BIOGAS FROM PALM OIL MILL EFFLUENT: FROM THE FIRST BIODIGESTERS IN THE 80' TO THE CDM (Clean Development Mechanism) PROJECTS POST- 2000

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ABSTRACT

This paper presents a worldwide summary of biodigester showcases in Palm Oil Mills (POM). This recollection analyses the evolution from the 80s up to the current productive/efficient biodigesters running in Honduras (Latin Amercia) and being implemented in Malaysia and Indonesia in 2009.

This new type of projects/biogas plants combine reasonable investment costs with a high revenue creation due to the use of biogas and issuance of carbon credits (CERs) under the CDM framework set up by the Kyoto Protocol. Additionally this latest generation of plants uses the fertilizing value of the biodigester' sludge and treated effluent through ferti-irrigation system in the neighbouring estates.

Average production per Ton of Fresh Fruit Bunch (TFFB):

- *Methane: 15m3 / TFFB*
- *Energy sold or substituted: 50 kWh or 15 L of fuel-oil per TFFB*
- *Issued carbon credits: 0,22 / TFFB*

Biodigester for Palm Oil Mill Effluent (POME) can generate up to 18 USD of yearly incomes or savings per TFFB.

In order to generate and issue CERs the plants must be equipped with relatively sophisticated instrumentation and control systems. BIOTEC's latest generation of plants in South America are all connected to the Internet for online monitoring purposes.

This paper presents real results of different plants in operation.

***Key words**: Biodigester, Biogas, Pail oil mill, POME, CDM, CER, Honduras*

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I. INTRODUCTION

It is general knowledge for the POM in the world that their effluents are a potential source of biogas as fuel. Methane-capture projects, rare and anecdotic in the 80', are common nowadays in several countries. This expansion of biogas projects is not due to the necessity of waste water treatment and contamination removal; existing open ponding systems have given satisfactory results at low cost. The expansion of biogas plants results from economic drivers, in particular due to the implementation of the Kyoto Protocol and its CDM projects. In some cases, investment in methane capture projects is recovered in 5 years. In some other cases, the recovery of investment is achieved in less than 2 years. Some companies have lead the way in building and running profitable and efficient biogas plants. Such plants are usually more sophisticated than most POM.

The second oil crisis in 2005 re-launched in the interest of biogas generation and capture from POME.

The path was not as straight as it seems. 25 years have passed from the beginnings initiated by Sime Darby in Malaysia (beginning of the 80s) and Palmeras del Llano in Colombia (1987) to today's biogas efficient plants such as the ones of Hondupalma in Honduras and Ulu Kanchong in Malaysia. The fluctuations of oil prices, agricultural inputs (fertilizers) and agricultural products (CPO) partially explain this long period of time and slow development.

The boom of biogas technology had to arrive some day considering:

a) The energy value of the biogas: on average. 15m3 of methane equivalent to 15 L of diesel or 40 kg of Palm Kernel Shells (PKS) per TFFB. We can safely consider a production of 1 500 000 m3 of CH_4 (equivalent to 1 500 000 L of diesel) for a POM processing 100 000 TFFB/y.
b) A fertilizer value of treated POME (> 0,7 m3/TFFB) which averages 5 USD/m3 translated in 3 USD per TFFB taking into account nutrients (N, P, K, Ca, Mg and S) and stabilized organic matter
c) International measures implemented through the Kyoto Protocol to mitigate climate change aiming at reducing Green House Gases (GHG) emissions

Environmental contamination generated by agro-industrial effluents resides mostly in their organic and nutrients contents. These elements are part of natural cycles. They do not disappear but they get transformed. When removed from the waste water they usually end up in the atmosphere under a form which is more damaging for the planet than the crude effluents themselves. Methane is a sub-product of these waste water treatment and is one of the main GHG.

As national environmental regulations have focussed on waste water contamination until recently, most of POM in the world emit, in absolute legality, environmentally-damaging GHG (methane) at a rate of approx. 0,2 T of CO_2 per TFFB. Through CDM projects, the capture and combustion of methane enable the generation and commercializatioon of carbon credits. Approx. 0,2 CER per TFFB equivalent to 3 USD / TFFB are robust estimates for well operated POM-biogas projects (estimates calculated using CERs September 2009's prices).

The economic value of POME is high but depends on:

- The possibility to use the biogas locally. In the best cases it substitutes fuel-oil of the neighbouring refiniery or biodiesel plant. It can also replace diesel used in the gensets or electricity bought to the grid for the Kernel Crushing Plant (KCP). In the "worst" case biogas can replace PKS and/or fibre in the biomass boiler. The biomass saved can be sold as fuel in the region. In Malaysia, PKS have a clear market price, approx. 120 RM per Ton in Peninsula Malaysia (equivalent to 35 USD/T of shells). When electricity is generated directly from biogas, the electricty production (50 kWh / TFFB) exceeds usually more than double of what the POM requires to run.

- The potential use of the treated effluent on the palm oil estate. This requires a ferti-irrigation system or a costly logistic of tankers/sprayers. The ferti-irrigation of such valuable effluent per cubic meter cannot be compared to the land application system encountered in Malaysia and Indonesia where ditches are open in the plantation in order to "dispose" the treated effluent at the lowest cost possible without maximizing its fertilizing value.

- The difficult and lengthy CDM process and the complicated verification system (auditing the amounts of emissions reduced and released) compulsory for CERs issuance

The use of the biogas has got a cost. So does the use of treated effluent. CDM processes and requirements are not only costly but also energy and time consuming.

The incomes generated by the usage of POME can vary between:

- Energy: 0 to 10 USD per TFFB
- Fertilizer: 0 to 4 USD per TFFB
- CER: 0 to 4 USD per TFFB
- Total: 0 to 18 USD per TFFB

In a nutshell, incomes of 18 USD / TFFB can sum up to 1,8 million of USD of gross income per year for a small 100 000 TFFB/y mill.
Such income potential deserves at least a tailor made feasibility study for the mill and estate in order to determine its specific conditions, biogas and fertilizing potential, options of uses of the gas and fertilizer, required investment, O&M costs, investment recovery period and the project's pertinence.

II. THE PIONEERS

History is moved by pioneers.
It is important to bear in mind some specific mills which opened the way during the 80s and 90s: Sime Darby Plantations in Malaysia (metallic biodigester tanks in Tennamaram mill), and three small mills in Colombia: Palmeras del Llano (concrete biodigester tank of 750m3), Palmar Santa Elena (concrete biodigester tank of 500m3) and Palmeiras (covered lagoon biodigester of 7 000 m3)

Palmeras del Llano as well as Palmar Santa Elena had already implemented the use of the treated effluent (organic fertilizer) in their estates. The first one did so via tankers, the latter through a micro-aspersion ferti-irrigation system.

The three Colombian mills have generated electricity with biogas adapting their existing diesel engines converting them to dual-fuel engines. The only one which managed this electrical generation in a sustainable way for 10 years (with the same Cummins engine) was Palmar Santa Elena. This achievement was due to the high qualification and commitment of the local team (Eng. Oswalda Granda being the mill manager at this time). The other two mills have faced corrosion problems due to lack of biogas filtration system (H2S and H2O) and tuning problems between power output and fuel mix. However the high diesel savings justified these operational hurdles.

The company Palmeiras enabled the implementation of a double technology leap: in 1999 from concrete (or metallic) biodigester tank it adopted a new system based on covered earth lagoon. The second stage of progress was made 3 years later when the locally adapted dual-fuel diesel engine was replaced by a full biogas engine/generator for the KCP (Conil, 2000).

These three projects implemented in Colombia (1987, 1991 and 1999) were implemented by BIOTEC (www.bio-tec.net).

The Tennamaram mill of Sime Darby focussed on reactor tanks to treat POME (Gilles & Quah, 1984). Biogas usage for electricity production was implemented via a Caterpillar engine (approx. 200kW). However such electricity generation system was abandoned in the later years due to the high O&M costs of the plants, especially the H2S scrubbing system.

The experience gathered in these four pioneer mills, documented in several publications, served to set up the base for large, sophisticated and efficient biogas plants for POM which have been constructed in Honduras and Peru in the last years.

III. CLEAN DEVELOPMENT MECHANISMS

From 2005, the possibility of generating up to 0,2 CER per TFFB (approx. 3 USD/TFFB) through methane capture and combustion has driven several POM to explore this new field.

The environmental pressures exerted on the palm oil sector by NGOs (mainly Europeans) questioning the sustainability of the palm oil production and accusing POM of forests' destruction has driven part of the palm oil sector to create and adhere to the RSPO (Round Sustainable Palm Oil) dynamics. This framework tackles also the question of effluent environmental management, renewable energies (including biogas) and sensible use of fertilization (chemical fertilizers).

The CDM processes are clearly administrative and frankly bureaucratic. The time required to register a project is on average 15 months when the process is handled by specialized companies with specific experience in the methodologies used for the project. This duration of time can be greatly lengthened if the Carbon companies are lacking of specific experience. Both technical project implementation and CDM processes must be carried out in parallel.

However, most of the time, the projects are usually commissioned several months before their CDM registration.

CDM processes generate an extra investment cost of approx. 10% due to the UNFCCC (United Nations Framework Convention on Climate Change) requirements regarding instrumentation and control. This extra cost enables monitoring the project's variables ensuring correct future verifications and due CER issuance.
CDM processes generate an over cost of approx. 100% when it comes to Operation and Maintenance (O&M) of the projects. This extra cost is due to the direct cost of annual verifications but also to the level of monitoring required. This monitoring needs highly trained professionals investing their time in order to ensure successful yearly verifications thanks to reliable data recording of methane capture and combustion.

On the other hand, CDM projects enable POM to achieve a technological and quality management leap. The CDM processes have numerous similarities with ISO processes and newly implemented RSPO dynamics. These processes are tools building the administrative and technical skills of POM. The other strength of the CDM is the focus it puts on O&M, inducing an increase of sustainability in the projects.

To be successful in CDM projects, being a good designer is not sufficient. It is imperative to be a good project implementer and above all, a reliable operator. Revenues come from a reliable and documented monitoring of each cubic meter of methane generated, captured and combusted.

CERs are generated from two sources:

a) The methane capture and combustion
b) Fossil fuel energy substitution through renewable energy (biogas use)

The first source represents 85 to 95% of the CERs generated.

IV. CDM BIOGAS PALM PROJECTS SINCE 2006: REVIEW

2005 was a key year in recent history due to:

a) The sharp increase of oil prices
b) The ratification of the Kyoto protocol and implementation of CDM

This double crisis (energetic and environmental) in 2005 was finally the opportunity, after 20 years, to see the development of biogas plants in the palm oil sector. However this new growth had two main focus targets:

- Large palm oil mills (>30 T/h – 120.000 TFFB/y, with an average size of 250.000 T/y) in order to generate economies of scale and justify the burden of the lengthy CDM process
- CDM framework with at least 30% of revenues of the project coming from the CERs sales

The CDM dynamic required its pioneers too in order to venture into the palm oil sector. Strangely enough, even if Asia produces 90% of the CPO in the world, it is in Latin America where the CDM palm history started. *Table 1* summarises the projects registered in the palm oil sector since 2006. From *Table 1* it appears that in the 27 registered projects since 2006, only 6 have effectively issued CERs and only 3 have issued more CERs than stated in their PDDs. The latter successful fact can be explained by two main factors (Conil, 2006):

1. A solid and reliable design and project implementation
2. A quality operation enabling the maximization of the biogas outputs and an efficient monitoring system

Table 2 presents the verified projects in the world with their respective results.

TABLE 1. BIOGAS PROJECTS REGISTERED IN THE PALM OIL SECTOR (Source: www.unfccc.org)

Registration N°	Date of registration	MILL	Country	Annual milling	Yearly CERs as PDD	Technology provider	Operator	CDM Developer	Methodology	N° of verification at 31-08-2009	CERs issued at 31-08-2009	Verifications periods
492	Sep-02-06	PALCASA	Honduras	120.000 [Ton/year]	27,615	BIOTEC	BIOTEC	OneCarbon	III.H	3	66251	
										#1	12,795	Sep 02/2006 - Mar 31/2007
										#2	28,445	Abr 01/2007 - Feb 29/2008
										#3	25,011	Mar 01/2008 - Ene 31/2009
867	Abr-08-07	Kim Loong Palm Oil Mill	Malaysia	430.000 [Ton/year]	57,656			Vitol S.A Private party	AM0022	0	0	
916	Mar-19-08	TSH Kunak Oil Palm Mill	Malaysia		76,611				AM0013	0	0	
1153	Nov-08-07	Jendarata Palm Oil Mill, Unitata (United Plantations)	Malaysia	45 [Ton/h]	20,271		United Plantations	The Royal Danish Ministry of Foreign Affairs	AM0013	1	55,841	Nov 08/07 - Abr 30/2009
1249	Sep-23-07	El Espino	Peru	30 [Ton/h]	26,716	BIOTEC	El Espino	OneCarbon	III.H	2	34150	
										#1	6,632	Sep 23/2007 - Dic 31/2007
										#2	27,518	Ene 01/2008 - Dic 31/2008
1483	Mar-08-08	Agrotor (Energeticos Jaremar)	Honduras	280.000 [Ton/year]	30,646	BIOTEC	JAREMAR + BIOTEC	OneCarbon	III.H	1	37,806	Mar 08/2008 - Dic 31/2008
1509	Abr-06-08	Extractora del Atlantico - Agrocaribe	Guatemala	220.000 [Ton/year]	30,333		AEROCARIBE	KYOTO Energy Pte Ltd.	III.H	1	12,148	Abr 06/2008 - Dic 31/2008
1616	Jun-17-08	Foong Lee Sawiminyak Sdn Bhd (Perak)	Malaysia	310.052 [Ton/year]	57,094	AES	AES	AES AgriVerde Ltd.	III.H	0	0	
1737	Oct-22-08	Desa Kim Loong Palm Oil Mill	Malaysia	210000 [Ton/year]	38,34			swb Erzeugung GmbH & Co. KG	AM0022	0	0	
1783	Oct-24-08	Bell Palm Industries Sdn. Bhd (Batu Perak)	Malaysia	240.000 [Ton/year]	48,234			Mitsui & co. Ltd.	III.H	0	0	
1888	Sep-27-08	Lekir (Kilang Kelapa Sawit Lekir Sdn. Bhd.)	Malaysia	100 [Ton/h]	33,955	BIOX	BIOX	BioX Carbon BV	III.H	0	0	
1899	Dic-03-08	Pabrik Kelapa Sawit (PKS) Milano Pinang Awan (Sumatera Utara)	Indonesia	298.162 [Ton/year]	33,39	AES	AES	AES AgriVerde Ltd.	III.H	0	0	
1942	May-29-09	Fedepalma (32 Extractoras)	Colombia	_	757,067			Andean Center for Economics in the Environment	AM0013	0	0	
2076	Feb-01-09	Lamthap Factory of Univanich Palm Oil Public Co. Ltd	Thailand		43,651	Waste Solutions	Univanich	Carbon Bridge Pte Ltd	AM0022	1	6,261	Feb 01/09 - Mar 31/09
2130	Ene-16-09	PT Victorindo Alam Lestari (Sumatera Utara)	Indonesia	321.722 [Ton/year]	39,218	AES	AES	AES AgriVerde Ltd.	III.H	0	0	
2148	Feb-09-09	Chumporn	Thailand	320.000 [Ton/year]	23,448				AM0013	0	0	
2181	Ene-26-09	Syarikat Cahaya Muda Perak	Malaysia	525.000 [Ton/year]	67,133			Vertis Environmental Finance Zrt	AM0022	0	0	
2185	Ene-26-09	Sungai Kerang Palm Oil Mill	Malaysia	500.000 [Ton/year]	78,962			Vertis Environmental Finance Zrt	AM0022	0	0	
2313	Feb-14-09	Rinwood - Mukah	Malaysia	80 [Ton/h]	43,152			Pacific Consultants Co.	III.H	0	0	
2330	Mar-20-09	TSH Lahad Datu (Sabah)	Malaysia	210.868 [Ton/year]	33,356			Energimidt Handel A/S	III.H	0	0	
2332	Mar-19-09	TSH Sabahan (Sabah)	Malaysia	362.366 [Ton/year]	53,439			Energimidt Handel A/S	III.H	0	0	
2336	Mar-15-09	Serting Hilir (FELDA)	Malaysia	287.587 [Ton/year]	37,251			EcoSecurities Group PLC.	III.H	0	0	
2421	Jun-30-09	Nubika Jaya	Indonesia		44,181			Mitsubishi UFJ Securities Co.	III.H	0	0	
2542	Jul-18-09	Besout (FELDA)	Malaysia	200.000 [Ton/year]	22,764			EcoSecurities Group PLC	III.H	0	0	
2644	Ago-29-09	Thachana	Thailand	1.000 [Ton/day]	23,844			Mitsubishi UFJ Securities Co, Ltd.	III.H	0	0	
2658	Ago-31-09	Green Glory Co., Ltd.	Thailand	170.000 [Ton/year]	16,916			Marubeni Corporation	III.H	0	0	
2661	Ago-24-09	TOPI (Univanish)	Thailand	330.000 [Ton/year]	41,174			Carbon Bridge Pte Ltd.	III.H	0	0	

TABLE 2. REGISTERED AND VERIFIED PALM CDM PROJECTS SINCE 2006

Registration N°	Date of registration	MILL	Country	Annual milling	Yearly CERs as PDD	Technology provider	Operator	CDM Developer	Methodology
492	Sep-02-06	PALCASA	Honduras	120.000 [Ton/year]	27,615	BIOTEC	BIOTEC	OneCarbon	III.H
1153	Nov-08-07	Jendarata Palm Oil Mill, Unitata (United Plantations)	Malaysia	45 [Ton/h]	20,271		United Plantations	The Royal Danish Ministry of Foreign Affairs	AM0013
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2076	Feb-01-09	Lamthap Factory of Univanich Palm Oil Public Co. Ltd	Thailand		43,651	Waste Solutions	Univanich	Carbon Bridge Pte Ltd	AM0022

Projects registered throughout the years:
2006: 1 (Eecopalsa)
2007: 3, with only two of them being verified (El Espino and Jendarata)
2008: 8, among which only two were verified (Jaremar and Agrocaribe)
2009: 15 until August 31st, only one verified (Univanish)

Out of the 27 registered projects, only 6 have been verified until now. 4 in Latin America, 1 in Malaysia and 1 in Thailand. Three of these projects were implemented by the Belgian company BIOTEC, (pioneer in POM biodigesters in the 80' and 90') and with the carbon development carried out by the ONECARBON.

Table 3 presents the entities in charge of the operation of each project and the related results (estimation of CERs per TFFB).

TABLE 3: OPERATIONAL RESULTS OF VERIFIED PROJECTS

Project	Operating entity	CER / TFFB
Eecopalsa (Honduras)	BIOTEC INTERNATIONAL	0,27
Jendarata (UP) (Malasia)	United Plantations	0,12
El Espino (Peru)	El Espino	0,15
Jaremar	BIOTEC INTERN. + JAREMAR	0.22
Agrocaribe (Guatemala)	Agrocaribe	0,09
Lamthap (Tailandia)	Lamphap	N.A.

Note: projects operated by BIOTEC largely exceed 0,2 CER/TFFB due to three main factors acting jointly:

1. The efficiency of a professional operator
2. A high Chemical Oxygen Demand (COD) in the POME
3. An intensive energetic use of the biogas (through electricity or steam generation) which enables the increase of 10 to 15% the amount of CERs generated and speeds up the investment recovery period of the projects.

It is important to bear in mind that some registered projects are not necessarily in operation and sometimes are not even built yet.

The opposite also happens. Some projects in operation are not necessarily registered or not even validated yet. The last three BIOTEC projects in POM (Exportadora del Atlántico, Hondupalma in Honduras and Ulu Kanchong in Malaysia) entered in operations before the date of their registration. The time required for the UNFCCC registration exceeds usually the time required to implement and commission biogas projects.

General observations:

1. Most of the verified projects (meaning technology which has been proven and the operation process in place meets the UNFCCC monitoring requirements) were developed in Central America. CPO production of this region of the world is small compared to the world totals. However, fossil fuels are expensive in the region and clear mechanisms exist to sell electricity to the national grid at a reasonable price (approx. 0,086 USD per kWh). Finally tax incentives are in place to favour renewable energy projects. This geographic concentration of successful projects is due to the example set by EECOPALSA/PALCASA in Honduras in 2006. This new type of projects propagates through success stories. Finally, the scarcity of quality biogas

technology provider in the world forces them to develop firstly CDM projects close to their bases and offices. No responsible technology provider offers implementing projects in remote locations from their bases. Geographical proximity enables the reduction of the investment (construction costs control) as well as the operation and monitoring costs.

Note: It is surprisingly in Honduras that the first CDM project in the world was registered, in a hydroelectric plant.

2. Very few projects have effectively generated CERs or gone through the process of verification. This process set up by the UNFCCC can be compared to a yearly test where a final verdict (number of CERs issued) determines the profitability as well as the success of the projects. This verdict depends on the quality of design, implementation and operation of the project. Until August 31st, only 6 projects in the world were verified. Among these, 3 were implemented by the same company. This shows that we are only at the beginning of a process.

3. In the CDM-POM sector Asia has started its development after Latin America although Asia represents 90% of the planted areas of palm oil in the world. Malaysia, Indonesia and Thailand have registered the majority of projects in 2008 and 2009. We will know in one to two years whether these projects are successful and how many CERs they are capable of issuing per TFFB.

In Asia, the development of CDM biogas projects started only in 2008 although United Plantations (UP) had lead the way in 2007 using metallic biodigesters to produce biogas for the boiler of its refinery.
The boom of CDM projects in Malaysia and Indonesia in the last couple of years was due to the dynamism of two foreign companies in particular (AES Agriverde (USA) and BioX (Holland)) which offered concessions projects to the POMs. Both companies have nevertheless stopped their biogas activities recently (2008 and 2009) due to:

- Constant changes in the UNFCCC rules
- Fluctuations in CERs prices
- Lack of specific knowledge in the treatment of POME
- Bad financial environment (world crisis)
- An oversimplification of designs in order to cut construction costs
- Dependence on one single income: CERs (their projects rarely included biogas energetic use or treated effluent uses on the estate)

In Latin America, POMs usually contract “Turn Key” projects. Some others, less professional, try building biogas plants with their own resources and management, sub-contracting engineering services and using various providers. Usually, the results of these projects are poor.
In Asia and in Malaysia in particular, agro-industries are usually larger and more structured. They usually do not wish to implement complicated projects which are out of their traditional business framework. These groups usually give their projects in concession to more or less specialized companies or they implement them in Joint Venture framework with the technology provider.

Colombia, being a pioneer in biodigesters development in the palm oil industry in the 80s and 90s, was strangely stuck in this CDM field in the last decade for peculiar reasons. Thanks to the success of the PALMEIRAS project developed by BIOTEC in 1999, the Federation of Palmers (Fedepalma) launched an ambitious and innovative initiative for a grouped registration in the UNFCCC for 32 POM of the country (bundled project). This process took 5 years and culminated in May 29th 2009 with registration of the projects (Registration N° 1942, 750,000 CERs). The peculiar conditions of implementation and verification of such a "bundle" project will be complex. It will take all the administrative capacity and maturity of the Federation jointly with Palmers' common sense to convert this try into a "goal".

V. SOME OPERATIVE RESULTS OF BIOTEC PLANTS IN HONDURAS

These plants/projects have been particularly efficient in methane capture and CERs generation with investment costs below the traditional costly metallic tank technology.

In the following paragraph we will show the results of 3 BIOTEC plants in Honduras, two of them registered and the third one being validated. For the sake of clarity, Honduras is characterised by a pronounced seasonality in FFB monthly milling (4 to 15%).

Besides the importance of quality design and construction, we can observe how crucial the quality of daily operation is. The direct commitment of the technology provider in the operation of the project is definitely a "plus" point in order to achieve the expected results of CERs/TFFB. The operation of these plants under the UNFCCC requirements is usually too complicated for traditional POM for whom the production of biogas and CERs is not the core business. The online monitoring of the plants (via internet) is one of the tools implemented by BIOTEC to optimise operational control and ensure daily consistency and coherence of UNFCCC data.

5.1) EECOPALSA (2006)

This biogas plant was sized for a 100,000 TFFB per year POM, located in Honduras. It has two biodigesters of 7,000m3 each, designed, constructed and operated by BIOTEC. The biogas is used in the biogas engines of 633 kW each which electricity is sold to the grid. The project was contracted under a Turn Key basis.
The project started operations in October 2006 and has been through 3 successful verifications with TUV-Sud as auditor. Its UNFCCC registration number is 492. *Figure 1* summarise the plant's characteristics.

Basic data of this plant are:

- COD / TFFB: 60 kilos
- CH_4 / TFFB: 17,5 m3
- CER / TFFB: 0,27 CER (including electricity generation)
- Gas flared: 26%
- Gas combusted in engines:74%
- Electricity generation: 14.292.900 kWh in 33 months
- kWh / TFFB: 47

Figure 1. Key data of the Eecopalsa plant.

The high percentage of biogas flared comes from the fact that the plant (and electricity generation) was sized for a 20 T/h mill and that currently the throughput has been increased to 30 T/h. Therefore the engines cannot cater for the whole biogas production. *Figures 2 to 6* show key operational results of the Eecopalsa plant since its registration.

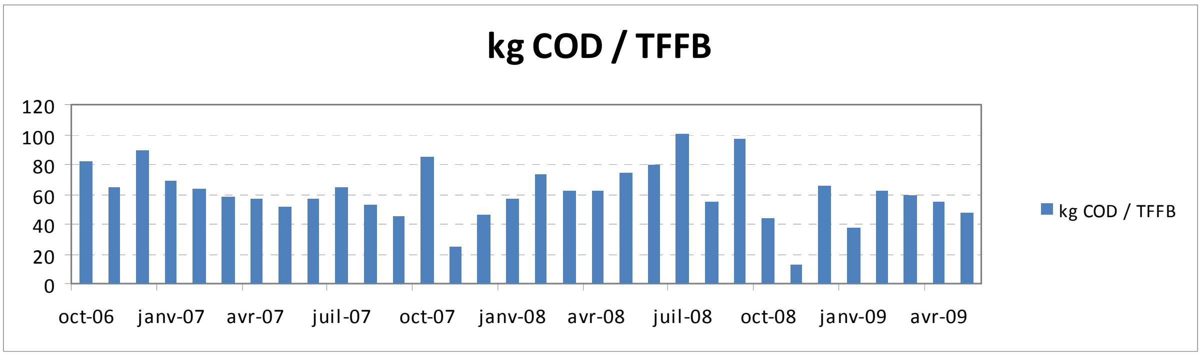

Figure 2. POME organic load per TFFB

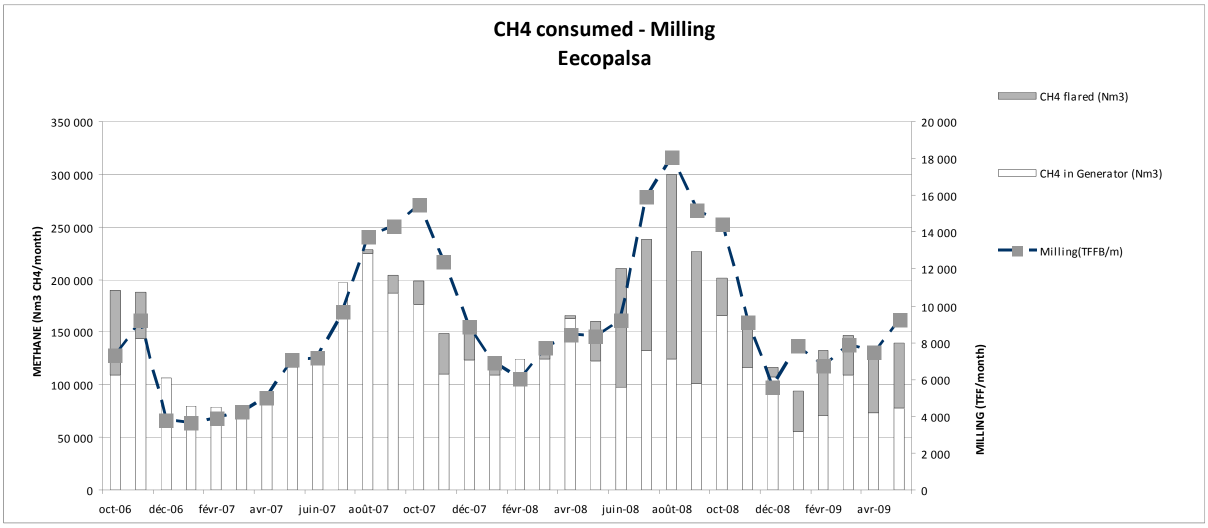

Figure 3. Usage of methane captured

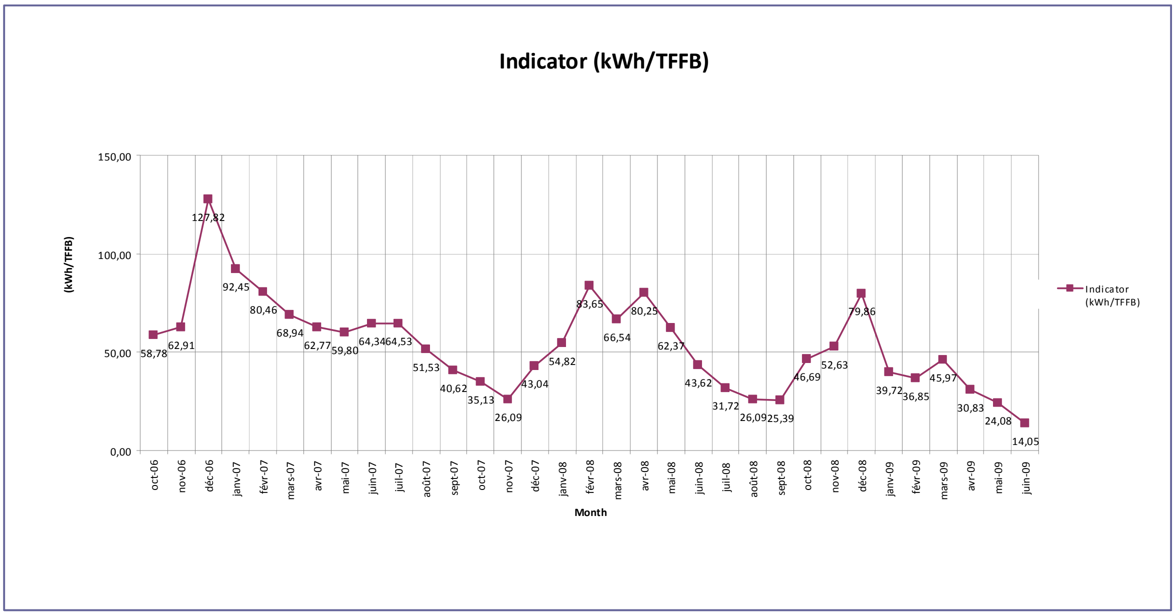

Figure 4. Electricity production per TFFB

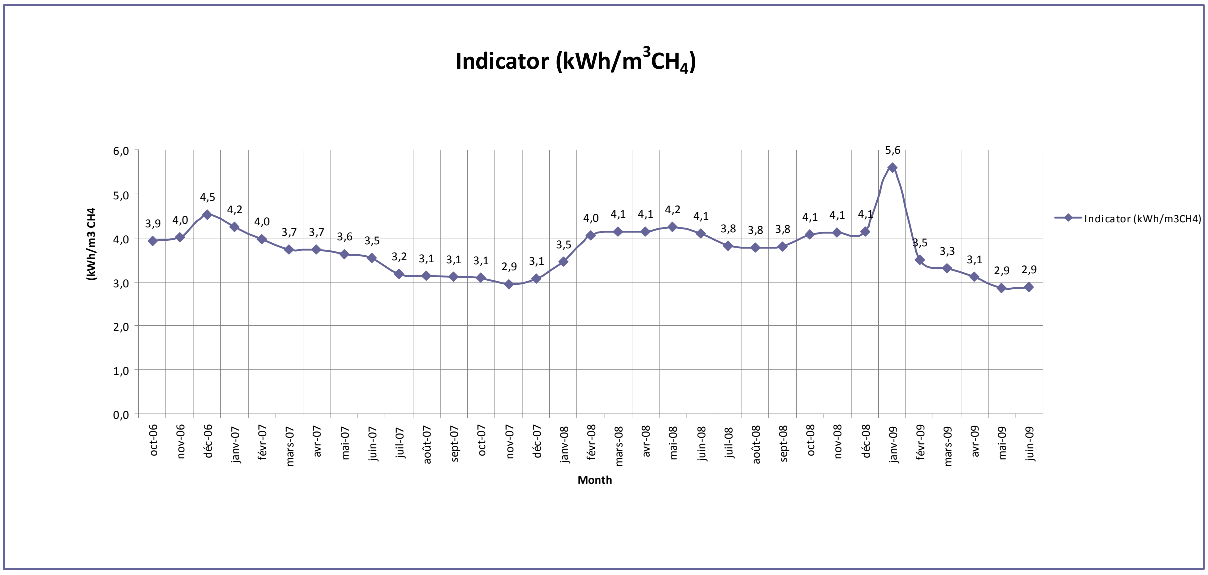

Figure 5. Electricity generated per cubic meter of methane captured

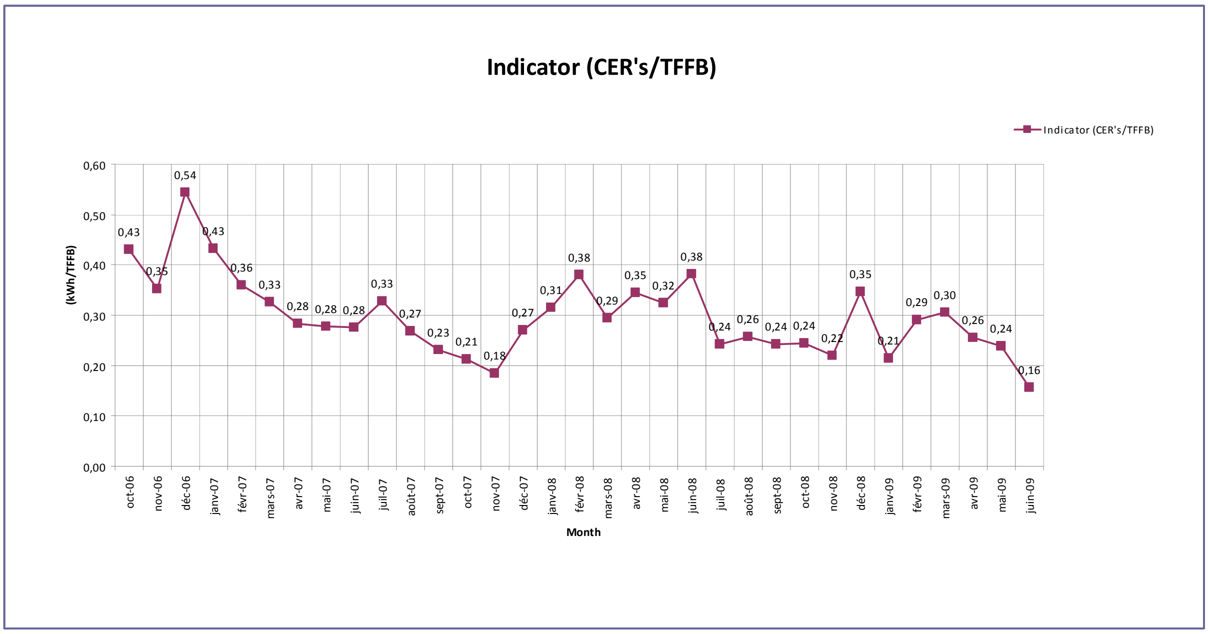

Figure 6. CER generation per TFFB

Comments on operational results:

- The mill presents a high COD concentration per TFFB due to a high POME generation factor (*Figure 2*).
- The electricity generation per m3 of CH4 is fairly constant (*Figure 5*) whereas the electricity generation per TFFB decreases (*Figure 4*). This is due to increase of throughput of the mill for which the biogas plant was not designed for.

5.2) ENERGETICOS JAREMAR - AGROTOR (2008)

This POM processes 280,000 TFFB per year. Biodigester were built via re-engineering existing ponds (12,500m3 each). They are located 2km away from the mill.
The biogas is intensively used for the refinery: steam boiler Cleaver Brooks of 10T/h, package boiler for thermal oil HTT, electricity generation (Jenbacher 830 KW). *Figure 7* summarise the key variables of the project. *Figures 8 to 12* present results of 14 months of operations.

Basic data of this plant:

- COD / TFFB: 65 kilos
- CH_4 combusted / TFFB: 13,4 m3
- CER issued / TFFB: 0,22 CER
- Gas flared: 5 %
- Gas in steam boiler: 64 %
- Gas in package boiler: 13%
- Gas in biogas genset: 18%
- kWh/ m3 CH_4: 3,15

Figure 7. Key variables of Energeticos Jaremar plant

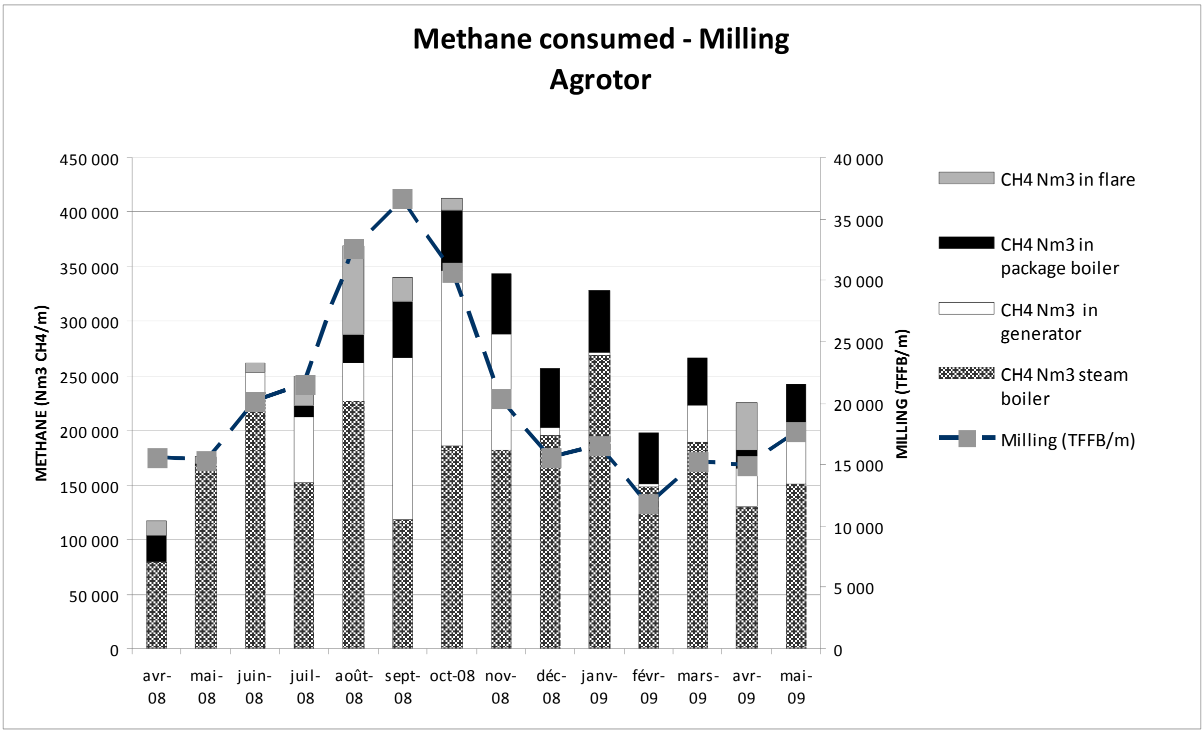

Figure 8. Distribution of biogas usage in the plant

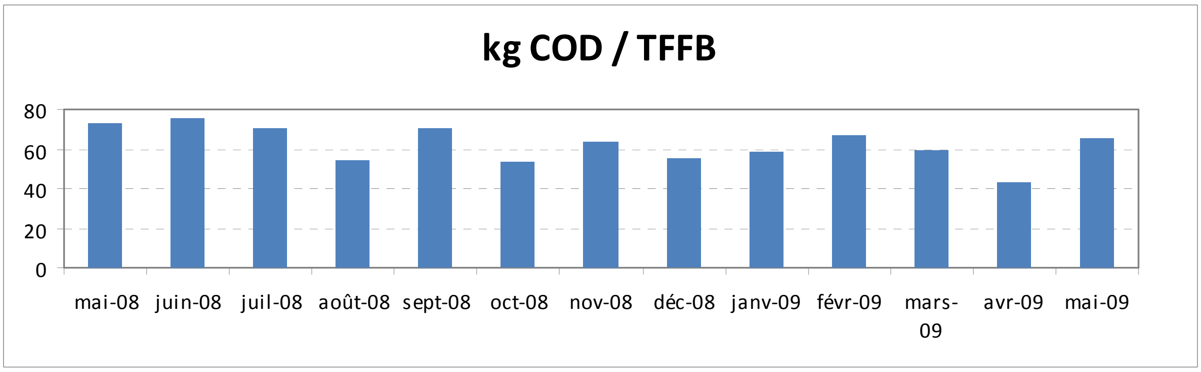

Figure 9. Organic load of POME per TFFB

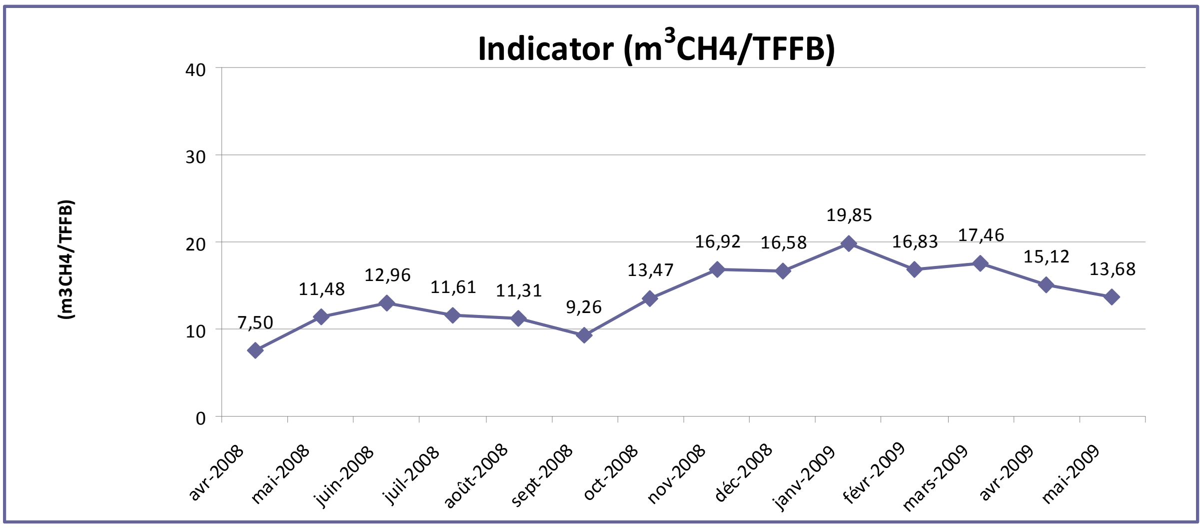

Figure 10: Methane production per TFFB

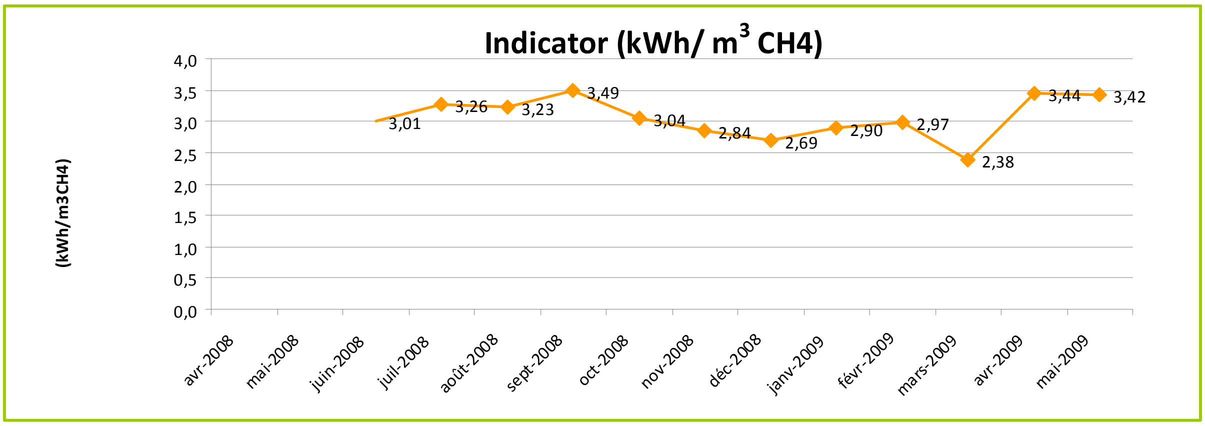

Figure 11. Electricity production per TFFB

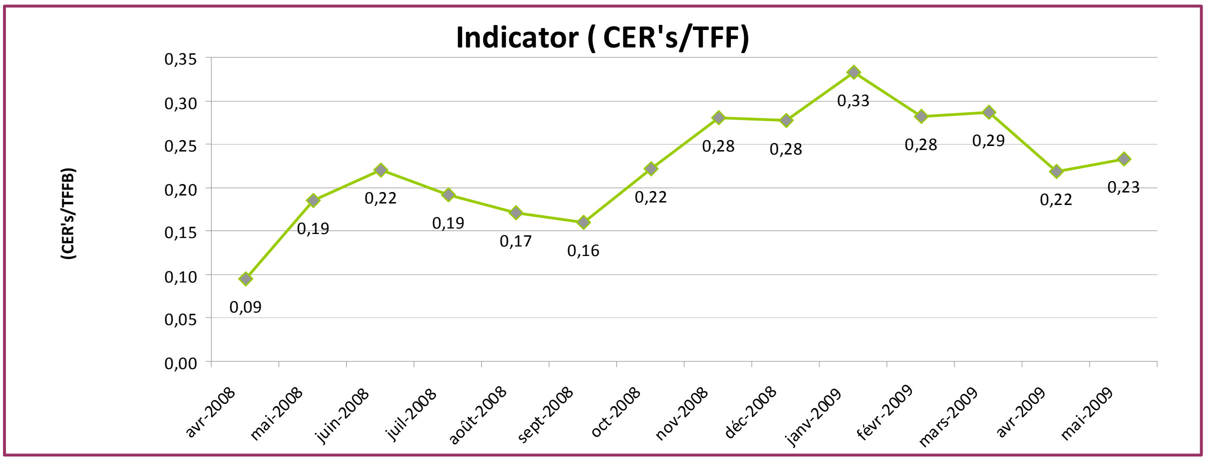

Figure 12. CERs production per TFFB

Comments on operational results:

- The overall indicators are more stable compared to the Eecopalsa plant due to the adequate sizing of the biogas plant with the mill's capacity.
- The general increase of the indicators shows the knowledge and experience acquisition of the plant operators under BIOTEC'supervision.

5.3) AGUAN (2008)

This plant is sized for a 250,000 TFFB/y mill. It has got two biodigesters of 12,000m3 each, designed and constructed by BIOTEC. The plant is operated by BIOTEC jointly with the mill. The CDM process of this project has been abnormally long due to the lack of experience of the CDM developer in regards with this methodology and this type of effluent.
The project was commissioned in September 2008. It has been in operations for a year without being registered yet. *Figure 13* shows the key variables of this plant. *Figures 14 to 18* present key operation indicators results for the last 12 months of operations.

Basic data of this plant are:

- COD / TFFB: 66 kilos
- CH4 / TFFB: 17 m3
- CER / TFFB: 0,24 (only VERs will be issued until registration in the UNFCCC)
- Gas flared: 28% (0 to 85% depending on months)
- Gas combusted in FULTON steam boiler: 70 %
- Gas combusted in GEKAKONUS package boiler: 2%

Figure 13. Key variables of the Aguan biogas plant

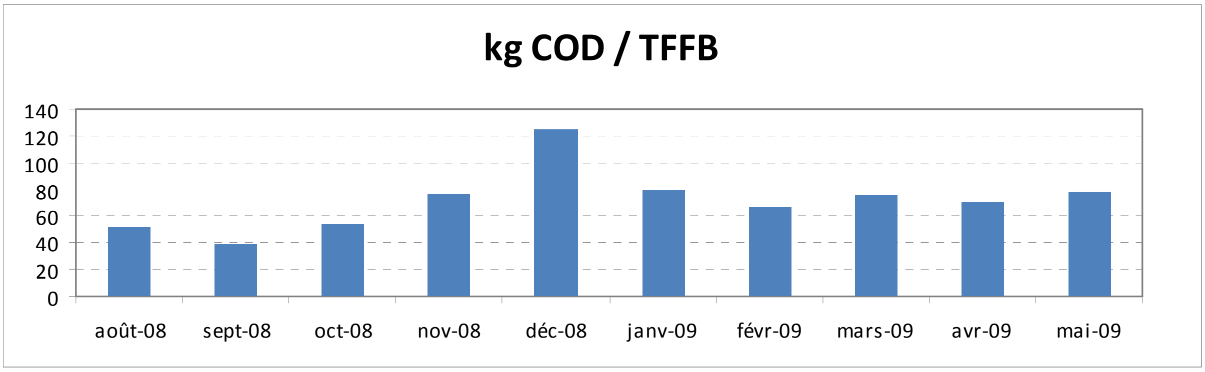

Figure 14. Organic load per TFFB

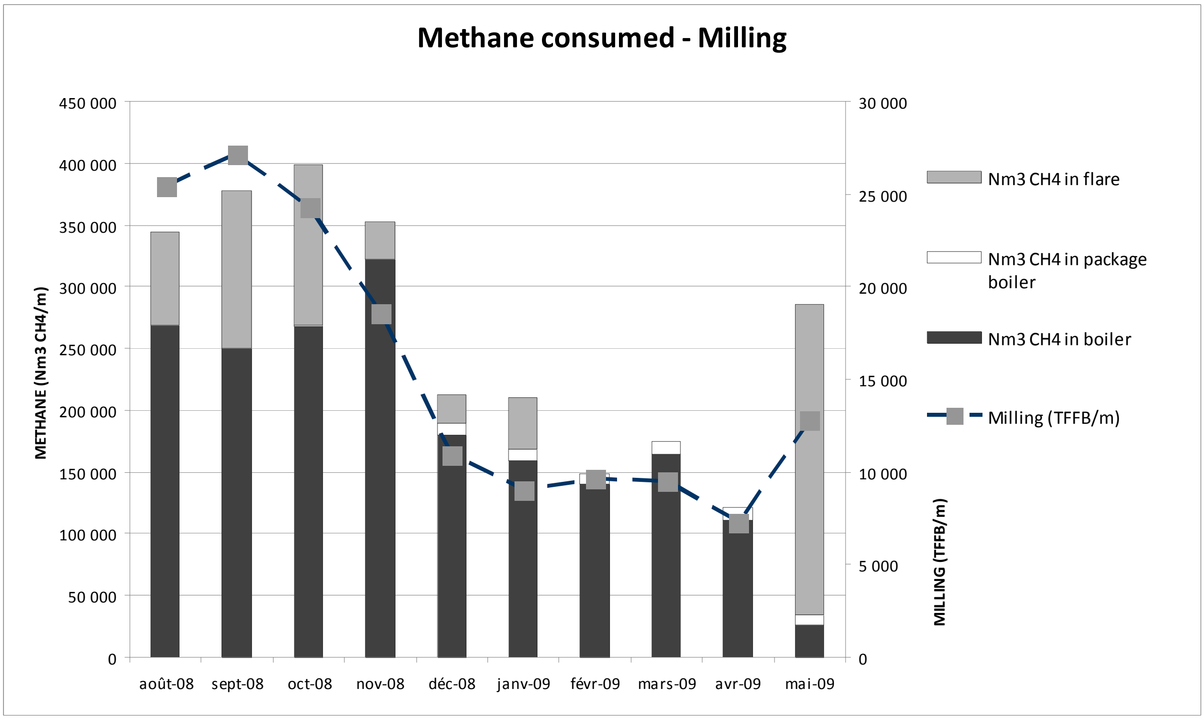

Figure 15. Distribution of methane captured usage in the plant

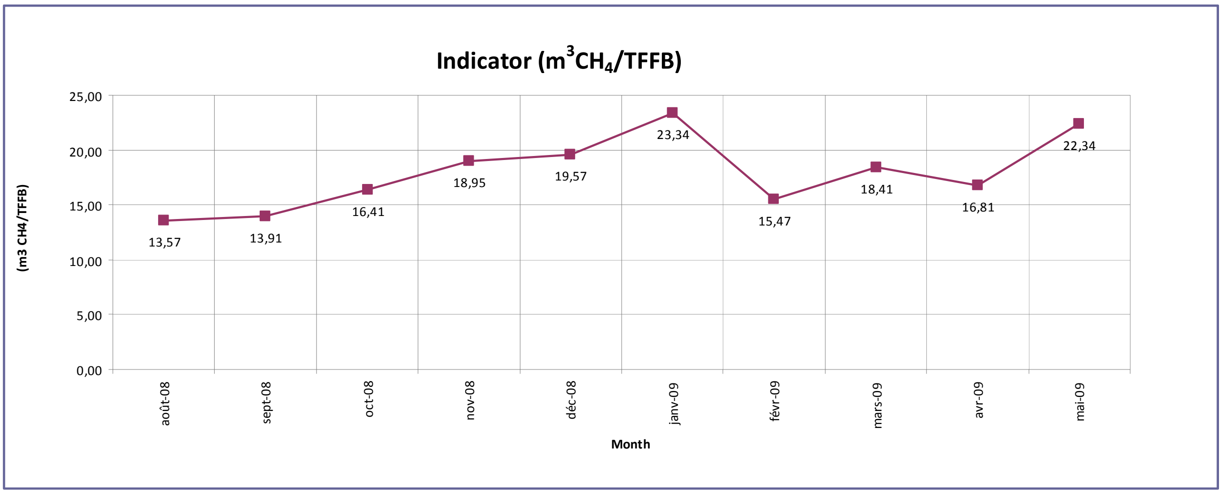

Figure 16: Methane captured per TFFB

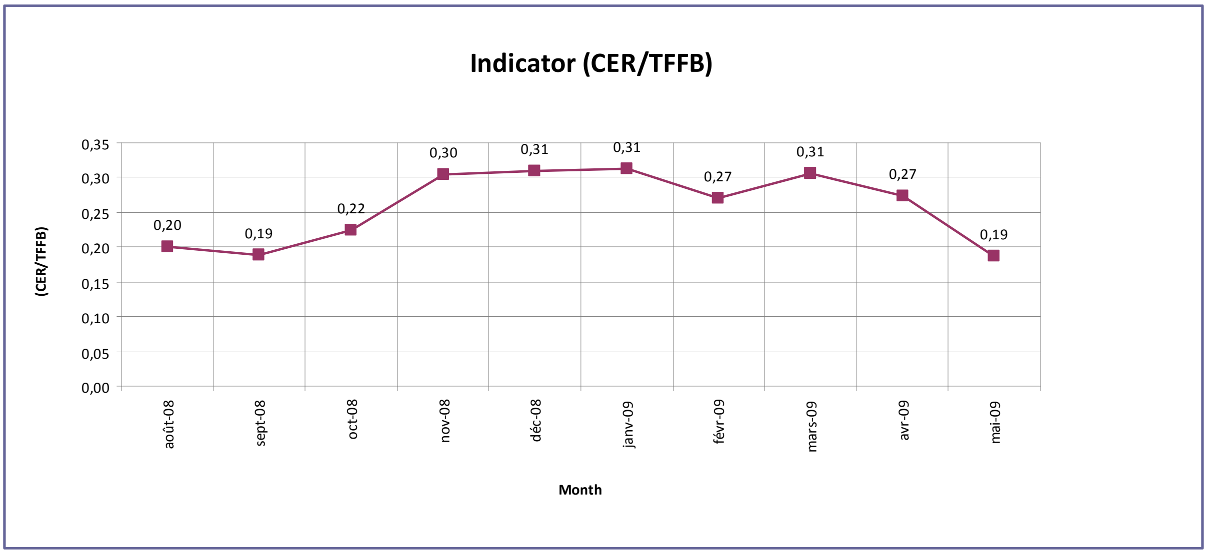

Figure 17. CER production per TFFB

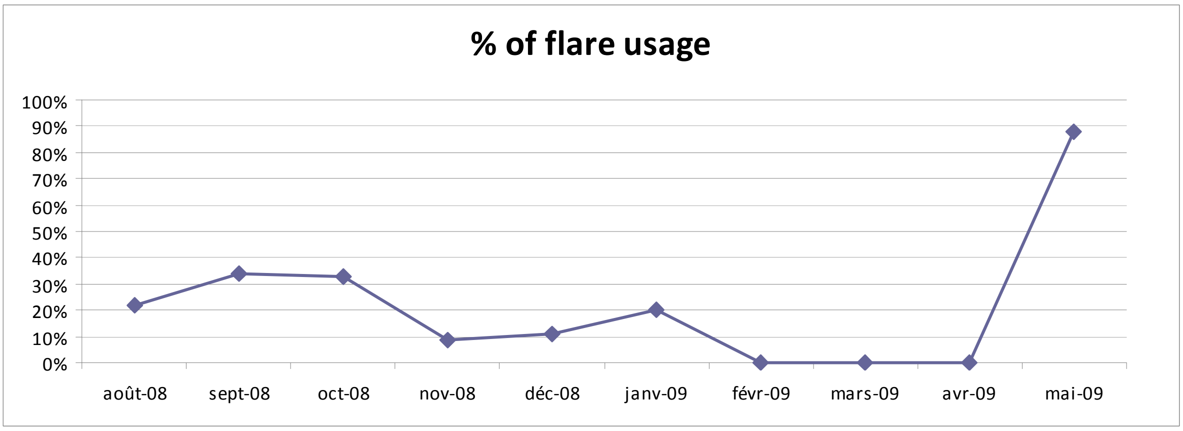

Figure 18. Flare usage

Comments on operational results:

- The steep decrease of biogas production (*Figure 15*) is due to the low cropping season reducing the availability of fruit and thus of biogas capture.

The consolidated results of all the CDM biogas plants implemented by BIOTEC at 30th of June 2009 are presented below.

- *Methane captured: 16,503,743 m3*
- *CERs generated: 246,405 CERs*
- *Fuel-oil or diesel saved: 7,945,420 litres*
- *Electricity generated: 16,395,500 kWh*

VI. CONCLUSIONS AND PERSPECTIVES FOR ASIA

After several biogas projects implementation in POM we can conclude that:

- The COD per TFFB in POM is on average 60 to 65 kg per m3, which is much higher than what is reported in the specialized literature until now. This factor results from the multiplication of the flow (m3/T) by the concentration (kg COD/m3). We are currently observing flows neighbouring 1m3/TFFB on average and a COD of 60 to 65 kg/m3.
- It is crucial to rely on the flare in any biogas project since the biogas production can be superior to consumption. Additionally when the usage points are under maintenance, the excess gas which cannot be accumulated for too long under the flexible covers, must be flared.

Honduras is nowadays the country with the more elevated number of CDM operating biogas plants in POM in the world. Besides the 3 plants shown above, BIOTEC is constructing and operating:

- HONDUPALMA project for the local planters' cooperative (240,000 TFFB/y)
- The extension of the EECOPALSA project justified by the throughput increase of the mill and the profitability of the first stage of the project (implemented 3 years ago)

Malaysia, Indonesia and Thailand are starting to walk the path taken by Latin America. Thailand presents the advantage that it developed biogas technology for other agro-industries previously.

For projects implementation, it is recommended to contract Turn Key projects. These biogas projects seem simple and straightforward at first sight. However they hide numerous technical details and complexities. Providing reliable biogas technology is a unique profession. Additionally it is preferable to involve the technology provider in the operation of the plant. This enables the optimization of the project results (organic load treated by the biodigester, CH4 production per TFFB, capture and combustion of biogas, CER/TFFB).

An innovative and safe way of implementation is the Joint Venture between the mill, the technology provider and a carbon developer. The chair needs to stand on three legs to be stable.

BIOTEC will commission in November 2009 its first CDM biogas project in Malaysia, close to Kuala Lumpur. It is the results of a Joint Venture project between the GTSR group and BIOTEC INTERNATIONAL ASIA Sdn Bhd (807700-A) for the Ulu Kanchong POM. The main characteristics of this Malaysian project are:

- Milling: 240,000 to 300,000 T/y
- Expected CERs issuance of approx. 45,000 T/y
- Biodigester: 32,000 m3
- Biogas use in biomass boilers for biomass savings

This project will be the result of BIOTEC's "biogas experience transfer" from Latin America (22 years of experience in POM) but also CDM experience in biogas plants.

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