CDM / JI Feasibility Study Programme

Methane and EFB Power Generation Project in Terengganu States, Malaysia

March 2006

EX CORPORATION

1. Purpose of the study

This project activity aims at greenhouse gas (GHG) emission reduction by utilization of by-products generated by crude palm oil (CPO) mills, to generate power and sell it to the national grid. The project is located at Sungai Tong mill in Terengganu State, Malaysia which is owned by TDM plantation Sdn Bhd.

2. Outline of the project

(1) Description of the project

Fresh Fruit Bunches (FFB) are brought to the CPO mills from plantations, then generally soaked by vapor and CPO is extracted. In this milling process, an enormous amount of solid by-products; EFB, fiber, and shell are generated. Among the by-products, fibers and shells which have relatively high energy value are usually utilized on site as boiler fuel. However, EFB has not been utilized because of its lower energy value, its bigger size (much bigger than fiber and shell) and high kalium content which may cause scale inside the boiler furnace. The Malaysian Environmental Quality Act of 1974 was amended in 1998 and prohibits open burning. EFB used to be combusted in incinerators at the CPO mills, but this no longer allowed by the Department of Environment, in order to prevent air pollution. Due to the above situations, EFB has been disposed in the plantations and left to decay anaerobically.

This project includes power generation utilizing the EFB generated by the mill and also neighbouring mills and the methane recovered from POME(Palm Oil Mill Effluent, POME) by installation of methane digester tank. The generated electricity will be exported to the national grid.

Disposal of EFB has been regarded as a very serious problem in Malaysia not only because it results in high costs, but also it can pose various environmental problems such as water pollution, fire hazards, insect pests, odor and also lack of land availability. Meanwhile, they have upgraded the effluent treatment system in 2005 due to the upgrade of the mill capacity. So the expectation of the counterpart is stronger for EFB power generation project.

Thus, this study places higher priority on EFB power generation which were strongly requested from the counterpart. The following two cases were set for investigation to select the more feasible case as a CDM project:

[Case1] EFB power generation ＋ Methane recovery from POME for power generation
[Case2] EFB power generation

(2) Description of the technology applied for the project

<u>EFB power generation system</u>

One of the technological features of the project is the EFB preprocessing technology, in particular the dewatering system. Existing EFB power plants usually apply dry systems for EFB preprocessing. Dry systems usually utilize waste heat from existing boilers which supply energy to CPO mills. This system often faces energy scarcity because the energy can be supplied only while the CPO mill operates. The advantage of the dewatering system is that it allows stable operation of the system because its energy is supplied by the EFB power plant which operates 24 hours a day.

Another feature is the EFB boiler which equipped the technology bi-drum, natural circulated, water tube boiler whose combustion system is called travelling stoker firing. This boiler can combust the fuel like EFB whose combustion response is low. This boiler can also be built with the parts that are available locally and operation will be conducted by local counterpart staff. It is important for the success of the project that plant operation can be done locally at low cost, because if the project requires frequent support from outside, it will increase running costs and lower project viability. The boiler also does not need special treatment against air pollutants or toxic wastes.

Methane recovery and power generation system

Methane recovery technology is the anaerobic fermentation technology by sealed anaerobic digesters will be employed in this project. Two digesters with a volume of 3,000m^3 for each will be installed. The applied technology is thermophillic system with which the effluent is treated only within 7 days. One of the features of this technology is the high efficiency of effluent digestion. Gas engine will be installed for power generation.

(3)CDM Project Boundary

The project boundary for each case is illustrated in the Fig.1 and Fig.2. The boundary includes the physical and geographical sites where EFB would have been disposed and the avoided methane emission occurs in absence of the proposed project activity, where the treatment of EFB combustion takes place, and in the itineraries between the transportation of EFB and combustion residues occurs.

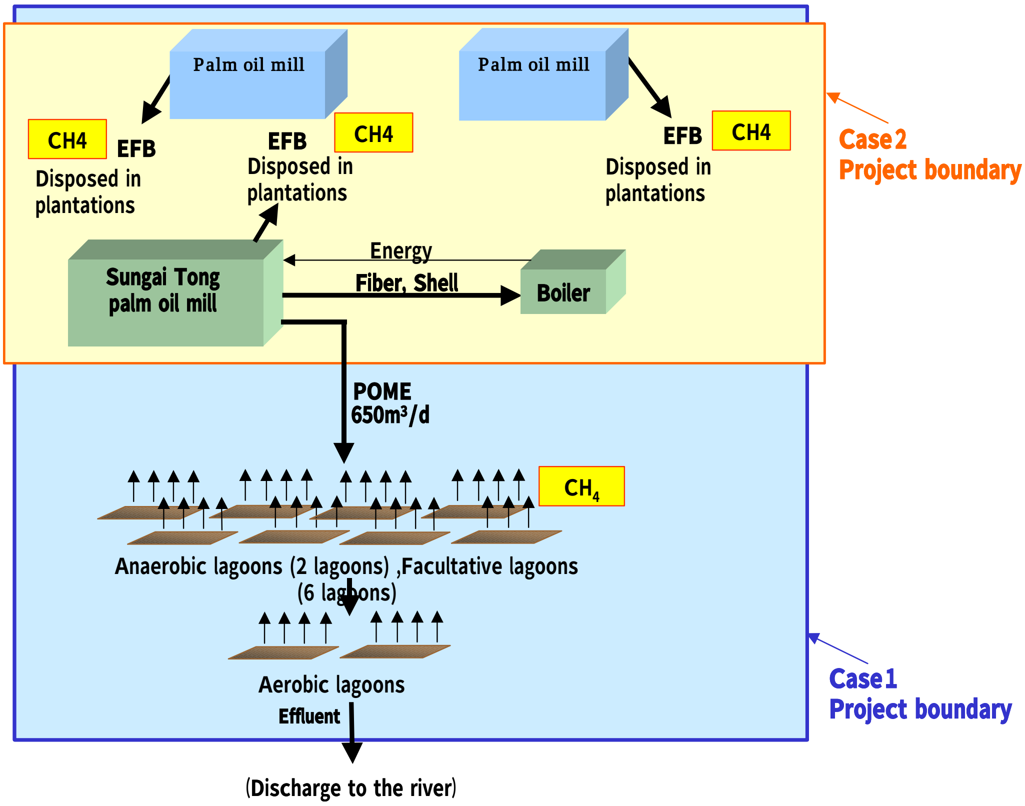

Fig1. Project boundary（Baseline Scenario）

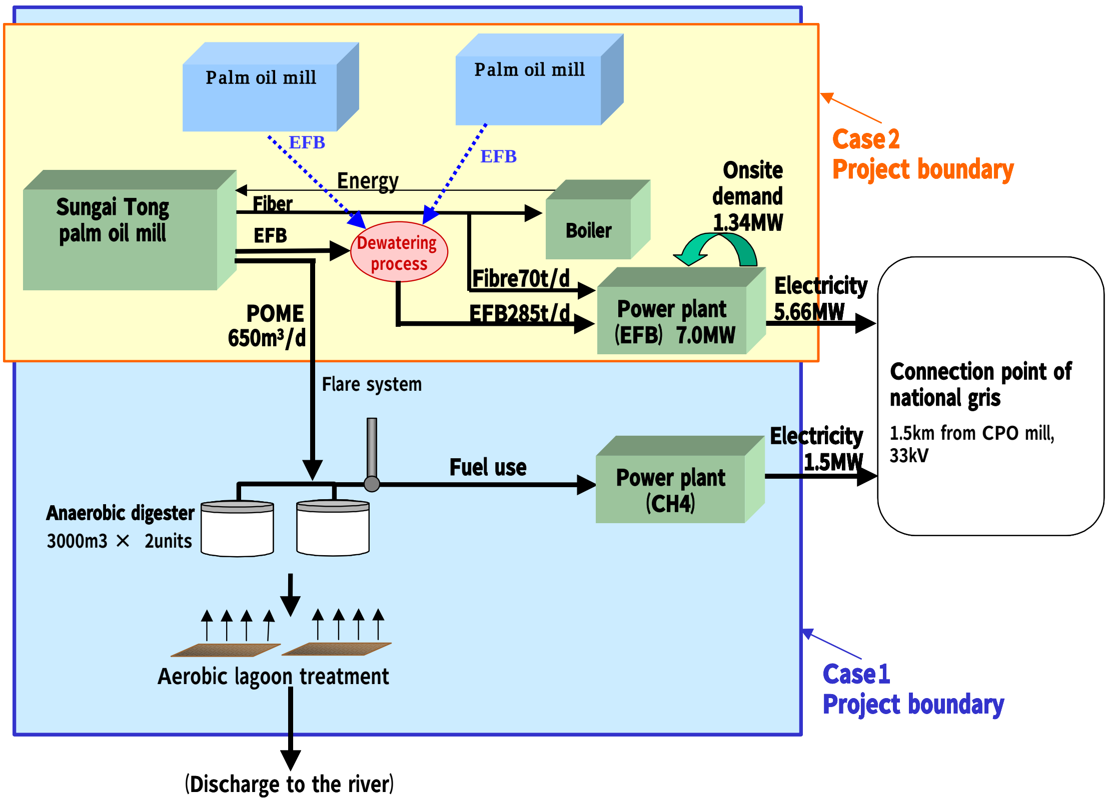

Fig2. Project boundary（Project Scenario）

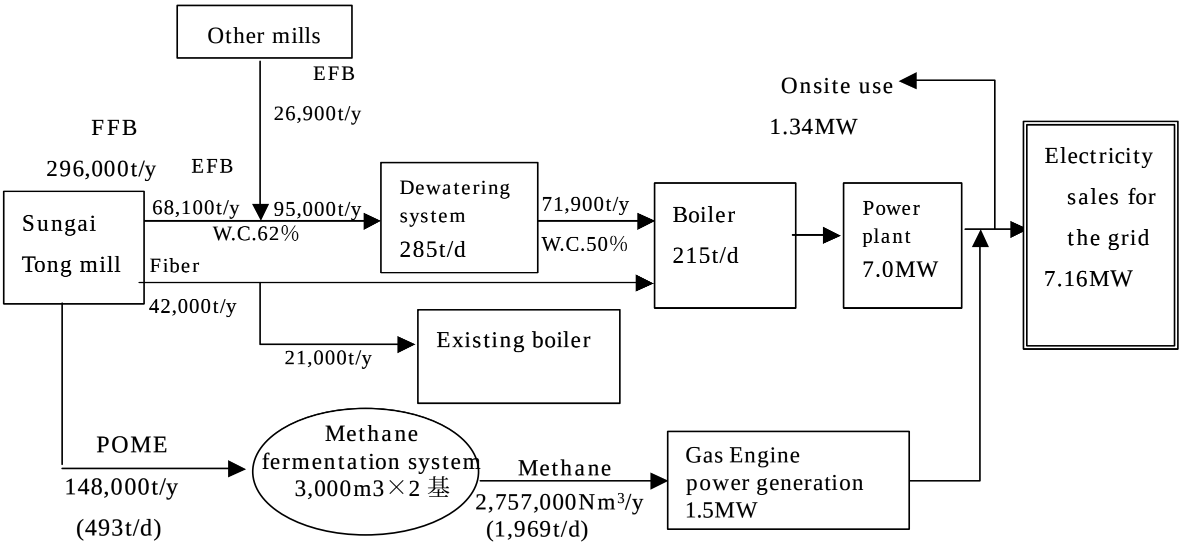

Fig.3 Material Flow (Case1)

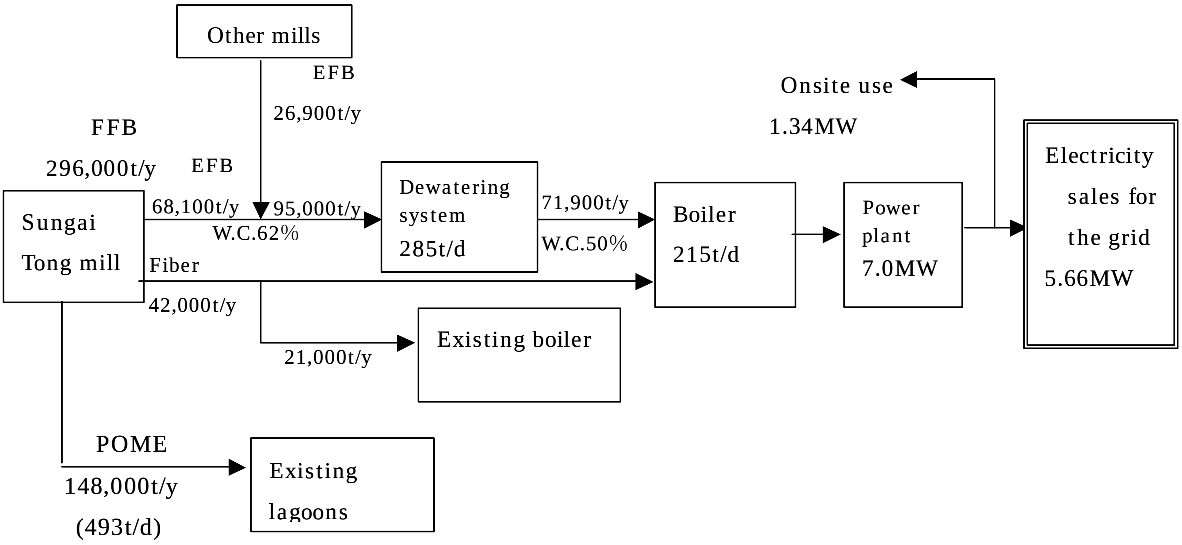

Fig.4 Material Flow (Case2)

3. Baseline Scenario and establishment of additionality

(1)Baseline Scenario

Continuation of the current system is assumed as a baseline scenario for this project activity as described below:

■Baseline of EFB treatment

In Malaysia, open burning of EFB is banned by the Environmental Quality Act 1974 which was amended in 1998. Meanwhile, there is no legislation or regulation that prohibits EFB disposal in the plantations, nor is there expected to be in the future.

Moreover, although much research has been done on the effective material utilization of EFB, there have been almost no commercially successful projects to date. Also there is almost no

EFB power generation project which runs successfully without CDM, due mainly to technological and financial barriers. Under this situation, palm oil producers near Sungai Tong mill have continued to dispose of EFB and leave it to decay anaerobically in their plantations. In this manner, in the absence of this project activity, EFB disposal will continue and an enormous amount of methane will be generated.

■Baseline of POME treatment

The project factory, Sungai Tong mill applies the open lagoon treatment for POME, complies with all applicable environmental standards posed by the Government of Malaysia while strengthening of the current environmental standards is not anticipated. Furthermore, they have upgraded the effluent treatment system last year. So it is obvious that the baseline scenario of POME treatment is continuation of the current system.

(2) Establishment of Additionality

This project will not result in a BAU scenario because of the following barriers:

-Investment barrier

Usually EFB power generation system needs larger investment compared to the systems that burn either conventional biomass or fossil fuel. Methane digester tank and gas engine is also expensive facility. The IRR(Internal Rate of Return) of case1 without CER sales is to low to be calculated(14years: 2 crediting periods) and case2 is 0.5%. The financial viability of the project will be improved when it is conducted under CDM and supplementary revenue is available, But without such support, the project activity without CER sales is not commercially viable.

-Technical barrier

Malaysian Government is actively promoting biomass power generation, however, very few EFB power generation projects have been implemented partially due to the difficulty in achieving a stable operation of the power system. It is obvious that this project which has higher risk is difficult to be implemented without incentives for CER acquisition by invest country. Therefore, it is apparent that there is a technological barrier for implementing this project activity.

-Barrier due to prevailing practice

There is no legislation or regulation that enforces EFB power generation or controlled combustion of EFB in Malaysia. Meanwhile, EFB open burning is banned by the Environmental Quality Act 1974 which was amended in 1998. Regarding POME treatment, Sungai Tong mill applies the open lagoon treatment for POME, complies with all applicable environmental standards posed by the Government of Malaysia while strengthening of the current environmental standards is not anticipated. Thus it is obvious that EFB combustion cannot be a natural course of action. Moreover, there is no EFB power generation implemented in Malaysia which did not assume to be a CDM projects Difficulties in operation have restricted the growth of this form of power generation.

4． Methodology for GHG emission calculation

This project activity involves Methane recovery system from POME, the boiler that combust EFB and the installation of new power generation units with a capacity of 8.5MW for case1 and 7.0MW for case2. Within the capacity, 7.16MW for case1 and 5.66MW for case2 will be exported to the national grid. Project emissions by this project activity does not exceed 15,000tCO_{2eq}/yr(see 5(1) "Effect of the project") and amount of electricity sales is also under 10MW. Thus, this project activity falls within the following categories:

- Type III.H. Methane recovery in wastewater treatment
- Type III.E. Avoidance of methane production from biomass decay through controlled combustion
- Type I.D. Renewable electricity generation for a grid

Calculations for emission reduction by this project activity is described as follows:

Table1. Emission reduction effect（Case1）

Year	Baseline emissions				Project emissions		Leacage	Annual estimation of emission reductions in tonnes of CO_{2eq}
	Methane recovery / electricity generation from POME		EFB power generation		Aerobic lagoon	Transportation increase		
	Anaerobic lagoon	Displaced electricity	Biomass decay	Displaced electricity				
	t_CO_{2eq}	T_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}
2008	32,634	5,089	6,986	26,670	8,081	367	0	62,931
2009	32,634	5,089	13,812	26,670	8,081	367	0	69,757
2010	32,634	5,089	20,484	26,670	8,081	367	0	76,429
2011	32,634	5,089	27,004	26,670	8,081	367	0	82,949
2012	32,634	5,089	33,376	26,670	8,081	367	0	89,321
2013	32,634	5,089	39,602	26,670	8,081	367	0	95,547
2014	32,634	5,089	45,688	26,670	8,081	367	0	101,633
合計	228,438	35,623	186,952	186,690	56,567	2,688	0	578,567

■GHG emission reduction by methane recovery from POME treatment

GHG emission reduction by methane recovery from POME treatment is calculated by the equation (i) based on Type III.H.:

$$\text{Emission reduction by methane recovery from POME } (t\_CO_{2eq}) = \text{Baseline emission from POME anaerobic lagoon treatment } (t\_CO_{2eq}) - \text{Projecte emission from POME aerobic lagoon treatment } (t\_CO_{2eq}) - \text{Leakage } (t\_CO_{2eq}) \quad \cdots \text{(i)}$$

■EFB emission avoidance from EFB decay

GHG emission reduction by avoidance of methane from EFB decay through controlled EFB combustion is calculated by the equation (ii) based on Type III.E.:

$$\text{Baseline emissions from EFB decay }(t\_CO_{2eq}) = \text{Methane generation potential }(t\_CH_4) \times \text{Global warming potential of methane} \quad \cdots (ii)$$

Where, Methane generation potential will be calculated based on the First Order Decay Model defined in the IPCC guideline.

$$\text{Project emissions from EFB combustion }(t\_CO2eq) = \text{Emissions from Non-biomass waste combustion }(t\_CO2eq) + \text{Emissions from transport increment }(t\_CO2eq) + \text{Emissions from power/diesel usage }(t\_CO2eq) \quad \cdots (iii)$$

Thus, emission reduction by EFB combustion can be obtained by the equation.

$$\text{Emission reduction by EFB combustion }(t\_CO_{2eq}) = \text{Baseline emissions from EFB decay }(t\_CO_{2eq}) - \text{Project emissions from EFB combustion }(t\_CO_{2eq}) - \text{Leakage }(t\_CO_{2eq}) \quad \cdots (iv)$$

■GHG emission reduction by electricity displacement for a grid

GHG emission reduction by renewable electricity generation and export to the grid is calculated by the equation (v) based on Type I.D.:

$$\text{Baseline emission from the grid }(t\_CO_{2eq}) = \{\text{power generation capacity of the plant }(kW) \times \text{Operating hours }(h/y)\} \times CO_2\text{ emission factor of the grid }(kgCO_{2eg}/kWh) - \text{Leakage }(t\_CO_{2eq}) \quad \cdots (v)$$

GHG emission reduction can be calculated by the components below:

[Case1：EFB power generation＋Methane recovery and power generation] (i)+(iv)+(v)

[Case2：EFB power generation] (iv)+(v)

(3) Monitoring plan

Monitoring plan is described as follows based on the three categories: Type III.H. , Type III.E. and Type I.D.

Table 2. Monitoring items for methane recovery and power generation(Type III.H.)

ID	Data variable	Unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1	Amount of biogass (inlet of gas engine)	Nm^3/h	m	continuous	100%	electronic	Minimum 2 years after last CER issuance	
2	Amount of biogass (inlet of flaring system)	Nm^3/h	m	continuous	100%	electronic	Minimum 2 years after last CER issuance	
3	Methane content of the biogas (inlet of gas engine)	%	m	minimum quarterly	100%	electronic	Minimum 2 years after last CER issuance	
4	Methane content of the biogas (inlet of flaring system)	%	m	minimum quarterly	100%	electronic	Minimum 2 years after last CER issuance	
5	Flare/combustion efficiency, (1)operation hours (2)the methane content in the exhaust gas	%	m	continuous/ minimum quarterly	100%	electronic	Minimum 2 years after last CER issuance	
6	Condition of plant operation	-	m	minimum quarterly	-	electronic	Minimum 2 years after last CER issuance	

Table 3. Monitoring items for EFB combustion and avoidance from being decay(Type III.E.)

ID	Data variable	Unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1	Amount of biomass combusted	t/y	M	Daily	100%	Electronic electronic	Minimum 2 years after last CER issuance	
2	Amount of biomass transported from other mills	t/y	M	Daily	100%	Electronic	Minimum 2 years after last CER issuance	
3	Composition of biomass	-	M	Once a year	100%	Electronic	Minimum 2 years after last CER issuance	
4	Amount of auxiliary fuel used	t/y	M	Daily	100%	Electronic	Minimum 2 years after last CER issuance	This project activity will not involve auxiliary fuel for running the system.
5	Amount of non-biomass carbon in the waste combusted	t/y	M	Daily	100%	Electronic	Minimum 2 years after last CER issuance	This project activity will not involve non-biomass carbon.
6	Average truck capacity	t/vehicle	M	Once a year	100%	Electronic	Minimum 2 years after last CER issuance	
7	Amount of power consumed and/or generated	MWh	M	Daily	100%	Electronic	Minimum 2 years after last CER issuance	This project activity will not involve any power or power generation utilizing fossil fuel.
8	Distance for transporting	Km	M	Once a year	100%	electronic	Minimum 2 years after last CER issuance	
9	If EFB is utilized in neighboring CPO mills	-	M	Once a year	100%	Electronic	Minimum 2 years after last CER issuance	If EFB in other mills are utilized and not disposed in plantation areas, BaU scenario that EFB is left to decay in plantation may not be valid.

Table 4. Monitoring items for electricity displacement for a grid(Type I.D.)

ID	Data variable	Unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1	Electricity	MWh	M	Daily	100%	electronic	Minimum 2 years after last CER issuance	

5. Effect of the project

(1) Emission reduction effect

The amount of GHG emission reduction in the case1 and case2 is obtained as follows. 578,567tCO_2 for case1, 371,073 tCO_2 for case2 are obtained based on the equations described before.

Table5. Emission reduction effect（Case1）

Year	Baseline emissions				Project emissions		Leakage	Annual estimation of emission reductions in tonnes of CO_{2eq}
	Methane recovery / electricity generation from POME		EFB combustion / power generation		Aerobic lagoon (POME)	Transportation increase (EFB)		
	Anaerobic lagoon	Displaced electricity	Biomass decay	Displaced electricity				
	t_CO_{2eq}	T_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}	t_CO_{2eq}
2008	32,634	5,089	6,986	26,670	8,081	367	0	62,931
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2013	32,634	5,089	39,602	26,670	8,081	367	0	95,547
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合計	228,438	35,623	186,952	186,690	56,567	2,688	0	578,567

Table6. Emission reduction effect（Case2）

Year	Baseline emissions		Project emissions	Leakage emission	Annual estimation of emission reductions in tonnes of CO_{2e}
	Biomass decay (tCO_{2eq}/y)	Displaced electricity (tCO_{2eq}/y)	Transportation increase (tCO_{2eq}/y)	(tCO_{2eq}/y)	Emission reduction (tCO_{2eq}/y)
Year 1	6,986	26,670	367	0	33,289
Year 2	13,812	26,670	367	0	40,115
Year 3	20,484	26,670	367	0	46,787
Year 4	27,004	26,670	367	0	53,307
Year 5	33,376	26,670	367	0	59,679
Year 6	39,602	26,670	367	0	65,905
Year 7	45,688	26,670	367	0	71,991
Total	186,952	186,690	2,688	0	371,073

(2)Energy substitute effect

Using the CO_2 emission factor 0.589 CO_2/kWh which is calculated based on the data provided by TNB and Energy commission, energy substitution effect of the electricity supply to the grid by this project activity is expected as follows:

Table7. Energy substitute effect

	EFB power generation		Methane power generation	
	MWh/y	MWh（7year）	Toe/y	toe（7year）
Electricity displacement (Amount of electricity sold)	45,280	316,960	8,640	60,480
Energy displacement（toe）	12,762	89,334	2,435	17,045t

6. Environmental Impact

No significant adverse environmental impact will arise from the project due to following reasons:

- ✓ No exploitation or destruction of natural resources and ecosystem arise from the project, since the project is carried out within the site of the existing project factory.
- ✓ The project is expected to contribute to reduction of water pollutant emissions from EFB by combusting it to generate power. Furthermore, it will also contribute to the mitigation of air pollutants and greenhouse gas emissions through replacement of national grid electricity generated by fossil fuel combustion.

The Malaysian Government requires environmental impact assessment (EIA) to be conducted for the development of power plants with installed capacity of more than 10MW. However, since the installed capacity of power plant in the project is only 7.0MW, EIA is not required for the project.

7. Stakeholders Comments

Stakeholders comments were received from the following two parties:

<u>TDM Plantation Sdn. Bhd</u>.

At the current situation, the cost of EFB disposal is considered very high in terms of both financial and environmental aspect. However, they do not know any effective measure to utilize EFB. POME treatment is also a sensitive issue for palm oil industry in terms of regulation compliance and local problems such as odor issues or land scarcity problem.
They showed their grate expectation for EFB power generation as a effective measure to solve the current problem and also increase their profit..

<u>TNB Bhd.</u>

Their recognition that renewable electricity supply from Sungai Tong mill to the grid is in accordance with the National Policy to promote renewable energy utilization was confirmed. There is a plan to build a school near Sungai Tong and it is expected that the electricity demand around the area will increase. Therefore, TNB is ready to receive the electricity from this project.

8. Project plan

(1) Financial analysis

The running cost for each case is estimated as follows:

Table8. Running cost

Items	Case 1 (millon yen / y)	Case 2 (millon yen / y)	Desription
Maintenance	62.6	103.7	3% of the initial cost （1% for the first 2 years）
Material purchase	8.1	8.1	Purchase from outside mills at RM10 / t_EFB
Medicine	4.4	4.4	
Manpower	2.3	2.3	17 workers, 2 superviser
Machine lubricant	4.8	4.8	
Commodity	3.6	3.6	
Insurance	8.3	13.8	0.4% of the initial cost
Administration	1.8	1.8	80% of the manpower cost
合計	95.9	142.5	

Table9. Initial cost（Case1：EFB power generation ＋Methane recovery and power generation）

Items	Case1		Case2	
	Yen basis (million yen)	Ringgit basis (million yen)	Yen basis (million yen)	Ringgit basis (million yen)
Boiler system	650	630	650	630
Gas turbine system	360	24	360	24
EFB preprocessing facility	60	10.5	60	10.5
Biogas collection system	650	720	-	-
Civil work	-	48	-	48
Installation work	24	195	24	195
Electricity transmission facility	25	12	25	12
Electricity transfer facility	not included	not included	not included	not included
Others	40	6.6	40	6.6
Sub-total	1,809	1,646.1	1,159	926.1
Total		3,455.1		2,085.1

Based on the cost and expected revenue (CER sales and electricity sales), the project internal rate of return (IRR) for 14 years is obtained as shown in the Fig.5. From this result, it is almost impossible to commercialize case 1 scenario.

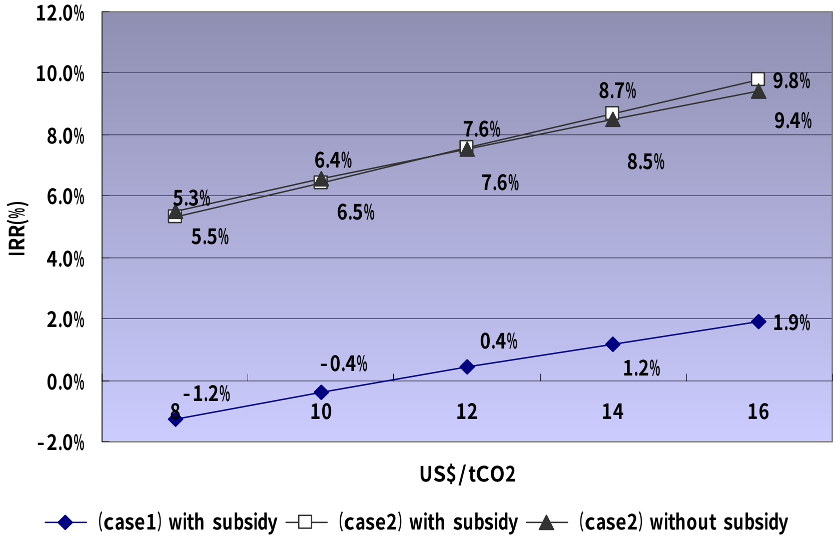

Fig5. IRR(14years) for case1 and case2

Meanwhile, if the initial cost can be lowered down to 1.5 billion yen, IRR for 14 years is obtained as shown in the Fig6. In other words, if the cost can be reduced, there is still a potential for case 2 to be commercialized. Therefore, this study will be continued to investigate the engineering company that can provide a reliable, stable and low price technology applied for this project (case2).

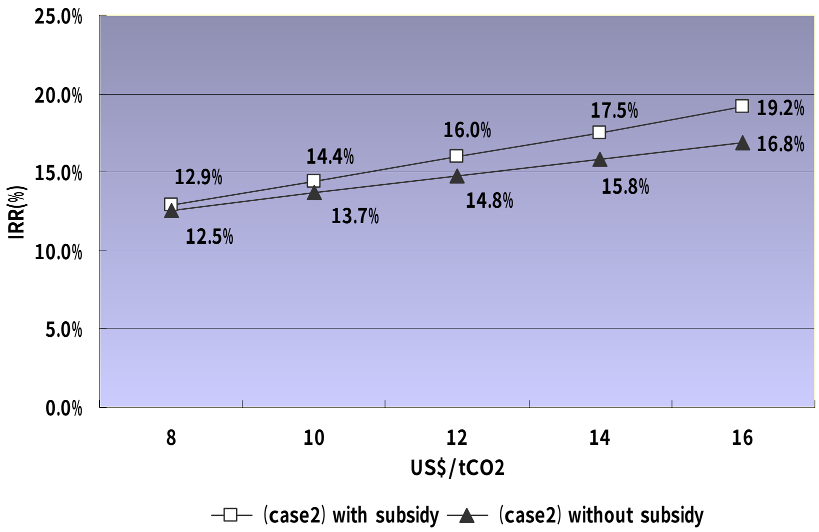

Fig6. IRR for 14years (case2, 1.5 billion)

(2)Implementation structure of the project

The participant from Malaysian side for this project is TDM Bhd and for Japanese side is Gas and Power Investment CO. LTD (GPI). SPC will be establishes by the two parties and GPI will purchase the CER from the SPC. The implementation structure is illustrated as follows:

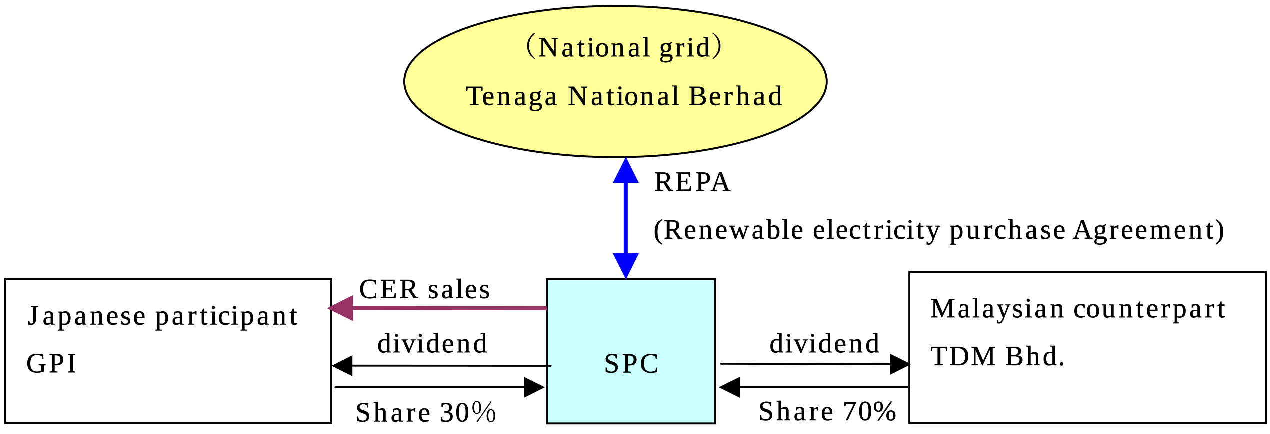

Fig7. Implementation structure of the project

(3)Schedule of project implementation

Assuming an appropriate technology is selected for this project, it is expected that construction will be implemented 1 May 2007 and the project will be launched 1 April 2008.

(4) Financing plan

Assuming an appropriate technology is selected for this project, it is expected that construction will be implemented 1 May 2007 and the project will be launched 1 April 2008. Initial investment of this project (case2) was estimated 2.1billion as described in the Table9. besides investment by GPI and/or TDM, it is assumed to utilize Japanese soft-loan such as JBIC funds and also there is a possibility to utilize the subsidy by the Japanese Government.