{1000} \quad \textbf{(Flare: 15)}$$

Where:
$TM_{RG,h}$: Mass flow rate of methane in the residual gas in the hour h
$\eta_{flare,h}$: Flare efficiency in hour h
GWP_{CH4}: Global Warming Potential of methane valid for the commitment period

$PE_{flare.y}$ ($E_{CH4\_IC\_flaring}$)= 17.265 * (1-50%) * (21/1000) * 8160[19]
$PE_{flare.y}$ ($E_{CH4\_IC\_flaring}$)= 1,479 t CO_2/yr

Total emissions from inefficient combustion emissions
$E_{CH4\_IC+Leaks}$ = 4,024 + 1,479 + 0
$E_{CH4\_IC+Leaks}$ = 5,503 tCO_2/yr

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. A conservative value of 1% was included in the ex-ante emissions reductions calculations. Leaks will be monitored on a daily basis and the pipeline will be pressurized annually, as required by AM0022.

Methane emissions from the CIGAR are expected to be zero in this project. Because the CIGAR is being operated effectively under sub atmospheric pressures, it is reasonable to expect that air will actually be sucked in as opposed to biogas leaking out. The biogas delivery pipe to the off-taker site is also less than 2km, and thus there is no expectation that there will be significant leaks of biogas.

The baseline scenario for the project is based on what would have happened in the absence of the project activities. In that case, the baseline scenario will be continued:

- Use of the facultative pond system to receive wastewater from the current facility;
- Use of heavy fuel oil to produce heat to dry starch;

Total Baseline Emissions:

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

[19] The facility operates 8,160 hr/yr

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 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.

Baseline emissions

Year	$E_{CH4\_lagoons\_BL}$ (tCO2)	$E_{CO2\_onsiteheat\_BL}$ (tCO2)	$E_{conservativeness}$	E_{BL} (tCO2)
2009	61,589	7,899	1,017	68,471
2010	61,589	7,899	1,017	68,471
2011	61,589	7,899	1,017	68,471
2012	61,589	7,899	1,017	68,471
2013	61,589	7,899	1,017	68,471
2014	61,589	7,899	1,017	68,471
2015	61,589	7,899	1,017	68,471
2016	61,589	7,899	1,017	68,471
2017	61,589	7,899	1,017	68,471
2018	61,589	7,899	1,017	68,471
2018	61,589	7,899	1,017	68,471
Total	677,480	86,889	11,191	753,179
Average	61,589	7,899	1,017	68,471

On Site Heat Generation Emissions displaced by generation based on biogas collected in the anaerobic treatment facility

In calculating CO_2 emissions from on site heat displaced by biogas collected in the anaerobic treatment, the use of fossil fuels is considered:

$$E_{C02\_heat} = F \cdot NCV \cdot EF \qquad \textbf{(9)}$$

where:

- **F** is the corresponding amount of fossil fuel used for on-site heat (dm^3 as specified in the tables of the AM0022). This is estimated as product of: 1) Average specific fuel consumption for the output of the facility and 2) the annual production.

- **NCV**$_{fuel\ oil}$ is the net calorific value of the fossil fuel considered (TJ/unit). A default IPCC value for NCV is applied in the absence of a site-specific value[20]. This is 0.0404 TJ/t divided by the density which gives 39.9 x 10^{-6} TJ/dm^3.
- **EF**$_{fuel\ oil}$ is the carbon emission factor of the fossil fuel considered (tCO_2/TJ). This is 77.37t CO_2/TJ for this project.

$E_{CO2heat}$ = 2,552,718 dm^3 fuel oil/yr * 77.377t CO_2/TJ * 39.996x10^{-6} TJ/dm$^3_{fuel}$
$E_{CO2heat}$ = 7,899 t CO_2/yr

On site and/or off site Grid Power Generation Emissions displaced by generation based on biogas collected in the anaerobic treatment facility

No electricity will be generated.

Baseline Organic Material Entering Lagoon System from Starch Facility:

$$M_{lagoon\_input\_BL} = M_{input\_total} \quad \textbf{(10)}$$

where:

- $M_{lagoon\_input\_BL}$ is the value used to specify the amount of organic material flowing into the lagoon system from the CIGAR in the project scenario equation (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.

In the baseline, organic material (COD) from the facility enters directly into the pond system with no degradation of the wastewater before entering the lagoon system and all the organic material to be treated enters the lagoon system. The pond based fugitive methane emissions are quantified by determining;

- How much material enters the pond system;
- How much is lost through aerobic and oxidative processes;
- How much is lost through sedimentation in the pond system; and
- How much is removed through anaerobic processes.

Leakage
As stated in AM0022, leakage is considered to be negligible.

Emissions reductions

$$ER = E_{BL} - E_{project} \quad \textbf{(11)}$$

Where:

***ER*:** Emission reduction (t CO_2e)

E_{BL}: Baseline emissions (t CO_2e)
$E_{project}$: Project Emissions (t CO_2e)
$E_{conservativeness}$: Emissions reduced from conservative clause (t CO_2e)

It must be verified 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:

$$E_{conservativeness} = E_{CH4\_lagoons\_BL} - (E_{CH4lagoon} + E_{CH4\_nawtf} + E_{CH4\_coll}) \qquad \textbf{(12)}$$

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 sum of the biogas sent to the heaters, the biogas sent to the gen sets and the biogas sent to the flare.)

Please see section B.6.4 for a summary of the project activity and baseline emissions and the total emissions reductions.

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

Emissions Reductions Profile

Year	Estimation of Project Activity emissions (tonnes CO_2e)	Estimation of Baseline emissions (tonnes CO_2e)	Estimation of emission reductions (tonnes CO_2e)
2009	20,304	68,471	48,167
2010	20,304	68,471	48,167
2011	20,304	68,471	48,167
2012	20,304	68,471	48,167
2013	20,304	68,471	48,167
2014	20,304	68,471	48,167
2015	20,304	68,471	48,167
2016	20,304	68,471	48,167
2017	20,304	68,471	48,167
2018	20,304	68,471	48,167
2018	20,304	68,471	48,167
Total	**223,340**	**753,179**	**529,839**
Average	**20,304**	**68,471**	**48,167**

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

B.7.1 Data and parameters monitored:

Data / Parameter:	WW_{input}
Data unit:	m^3
Description:	Daily wastewater flows entering system boundary
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1,692
Description of measurement methods and procedures to be applied:	Will be measured continuously with a cumulative flow meter located at the incoming pipe to the CIGAR and reading recorded daily
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / Parameter:	WW_{output}
Data unit:	m^3
Description:	Daily wastewater flow leaving project treatment facility.
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1,607
Description of measurement methods and procedures to be applied:	Will be measured continuously with a cumulative flow meter located at the pipe leaving the CIGAR and reading recorded daily.
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / Parameter:	COD_{input}
Data unit:	kg COD/ m^3
Description:	Wastewater organic material concentration entering the project boundary
Source of data to be	Measured

used:	
Value of data applied for the purpose of calculating expected emission reductions in section B.5	26
Description of measurement methods and procedures to be applied:	Wastewater is sampled and analysed onsite at the facility's laboratory daily.
QA/QC procedures to be applied:	Weekly samples are sent to an accredited analytical laboratory for cross-checking with on-site data to assure accuracy.
Any comment:	
Data / Parameter:	COD_{output}
Data unit:	kg COD/m^3
Description:	Wastewater organic material concentration leaving the treatment facility.
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	6
Description of measurement methods and procedures to be applied:	Wastewater is sampled and analysed onsite at the facility's laboratory daily.
QA/QC procedures to be applied:	Weekly samples are sent to an accredited analytical laboratory for cross-checking with on-site data to assure accuracy.
Any comment:	
Data / Parameter:	V_{heat}
Data unit:	Nm^3
Description:	Volume of biogas sent to facility heaters.
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	13,601
Description of measurement methods and procedures to be applied:	Volume in Nm^3 will be measured continuously by a flow meter and reading recorded daily.
QA/QC procedures to	Biogas meters should be subject to a regular maintenance and testing

be applied:	regime to ensure accuracy.
Any comment:	
Data / Parameter:	V_{flare} (also $FV_{RG,h}$)
Data unit:	Nm^3
Description:	Biogas sent to flare
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	941
Description of measurement methods and procedures to be applied:	Volume in Nm^3 will be measured continuously by a flowmeter and reading recorded hourly.
QA/QC procedures to be applied:	Biogas meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	This parameter is equivalent to the variable FVRG,h (volumetric flow rate of the residual gas in dry basis at normal conditions) as described in the "Tool to determine project emissions from flaring gases containing methane".
Data / Parameter:	C_{CH4} (also $FV_{CH4,y}$)
Data unit:	% of Nm^3/Nm^3
Description:	Biogas methane concentration
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	61.5
Description of measurement methods and procedures to be applied:	Measured continuously by infrared spectrometer and data recorded hourly.
QA/QC procedures to be applied:	
Any comment:	Also referred as $fv_{CH4,h}$ (Volumetric fraction of component i in the biogas in the hour h, where i = CH_4) in the "Tool to determine project emissions from flaring gases containing methane". Only CH_4 will be monitored, the remaining part will be considered as N_2 (simplified approach according to Tool). The monitored value will actually have to be multiplied by the CH_4 density of 0.0007168 $t_{CH4}/m3_{CH4}$ from ACM0001 at normal conditions to obtain the

	value of C_{CH4} in tCH_4/Nm^3.
Data / Parameter:	$Cso_4{}^{2-}{}_{in}$
Data unit:	$Tonnes/m^3$
Description:	Amount of chemical oxidising agents entering system boundary.
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.116×10^{-3}
Description of measurement methods and procedures to be applied:	The wastewater contains SO_4^{2-} which is an oxidising substance. Its concentration in wastewater at the entrance of the treatment facility will be monitored. Samples are collected daily, mixed, and concentration measured weekly. For emission reduction calculations the most recent value from testing will be kept until a new test result is received from the lab.
QA/QC procedures to be applied:	
Any comment:	
Data / Parameter:	$Cso_4{}^{2-}{}_{out}$
Data unit:	$Tonnes/m^3$
Description:	Amount of chemical oxidising agents out of the digester.
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.037×10^{-3}
Description of measurement methods and procedures to be applied:	The wastewater contains SO_4^{2-} which is an oxidising substance. Its concentration in wastewater at the outlet of the digester will be monitored. Samples are collected daily, mixed, and concentration measured weekly. For emission reduction calculations the most recent value from testing will be kept until a new test result is received from the lab.
QA/QC procedures to be applied:	
Any comment:	This is used for the calculation of the project emissions.
Data / Parameter:	$ww_{bypassing}$
Data unit:	m^3
Description:	Flow of wastewater directly to the current water treatment system, and bypassing the new wastewater treatment facility

Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	After commissioning of the project activity, all wastewater will flow from the factory into the CIGAR. In the event that wastewater bypasses the CIGAR and flows directly into the lagoons, this wastewater volume will be measured with a flow meter.
QA/QC procedures to be applied:	Regular maintenance and calibration of the flow meter
Any comment:	

Data / Parameter:	Biogas loss from pipeline
Data unit:	%
Description:	Loss of biogas from pipeline
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1
Description of measurement methods and procedures to be applied:	Integrity of biogas pipeline for losses of biogas methane will be tested annually through pressurizing the system and establishing pressure drops through leakage.
QA/QC procedures to be applied:	
Any comment:	In order to be a conservative, a 1% loss of biogas is used in ex-ante calculations.

Data / Parameter:	$M_{Removed}$
Data unit:	t COD
Description:	Organic material removed from wastewater facility
Source of data to be used:	Calculated
Value of data applied for the purpose of calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be	This parameter will be calculated based on monitored parameters COD_{input} and COD_{output}.

applied:	
QA/QC procedures to be applied:	
Any comment:	
Data / Parameter:	NCV_{biogas}
Data unit:	J/Nm^3
Description:	Biogas calorific value
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	25,870,000
Description of measurement methods and procedures to be applied:	Samples are taken annually and sent to an external laboratory.
QA/QC procedures to be applied:	
Any comment:	The value used for estimations is the result of the product of an estimated 65% of biogas methane content with the NCV of methane of 55.53 MJ/kg and the methane density of 0.7168 kg/Nm^3.
Data / Parameter:	PE_{flare}
Data unit:	tCO2
Description:	Project emissions from flaring of the residual gas stream.
Source of data used:	Data from Project developer and “Tool to determine project emissions from flaring gases containing methane”
Value applied:	1,479
Justification of the choice of data or description of measurement methods and procedures actually applied :	Calculated
QA/QC procedures to be applied:	
Any comment:	
Data / Parameter:	F
Data unit:	dm^3
Description:	Fossil fuel volume equivalent to generate the same amount of heat generated from the biogas collected in the anaerobic treatment facility
Source of data used:	Measured and calculated
Value applied:	7,474

Justification of the choice of data or description of measurement methods and procedures actually applied :	Calculated from the monitored V_{heat} multiplied by monitored NCV_{biogas} and divided by fixed parameter $NCV_{fuel\ oil}$
QA/QC procedures to be applied:	
Any comment:	
Data / Parameter:	f_{heat}
Data unit:	%
Description:	Heating system combustion efficiency
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	91
Description of measurement methods and procedures to be applied:	Annually
QA/QC procedures to be applied:	Boiler is maintained regularly by Weishaupt in order to ensure optimal performance.
Any comment:	There will be 2 boilers used: Bertrams Konus (f_{heat}=87) and Wieslock (f_{heat}=89.5). The average of the two boilers will be considered as overall f_{heat}

B.7.2 Description of the monitoring plan:

>>

This section details the steps taken to monitor on a regular basis the GHG emissions reductions from the project.

Prior to the start of the crediting period, the organisation of the monitoring team will be established. Clear roles and responsibilities will be assigned to all staff involved in the CDM project. The Project Developer will have a designated staff member who will be responsible for monitoring emissions reductions of the project activity. All staff involved in the collection of data and records will be coordinated by the staff member in charge of monitoring. In addition to this staff, qualified personnel will be designated to handle and operate equipment and machinery at the project site.

Monitoring procedures will be established prior to the start of the project. These procedures will detail the organisation, control and steps required for certain key monitoring system features. This will ensure that high quality data is obtained. Specifically, data and records will be checked prior to

being stored and archived. Data from the project will be checked to identify possible errors or omissions.

All data required for verification and issuance will be kept for at least two years after the end of the crediting period or the last issuance of CERs of this project, whichever occurs later. Data will be archived electronically and data backup will be maintained. Paper data back up will also be available.

All equipment will be calibrated and maintained in accordance to the manufacturer's recommendations to ensure accuracy of measurements. Records of calibration and maintenance will be retained as part of the CDM monitoring system.

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

>>

The baseline study was concluded in October 2007 following approval of a relevant methodology, AM0022. The baseline study was conducted by Courtney Blodgett (Courtney@ecosecurities.com) and Chanitra Dokmali (Ning@ecosecurities.com) at EcoSecurities.

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:

>>

28/07/2005[21]

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

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

>>

Not Applicable

C.2.1.2. Length of the first crediting period:

>>

[21] This is 6 weeks before the date of the invoice for milestone 2 from the technology provider. As stated in the invoice, the final budget was provided and the decision to proceed with the project was made.

Not Applicable

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>
01/01/2009 or on the date of registration of the CDM project activity

C.2.2.2. Length:

>>
10 (ten) years

SECTION D. Environmental impacts

>>

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

>>
This project does not require an Environmental Impact Assessment (EIA) under Thai Law. The project has tight project boundaries, with immediate physical impacts focused within these boundaries. These include:

- Dramatic reduction in biogas production and fugitive emissions of biogas from current pond system;
- Improved water quality in these ponds;
- Improved biodiversity impacts within the pond system environs.

Outside these boundaries, impacts felt at a national level include:

- Reduced demand for oil products.

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 positive environmental impacts mentioned above are considered significant, but by their nature are improvements on the current situation, and therefore do not require ongoing monitoring and management.

No significant negative environmental impacts have been identified, apart from the development of the CIGAR, which requires the development of previously unused land. This impact is not considered significant under Thai law, and does not require an EIA. Apart from the utilisation of this scrub-land, no other impacts (e.g., on ground water) or other environmental emissions can be determined.

SECTION E. Stakeholders' comments

>>

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

>>

TBEC invited a number of stakeholders to attend the Public Forum including government officials, local officials, NGOs, members of academia and others. The Public Participation event was publicized via the following channels:

1) Direct invitations: invitation letters were sent directly to the ONEP, Saraburi Industrial Estate, several local newspapers, Bank Thai Securities, Proparco and Owners of the host company as well as one other Starch processing company;
2) Adverts in newspapers: adverts, in English and Thai, informing stakeholders to attend the Public Participation event were placed in 2 different Thai newspapers. **a) Siam Time**, the advert ran for 14 days (in English and Thai) and; **b) Pasuk Post**, the advert ran for 14 days;
3) Word of mouth: TBEC's team spread the word among the local community.

The stakeholder consultation meeting was held 8 October 2005 at the Saraburi Inn in Saraburi. The consultation was attended by 43 people. Presentations were given about the project and TBEC and climate change and the Clean Development Mechanism. After the presentations, a question and answer session was held. Audience member asked questions about carbon credits, the Thai Designated National Authority, the US's lack of involvement in the Kyoto Protocol, the technology involved in the project activity and its applicability to other sectors. All of the questions were satisfactorily answered.

E.2. Summary of the comments received:

>>

No comments were received.

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

>>

Not applicable, given that no comments were received.

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.

ANNEX 3
BASELINE INFORMATION

Inputs				
Value	Data Unit	Data/Parameter	Description	Source
1,692	m^3/day	Q	Daily wastewater volume	Historical data
340	day/year		Operating days per year	Developer
575,280	m^3/year	Q		Historical data
26,099	mg COD / l	COD_{in}		Historical data
1.16E-04	t/m^3	$Cso_4 2\text{-}_{in}$	Concentration of oxidative substance SO_4^{2-} at the entrance of the ww treatment facility	Historical data
3.70E-05	t/m^3	$Cso_4 2\text{-}_{out}$	Concentration of oxidative substance SO_4^{2-} at the effluent of the digester	Historical data
651	kg COD/t	$R\_SO_4^{2-}$	Specific reduction factor for SO_4^{2-} oxidative substance	AM0022 v4
15,014,233	kg COD	M_{input_total}	total amount of org material fed into the new project water treatment facility	Calculated by COD_{in} and amount of ww
2.09	ha	$A_{lagoon\_aerobic}$	surface area of anaerobic lagoons within project boundary	Developer
75.0%	ratio	R_{NAWTF}	org material removal efficiency of the new project water treatment facility	Historical data
96%	ratio	R_{lagoon}	org material removal ratio of the lagoon	Based on COD testing of wastewater entering and leaving the baseline anaerobic lagoons
1.78%	ratio	R_{dep}	org material deposition ratio of the lagoon	Based on pre-project analysis
4,944,280	Nm3	V_{total}	Total amount of biogas produced	Historical data
1%	%	$biogas_{loss}$	Loss from leaks in biogas system	Conservative assumption
319,940	Nm3	V_{flare}	biogas combustion process volume sent to flare	Historical data
4,624,340	Nm3	V_{boiler}	Biogas sent to boiler	Historical data
90.6%	%	$efficiency_{boiler}$	Combustion efficiency	Manufacturer
-	tCO_2e	E_{CH4_NAWTF}	fugitive emisions from new anaerobic ww treatment facility	Assumed to be 0
1,479	tCO_2e	PE_{flare}	PE from PE from flaring tool	Calculated as according to flare tool
39.21	m^3/h	$FV_{RG,h}$	Flow rate of biogas sent to flare	Historical data
61.50%	Fraction	$fv_{(CH4,h)}$	Volumetric fraction of CH4 in the biogas	Historical data
Open	Type of flare		Type of flare	Developer
50%	%	$n_{flare,h}$	Default flare efficiency	In accordance with the flare tool
8160	h	h/yr	Operating hours per year	Developer
7,516,712	dm^3		Maximum amount of fossil fuel displaced by the use of the biogas	Developer
34%	%		Percent to be replaced by biogas	Historical data
2,552,718	dm^3	F	Amount of fossil fuel to be displaced	Historical data
Fuel oil			Fuel type	Developer
3.126	tCO2/t fuel	EF	emissions factor of the fossil fuel	2006 IPCC

Defaults				
0.21	kgCH4/kgCOD	ECH4	methane emissions from the lagoon	In accordance with AM0022
21		GWP	GWP of methane	Marrakesh Accords
254	kg COD/ha	$M_{lagoon\_aerobic}$	amount of org material degraded aerobically in the lagoon system	In accordance with AM0022
7.17E-04	tCH4/m3		Density of methane	ACM0001
3.59E-05	TJ/Nm3		$NCV_{methane}$	Environment Agency
5.01E-02	TJ/tCH4		Energy content of methane at normal conditions	Calculated based methane energy content from EA and density
3.9996E-05	TJ/dm^3 fuel oil		NCV of fuel oil	2006 IPCC default
77.367	tCO2/TJ		EF_{fuel}	2006 IPCC default

Annex 4
MONITORING INFORMATION

Data generated by the monitoring of the parameters relevant for the CDM project activity will be collected on-site and after quality checks transferred to EcoSecurities, who will perform a further quality check and calculate emission reductions.

In addition to the information contained within the main text of the PDD, to ensure the successful operation of the project and the credibility and verifiability of the emission reductions achieved, the project must have a well-defined management and operational system. It is the obligation of the operator to put such a system in place. It must include the operational procedures and responsibilities associated with the monitoring activities and adequate record keeping. In order to meet this requirement, the project developer has implemented ISO 9001 on the site.

Annex 5
SURFACE OXIDATION SENSITIVITY ANALYSIS

Surface Oxidation Factor Sensitivity Analysis

An assessment is carried out here to determine the suitability of the 254kg COD/ha/day surface removal factor.

Surface Oxidation Factor Sensitivity Analysis

Surface Oxidative Removal Rate	Error Factor Applied	Baseline Lagoon Emissions	Sensitivity	Project emissions	Sensitivity	Emissions Reductions Estimated	Sensitivity
kg/ha/day	%	T CO2e	%	T CO2e	%	T CO2e	%
254	-	68,471	-	20,304	-	48,167	-
318	25%	68,270	0.29%	20,103	0.99%	48,167	0.00
381	50%	68,073	0.58%	19,906	1.96%	48,167	0.00
508	100%	67,675	1.16%	19,508	3.92%	48,167	0.00
1,270	400%	65,287	4.65%	17,120	15.68%	48,167	0.00

The purpose of the sensitivity factor is to demonstrate that the surface area oxidation factor does not have significant or measurable influence on the total project emission reductions. A surface area oxidation factor of 254 kgCOD/ha/day was chosen based on the literature, but the sensitivity analysis shows that a higher surface area oxidation factor would not have produced a significant change in the emission reductions. This analysis clearly shows that the emissions reductions calculated are independent of the surface oxidative removal of COD in this project, and thus the 254kg COD/ha/day removal factor is appropriate for this project.

The baseline and project emissions scenarios were calculated using 254 kgCOD/ha/day, as per AM0022. If, however, the surface area oxidation constant were to be increased, emissions reductions would not change significantly. Changes that do occur when applying a higher surface area oxidation constant affect both the baseline and the project emissions such that a decrease in emission reductions is seen in both the baseline and project emissions, but that the difference between the two - the total project emissions - is the same as the total calculated using 254 kgCOD/ha/day. The total emissions reductions when the surface area oxidation constant is increased 100% to 508 kgCOD/ha/day remains constant. In effect, total emissions reductions show 0% sensitivity to the value used for surface area oxidation.

Annex 6

Barrier analysis documentation

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5th November 2007

Khun Chanitra Dokmali
CDM Project Manager
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10330, Thailand

Dear Khun Chanitra Dokmali,

Biogas Plant Operations Training for Thai Biogas Staff

This letter is to confirm that our Mr Neramit Arunkhajornsak provided a detailed training course to staff from the Kitroonruang, Jiratpattana and Chow Khun Agro sites of Thai Biogas Energy Company Ltd on 14 November 2006.

Yours faithfully,
Waste Solutions Ltd

M Campbell-Board

Martin Campbell-Board
Project Manager

Annex 7

REFERENCES

- Biopact. *Thailand encourages biogas production from cassava and palm oil waste*. 2007. http://biopact.com/2007/02/thailand-encourages-biogas-production.html.
- IPCC (2006). Guidelines for National Greenhouse Gas Inventories
- J P Arthur. Notes on the Design and Operation of Waste Stabilisation Ponds in Warm Climates. Urban Development Paper No 6, The World Bank, Washington, USA
- Economist Intelligence Unit. Country Risk: Thailand. 2006. http://store.eiu.com/product/60000206TH-sample.html
- Food and Agriculture Organization of the United Nations International Fund for Agricultural Development. Strategic Environmental Assessment: An Assessment of the Impact of Cassava Production and Processing on the Environment and Biodiversity, Volume 5. 2001.
- Parr, J., Smith, M.D. and Shaw, R.J., "Wastewater Treatment Options", *Waterlines, the Journal of Appropriate Technologies for Water Supply and Sanitation,* April 2000.
- World Energy Council. “Electricity Market Design and Creation in Asia Pacific - Thailand.” http://www.worldenergy.org/wec-geis/publications/reports/emd/status/thailand/default.asp#background. 2005.
- Peña Varón, Miguel Ricardo. Waste stabilization ponds for wastewater treatment. International Water and Sanitation Center. 2003.
- Environment Agency. *Guidance for Landfill Gas Flaring*. 2002.
- Prasertsan, Sajjakulnukit. Biomass and biogas energy in Thailand: Potential, opportunity and barriers.