2008 CDM/JI Feasibility Study Report

Executive Summary

Title of the feasibility study

CDM Feasibility Study of the "Power generation with waste materials and recovered gas of palm oil mill in Selangau, Malaysia".

Main implementing entity

Smart Energy Co., Ltd.

1. Overview of the project

(1) Host country and the region

Malaysia, Sarawak State, Sibu City, Selangau

(2) Summary of the project

This project aims to build a biomass power plant adjacent to the Selangau palm oil mill. The biomass power plant plans to combust biomass residues from the mill to produce 16MW electricity and 75t/h steam. Generated steam and electricity would be consumed by the mill and remaining electricity would be sold to the grid system, which is owned and operated by Sarawak Energy. The project also plans to collect biogas from Palm Oil Mill Effluent (POME) and combust together with the biomass residues in the CFB boiler. The mill is owned by Rimbunan Hijau (RH) Group and managed by its subsidiary company Ribunan Sawit Berhad (RHB). Selangau mill is expected to increase its Fresh Fruit Bunch (FFB) processing capacity from 60t/h to 120t/h by the year 2011. The mill receives FFB from a plantation, 7km away, which is also owned by RH Group. All the biomass residues for the biomass power plant is expected to be supplied from Selangau mill, thus the project does not depend on sourcing biomass residues from external sources. This proposed project would enable the mill to meet its future energy demand and gain new sources of revenue through sales of electricity, thus diversify its source of income and stabilize its business operation. The project is also expected to improve the local environmental conditions such as air and water qualities. Special Purpose Company (SPC) will be formed by the interested parties, including RH Group, which will build and operate the power plant.

2. Contents of the feasibility study

(1) Objectives of the feasibility study

- **To investigate the present management of fiber, shell and EFB**

  Waste management practices for fiber, shell and Empty Fruit Bunch (EFB) would be investigated to determine the baseline scenarios of the two methodologies used for this project.

- **To investigate the present status of anaerobic lagoon and EFB disposal site**

  Present POME and EFB disposal methods would be investigated to determine the applicability of the baseline scenarios of the two methodologies.

- **To examine the present status and future plan of the grid connectivity**

The present status and future plan of the grid connectivity would be examined to collect information necessary for the determination of the baseline scenario as well as calculation of the emissions reduction.

- **To examine the present status of the captive power generation**

  Confirmation on the present electricity consumption and steam production rate, as well as estimates on the amount of electricity that could be sold to the grid are examined for the baseline emissions calculation.

- **To examine current FFB production and transportation practices**

  Stable supply of biomass residue is essential for the operation of the project, so this study analyzes the supply of FFB from the plantation to the mill. It also examines any leakage emissions related to the transportation of the biomass residues and methods to calculate and monitor such emissions.

- **To evaluate the present operation of the mill**

  There is a seasonal variation to the operation of the mill, which would affect the power generation and power distribution pattern of the power plant. Present FFB processing data of the mill would provide some indication of this variation that the power plant will face.

- **To investigate the Environmental Impact Assessment and Environmental Regulations**

  The project may be required to meet specific environmental standards.

- **To obtain specification of the proposed power plant**

  Part of project emission and baseline emission could be calculated based on the specification of the proposed biomass power plant.

(2) Feasibility study team

This feasibility study was conducted by Smart Energy Co., Ltd. together with the assistance of the following parties:

Japan:	**Sumitomo Heavy Industries Ltd.**	Examined the design of the power plant including its technical aspects
Malaysia:	**Rimbunan Hijau Group**	Gathered information regarding the mill and the plantation, which was required for the project development.
	Titan Energy Sdn. Bhd.	Assisted field studies and advised on the technical aspects of the proposed power plant.

(3) Result of the feasibility study

■ Present management of Fiber, shell, and EFB

Biomass residues	Annual production	Handling method
Shell	14,000t	Used as a fuel for the captive power plant
Fiber	32,000t	Used as a fuel for the captive power plant
EFB	42,000t	Small proportion used for mulching, rest are disposed
POME	90,000t	Treated in an anaerobic lagoon. Treated effluent is discharged to the river.

■ Present status of anaerobic lagoons and EFB disposal site

POME is treated using 6 lagoons. The final treated effluent has never been discharged to the river since the beginning of the operation of the mill. The final lagoon is still half empty. The lagoon is designed to meet the environmental standard of final effluent with BOD of 20mg/l. The measurement required for the baseline design will be conducted at a later stage.

Fraction of the EFB is sent back from the mill to the plantation by tucks for mulching, but this is only very small portion of the EFB and the rest is buried inside the valley behind the mill.

■ Present status and future plan of the grid connectivity

The long transmission lines, such as over 10km, prior to the connection to the main grid would have significant electricity loss that would create discrepancy between the power supplied to the gird and the Renewable Energy Purchase Agreement (REPA). Therefore, Sarawak Energy demands the meter (for the power purchase) to be placed immediately before the connection to the main grid. The transmission line to the main grid for the project is expected to be less than 10km, but Sarawak Energy would still desire the meter to be immediately before the connection to the main grid.

■ Present status of the captive power generation

The electricity for the mill is supplied by 1.6MW steam turbine generator. There is also a diesel generator for a back up. Steam generated from the boiler during the FFB processing is used for the 1.6MW power generation, but when the mill is not in operation, such as during night time and the weekends, back up diesel generator is used to generate electricity. RSB is planning to expand its FFB processing capacity from 60t/h to 120t/h, but this will require 2MW of electricity. Also 1.5MW is required for the PKS crushing plant.

■ FFB production and transportation practices

Roughly 80% of the FFB that is processed in the Selangau mill comes from RSB plantations. The nearest 5 year old Selangau plantation supplies FFB to the mill. Area of the plantation is 5824ha, of which 3350ha is suitable for plam oil plantation. 3000ha has mature palm oil, and the remaining 350ha has been planted only recently. The plantation is located on a hilly, terrain thus the production of the FFB is lower compared to a plantation on a flat terrain.

■ **Evaluation of the present operation of the mill**

Selangau mill is now processing 180,000tons of FFB per year, and it is expects to increase its annual FFB processing amount to 500,000ton by year 2013. The annual FFB production variation is around 30%, but since the processing amount is on its increase, the increase of FFB production is exceeding 30%.

At the moment, the mill has a FFB processing capacity of 60t/h which has the maximum output of 300,000tons of FFB per year (5000 operational hours). For the mill to process 350,000tons of FFB in year 2011 as planned, it needs to install 120t/h FFB processing facility in year 2010.

■ **Environmental Impact Assessment and Environmental Regulations**

Gas Emission	Environmental Quality (Clean Air) Regulation, 1978
Wastewater regulation	Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979
Lubricating oil	Environmental Quality (Scheduled Wastes) Regulations, 2005
Toxic Chemicals	Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979

The two main government departments responsible for the environmental regulation concerting the project are Department of Environment (DOE), which is under the federal government and Natural Resources and Environment Board (NREB), which is under the state government. DOE controls the environmental regulation of the palm oil mill, such as stack emission and POME management, whereas NREB is involved in regulation on palm oil plantation management such as prohibition of open burning.

■ **Sspecification of the proposed power plant**

CFB Boiler

The circulating air flow, within the boiler, enables combustion of small and large materials. The air blows up from the bottom of the boiler and circulates vertically to enable the combustible materials to distribute throughout the boiler for efficient combustion. Three main characteristics of the CFB boiler are:

1) Wide variety of combustible materials
2) Ability to combust waste materials
3) Low combustion temperature

Anaerobic digester

Sumitomo Heavy Industries have installed an anaerobic digester system to FELDA in Peninsular Malaysia. Since then, the system has developed to tackle POME with characteristically high levels of Suspended Solids (SS), and Fats, Oils and Grease (FOG) by improving the skimming technology. Its performance is stable under long Hydraulic Retention Time and achieves efficient mesophilic fermentation. It is a tank system, thus it does not require any cleaning of the lagoon, requires very little maintenance and is durable. Its overall high efficiency achieves high operational performance.

3. Summary of the CDM feasibility study

(1) Identification of the project boundary and baseline

Methodology selection process

The project archives emissions reduction through ①Avoidance of methane emission through alternative use of EFB as a fuel, ② Avoidance of methane emission from the anaerobic lagoon, by collection biogas to a tank, and ③ Providing renewable energy to replace grid electricity from the fossil fuel fired power plants. Two methodologies, "ACM0006 Consolidated methodology for electricity generation from biomass residues" and "ACM0014 Mitigation of greenhouse gas emissions from treatment of industrial wastewater" were selected. Small scale methodologies were not chosen as the emission reductions was expected to exceed 60,000tCO_2/y.

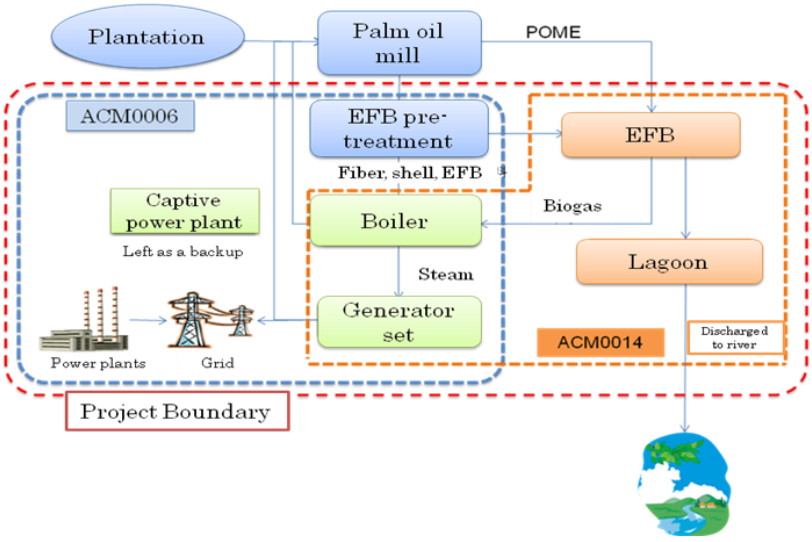
Emission Reduction Method		Methodology Number	Methodology title
①	Avoidance of methane emission from alternative EFB waste management	ACM0006	Consolidated methodology for electricity generation from biomass residues (Version 6.2)
②	Replacement of fossil fuel generated grid electricity to the one generated from biomass energy		
③	Avoided methane emission from the POME	ACM0014	Mitigation of greenhouse gas emissions from treatment of industrial wastewater (Version 02.1)

Grid electricity replacement

Emission reductions for the replacement of fossil fuel generated grid electricity to the one generated from biomass energy (grid electricity replacement) is calculated using the methodology ACM0006 and not ACM0014 although this methodology could also account for replacement of grid electricity, since biogas energy is used for electricity generation. The CFB boiler use both biomass and biogas to generate electricity. The renewable electricity generated derives from both biomass and biogas, thus the amount of electricity that replaces grid electricity, which is calculated in ACM0006 also contains the electricity generated from the biogas (i.e. ACM0014). Therefore, in order to prevent double counting, only the ACM0006 was used to calculate the emission reductions due to the replacement of grid electricity with renewable energy.

Boundary

This project use two methodologies, thus project boundary for each methodology must be determined.



The red boundary of the graph indicates the boundary for this project activity.

Selection of the baseline scenario

Selection of the baseline scenario for ACM0006

Applicability of baseline scenario for ACM0006

	Applicability	Project Status	Applicable scenario
Project	With/without cogeneration	With Cogeneration	1,2,3,4,7,8,10,11,12,13,14,15,16,17, 18,19,20
Baseline	Power supply method	Power generated using biomass residues from the palm oil mill	9,10,11,12,13,14,16,18,19
	Use of biomass	Fiber and PKS – as fuel EFB – Disposed to landfill	2,3,5,7,10,15,16,17,20
	Heat generation	Heat generated using biomass residues from the palm oil mill	3,12,16,20

Table above show that the only baseline scenario that are applicable for this project activity is scenario 16. The baseline scenario of the project activity is "cogeneration with biomass residues", but the scenario 16 only identifies "boiler with biomass residue" as an applicable project. However, scenario 16 mention that "biomass residues would in the absence of the project activity (partly) be used for heat generation in boilers at the project site and may, in addition, partly be used in the existing power plant(s)", thus it was concluded that scenario 16 would be used as a baseline scenario.

Selection of the baseline scenario for ACM00014

Applicable ACM0014 baseline scenario for the project activity was selected.

Applicability of baseline scenario for ACM0014

Scenario	Requirements	Applicability	Comment
1) The wastewater is not treated, but directed to open lagoons that have clearly anaerobic conditions	The wastewater is treated in a new anaerobic digester.	○	Anaerobic digester tank is planned to be installed.
	The biogas extracted from the anaerobic digester is flared and/or used to generate electricity and/or heat.	○	Biogas is going to be used for cogeneration.
	The residual from the anaerobic digester after treatment is directed to open lagoons or is treated under clearly aerobic conditions (e.g. dewatering and land application).	○	The POME must meet the environmental regulation of BOD of less than 20mg/l, prior to the release of wastewater to the river, thus the effluent from anaerobic digester must be treated.
2) The wastewater is treated in a wastewater treatment plant. Sludge is generated from primary and / or secondary settlers. The sludge is directed to sludge pit(s) that have clearly anaerobic conditions.	The wastewater is treated in the same wastewater treatment plant as in the baseline situation.	×	The project plans to install a new anaerobic digester.
	The sludge from primary and/or secondary settler is treated in one or both of the following ways:		
	1) The sludge is treated in a new aerobic digester. The biogas extracted from the anaerobic digester is flared and/or used to generate electricity and/or heat. The residual from the anaerobic digester after treatment is directed to opens lagoons or is treated under clearly aerobic conditions.	○	The sludge is treated in the anaerobic digester together with the wastewater.
	2) The sludge is treated under clearly aerobic conditions.	×	The sludge is treated in the anaerobic digester together with the wastewater.

The analysis above indicates that scenario 1 of ACN0014 is the most appropriate scenario for the project activity.

Leakage

No leakage is estimated for ACM0014. Methodology ACM0006 identifies "an increase in emissions from fossil fuel combustion or other sources due to diversion of biomass residues from other uses to the project plant as a result of project activity" as a main source of leakage. For the case of this project, leakage may happen if increase in the use of EFB due to the project activity affects other operators that utilize EFB for power generation. The project demonstrated that the project activity did not cause any increase in fossil fuel consumption, outside of the project boundary, by identifying that in Sarawak State, the amount of EFB that is underutilized is more than 25% of what is being utilized.

(2) Monitoring Plan

This project activity requires monitoring of data and parameter for the two methodologies (i.e. ACM0006 and ACM0014). The main monitoring data and parameters for ACM 0006 includes quantity of biomass residues combusted in the project plant, the amount of electricity and steam generated, the amount of electricity sold to the grid, and the amount of electricity consumed for the pre-treatment of EFB. The main monitoring data and parameters for ACM0014 includes, COD values of the POME, the quantity of POME treated, the quantity of biogas collected, and the amount that was flared. This project is not planning to use trucks to transport biomass residues or apply sludge to a land, but these are accounted in the monitoring plan just in case such activities do happen.

(3) GHG emission reductions

The table below shows the expected emissions reduction of the project activity

Year	ACM0006					ACM0014			Emission Reductions (e+C)
	a.	b.	c	d.	e.	A	B	C	
2011	0	56,476	12,906	1,739	67,642	56,236	29,944	26,292	93,934
2012	0	73,416	26,929	2,162	98,183	69,893	37,216	32,677	130,860
2013	0	86,370	41,157	2,485	125,042	80,337	42,778	37,559	162,601
2014	0	86,370	53,160	2,485	137,045	80,337	24,117	37,559	174,605
2015	0	86,370	63,287	2,485	147,172	80,337	24,117	37,559	184,731
2016	0	86,370	71,830	2,485	155,716	80,337	24,117	37,559	193,275
2017	0	86,370	79,038	2,485	162,923	80,337	24,117	37,559	200,483
2018	0	86,370	85,119	2,485	169,005	80,337	24,117	37,559	206,564
2019	0	86,370	90,250	2,485	174,135	80,337	24,117	37,559	211,694
2020	0	86,370	94,578	2,485	178,463	80,337	24,117	37,559	216,023
Total					**1,415,326**			**359,443**	**1,774,773**
Annual Average					**141,533**			**35,944**	**177,477**

a. Heat energy replacement
(baseline is also renewable energy)
b. Grid electricity replacement
c. Avoidance of methane emission from biomass residues
d. Project emission
e. ACM0006 emission reductions (a+b+c-d)

A. Avoidance of methane emission from lagoons
B. Project emission
C.ACM0014 emission reductions (A-B)

(4) Project duration and crediting period

The project lifetime is expected to be 15 years, so the 10 year crediting period was chosen, starting from year 2011 up to 2020. The start of the crediting date is same as the start of the operation of the biomass power plant and it is planned to be on 1st of January 2011.

(5) Environmental impacts and other indirect effects

There is no legal requirement to conduct Environmental Impact Assessment (EIA) for the project. However, the project developer must submit Site Evaluation Report (SER) to the local Department of Environment (DOE). Also, "Stack Emission Monitoring Report" and "Wastewater Monitoring Report" must be submitted to the DOE on annual basis. The palm oil mill is already submitting the Stack Emission Monitoring Report to the local DOE, but it has not submitted the Wastewater Monitoring Report, because the lagoon is still not full and it has not released the treated POME to the river. SER must be submitted to obtain authorization from the DOE for the construction of the biomass power plant. It is expected for the construction to start from July 2009, so the SER must be ready by then. SER should be included in Section D (Environmental impacts) of the PDD.

(6) Comments received from the stakeholders

Local communities and the Stakeholder meeting

Stakeholder meeting was held on 8th of December 2008, which is required for the PDD, and also social survey was conducted to obtain information regarding the local communities. There was a request from the local community to hold a second stakeholder meeting explaining the technology and environmental impacts after the technical specification of the biomass plants are finalized. The co-benefits, which the local communities could receive includes improvement of local water and air quality that are long term effects. It is important to hold several meetings with the local communities for them to understand these long term and intangible benefits.

(2) Comments received during the field studies

Sarawak Energy Berhad

Attendee(s): Leslie Chiai Kim Pau, Senior Manager, Renewable Energy
Goh Wei Chiun, Electrical Engineer, Renewable Energy

Comments:

- The most realistic renewable energy for the Sarawak Energy is biomass energy and especially palm oil biomass residues.
- This project use the palm oil mill and the plantation, which both of them are owned by RH Group. This means that stable and reliable supply of EFB could be obtained for the biomass power

generation.

- Sarawak Energy would like the metering of the renewable energy power generation (for the power purchase) to be immediately before the connectivity to the main grid.

Department of Environment (DOE), Sibu office

Attendee(s): Ching Yuan Kong

Comments:

- The environmental concerns of the project activities for the DOE are Air pollution, chemical pollution (if chemical is used for the pre-EFB treatment process), water pollution, and handling of waste lubricating oil. The regulation for these pollutants is stated in the Environmental Quality Act and Regulation.
- The expected benefits from the project are creation of jobs, technology transfer and development of efficient palm oil biomass waste management method.

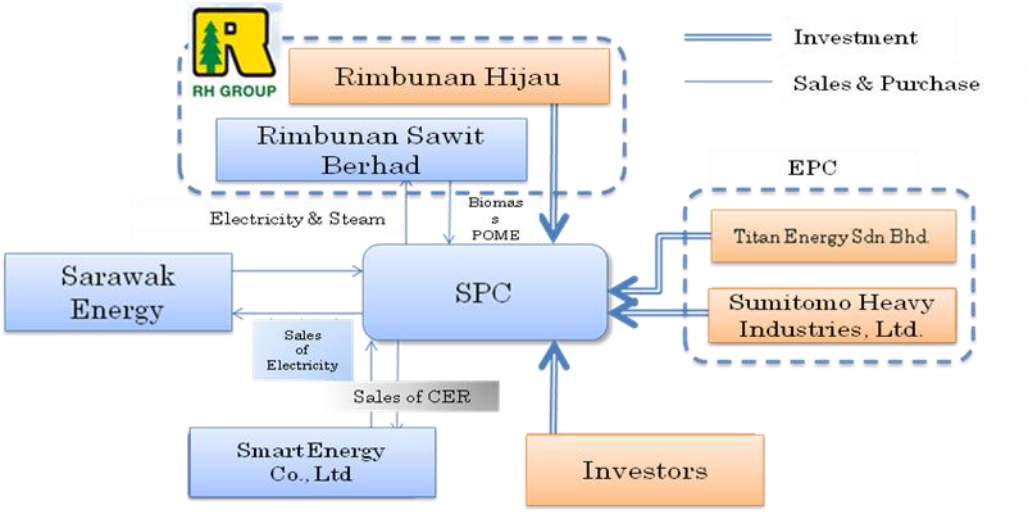
Natural Resources and Environment Board (NREB)

Attendee(s): Elizabeth Nyomek, Regional Environmental Control Officer

Comments:

- EFB is left out for mulching, but this produces termites and pests that is not good for the health of the workers
- NREB is interested in seeing the future development of the biomass power plant project.

(7)Project implementation



Implementation structure for the biomass power plant project

The overall structure of the project implementation is as indicated in the diagram above. Special Purpose Company (SPC) will be set up to own, operate and manage the biomass power plant. Potential investors would be able to make investment decision after the technical specification and the total capital cost of the project are finalized.

(8)Financial plan

The table below is the schedule for the project. CDM development and investment negotiation are conducted in parallel to achieve start of construction of the power plant by 1st quarter of year 2010.

Project implementation schedule

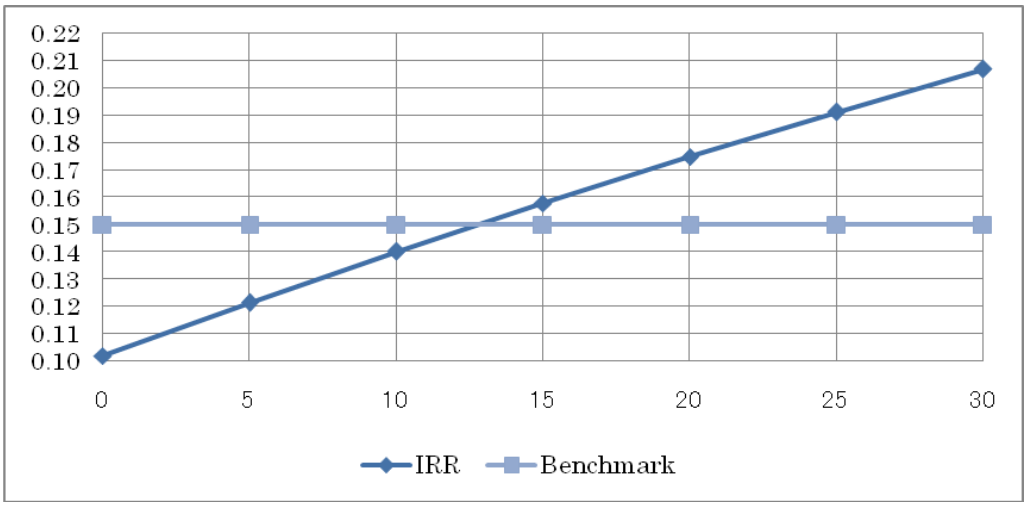
	2Q09	3Q09	4Q09	1Q10
Decision on plant specification and capital cost	→			
Seek for investment	→	→		
Negotiate with potential investors		→	→	
Start construction of the power plant				★
Modification of the PDD after decisions are made for the plant specification	→			
Host country approval		→		
Validation		→	→	
Executive Board meeting			→	

(9)Economic feasibility analysis

Assumptions

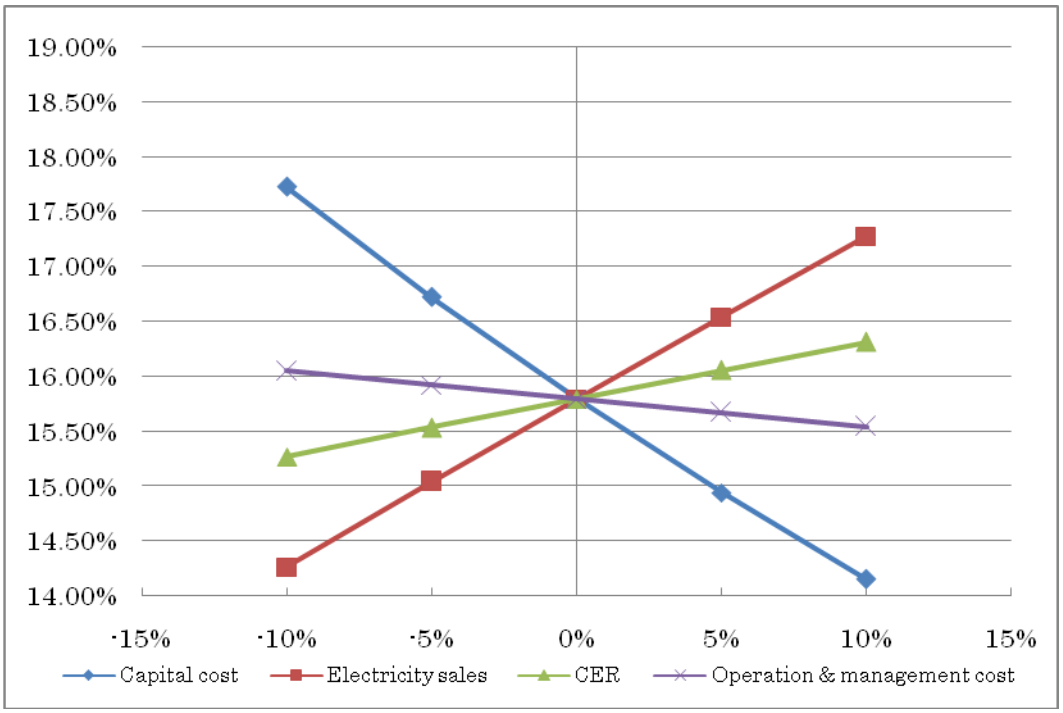
- Sales of electricity: 0.057USD/kWh (RM/kWh 0.18)
- Capital cost: 28million USD
- Tax: 28%
- Palm mill operational hours: 5000hours
- Power plant operational hours: 8000hours

Internal Rate of Return (IRR): 10.2% without CER, 15.8% with CER (at 15USD/tCO_2e)



Without the CER, IRR of the project is 10.2%, which does not meet the benchmark IRR of 15%. For the project to achieve the bench mark IRR of 15%, the CER price must be over 12.73 USD/tCO_2e. The benchmark of IRR15% was used by the Malaysian government for its research. (Ministry of Water, Energy and Communication/Malaysia Energy Centre/DANIDA. Study on the CDM potential in Waste Sectors in Malaysia, 2005.)

Sensitivity analysis



The sensitivity analysis shows that the cost of the project plant and the revenue from the sales of electricity are the two main determinants for the economic viability of the project.

(10)Assessment of additionality

Technology barrier

This project is the first of its kind in Sarawak state to use CFB boiler to combust palm oil residues and generate electricity and steam. There is not enough knowledge and capacity to build and operate CFB boiler in Sarawak, thus there is a technology barrier, which prevents realization of the project. CDM allows technology transfer from Japan to Sarawak state and enable implementation of the project activity, thus this project is additional.

"Combined tool to identify the baseline scenario and demonstrate additionality" was used to analyze the additionality of the project for methodology ACM0006.

Step1 **Alternative scenario**	**Power generation (P1-9)**	**Heat generation (H1-8)**	**Biomass residue (B1-8)**
Step2 **Eliminate alternatives that are not complying with applicable laws and regulation**			B3 does not comply with the regulation.
Step3 **Barrier analysis**	Only P4 remains	Only H4 remains	Only B2 remains

From the additionality assessment,

- **P4:** The generation of power in the grid
- **H4:** The generation of heat in boilers using the same type of biomass residues
- **B2:** The biomass residues are dumped or left to decay under clearly anaerobic conditions.

These three baseline scenarios indicate that the project activity is additional.

"Tools for the demonstration and assessment of additionality" is used to demonstrate the additionality of the project activity for the methodology ACM0014.

Step1: Identification of alternative scenarios	**Wastewater treatment (W1-5)**	**Generation of electricity (E1-3)**	**Heat generation (H1-3)**
Step2: Eliminate alternatives that are not complying with applicable laws and regulation	W2 is eliminated as this is against the law		
Step3 Barrier analysis	W3-W5 are eliminated. Only W1 remains	E1 and E3 are eliminated. Only E2 remains	H1 and H2 are eliminated. Only H3 remains

The baseline scenarios of the project activity for ACM0014 are:

- W1: The use of open lagoons for the treatment of the wastewater.
- E2: Electricity generation in the grid
- H3: Heat generation using renewable energies

The analysis defines the baseline scenario and show that the project activity is additional.

(11)Issues regarding implementation of the project

Electricity sales price

Sales price of RM0.18/kWh for the project activity has been suggested by the Sarawak Energy. However, Power Purchase Agreement (PPA) has not been concluded, thus financial plan for the project activity cannot be finalized at this stage. It is though that there are several reasons behind why the rate of the electricity for the renewable energy is not defined. First, the development of Hydropower plant has been delayed and Sarawak energy would like to develop some biomass power plants to suffice the electricity demand, however the future progress of the hydropower development is unclear, hence the planning becomes difficult. The present Renewable Energy Power Purchase Agreement (REPPA) between the Independent Power Producer (IPP) and Sarawak Energy is decided upon project to project cases. There has been demand to increase the transparency on the pricing of the electricity. Sarawak Energy is considering increasing the electricity purchasing price and introducing fixed price for renewable energy.

Operational pattern of the power plant

The power generation of the biomass power plant depends on the operational rate of the palm oil processing mill as this will define the amount of biomass residues. From the palm oil mill management point of view, it is logical to consume the energy from the power plant during day time when the mill is operating and sell the electricity to the grid during night time when the mill is closed. This means that most of the electricity is sold to the grid during night time when the electricity purchase price is low (assuming variable electricity price). There needs to be a fine balance between the mill management and the power generation management to achieve maximum return from the two operations.

Projection of the FFB production

Capacity of the proposed power plant (16MW) is based on the future availability of the biomass residues. This depends on the future FFB processing quantity by the palm oil

mill, which consequently depends on the FFB production of the plantation. The realization of the project, thus depends on the reliability of the projection of the FFB production covering the crediting periods. The feasibility study has investigated the FFB processing track record, plan for the increase in FFB production, and the scale of the emissions reduction that could be achieved with the given future FFB production estimates, however further examination on issues such as identification of risks associated with the failure to meet the FFB projection targets, the degree of reliability of the future production projections, risk management in terms of identifying alternative ways to secure biomass residues for example, purchasing biomass residues from nearby mills are necessary for the project developer to take appropriate risk management measures and achieve steady supply of biomass residues necessary for this power generation project.

Co-benefit study

(1)Evaluation of the pollution control in the host country

Easement of air and water pollution, reduced odor, and reduction of pest outbreaks has been identified as the co-benefit factors of this project activity.

Air pollution

Environmental performance of the biomass power plant could be measured by setting the stack emission profile of a general coal fired power plant as a baseline and comparing it with the stack emission data of the biomass power plant.

	Stack emission profile estimates of the proposed biomass power plant.	**Stack emission profile of a general coal fired power plant.**
SO2	23 ppm-6%O_2	126 ppm-6%O_2
NOx	99 ppm-6%O_2	216 ppm-6%O_2
HCl	8 ppm-6%O_2	14 ppm-6%O_2

The project activity is required to submit stack emission monitoring report to the DOE on annual basis, thus this data could be used to create the emissions reduction index to quantitatively measure the co-benefit effect without the effort of conducting extra measurements.

Water pollution

The quality of the wastewater from the lagoon system could be compared with the new anaerobic digester system. Leachate from the EFB disposal site may have an effect on the local water bodies such as rivers and groundwater, however it is difficult to quantify such effects especially when there are other actors who may also be contributing to the pollution of the local water bodies. The most reliable measurement of the co-benefit effect would be to measure the treated POME effluent data and compare it with the environmental standard. The effluent data must be submitted annually to the DOE, thus no extra effort is required by the project manager to collect the data necessary for the quantitative analysis of the co-benefit effects.

Wastewater quality standard

Parameter	Units	Standard
BOD	mg/L	Below 20
Suspended Soil	mg/L	Below100
Oil & Grease	mg/L	Below 25
Ammoniacal Nitrogen	mg/L	Below100
Total Nitrogen	mg/L	Below100
pH		5-9(Range)
Temperature	℃	Below 45