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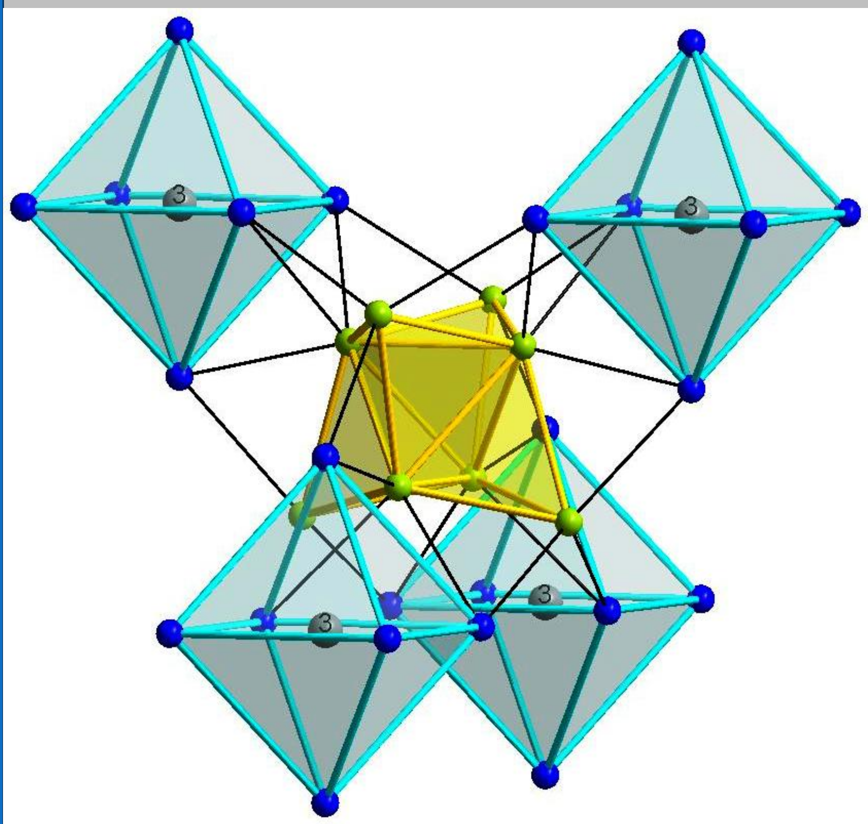

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CONTENT

STUDY OF PALM OIL RESIDUE POTENTIAL FOR ELECTRICITY GENERATION IN SOUTH SUMATRA INDONESIA

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ABSTRACT

This study was aimed to asses technical and economic potential of palm oil residue in south Sumatra taking into account availability, present usage, cost involved and other issues to review the state of art of palm oil residue conversion technology and identify suitable technologies for using in South Sumatra and to identify possible biomass electricity generation and carry techno-economical and environmental analysis of the system. The results show that the potential energy that can be extracted from oil palm solid residue in South Sumatera province taking the efficiency of biomass power generation is about 4.4 PJ/year.It can generate electricity up to 308 GWh/year. The waste water generated was about 1 Million meter cube POME/year. This POME can produce 11,058 m^3 methane which is equivalent to 0.4 PJ/year and generate electricity as much as 150 GWh /year. Based on the scenario have been analyzed using GIS software shows that the potential area for 15 MW independent power plant constructions have been identified taking into account availability of feedstock and the maximum allowable distances. Analysis of the financial viability of the projects evaluated using RETScreen. The results for independent power plant showed that the project IRR is lower than the discount rate. However, with the implementation of CER for CDM, the project financial analysis becomes viable. Moreover, other advantages that can be obtained from these projects are the reduction of GHG emission. Overall, the study clearly indicates the high potential for the generation and use of palm oil residue in South Sumatra.

Keywords: Palm Oil residue, power plant, CHP, methane capture, RETScreen, GIS Software

1. INTRODUCTION

Energy consumption in Indonesia is growing rapidly as a consequence of massive economic development as well as population growth. The dependence of Indonesia on imported oil has burdened the government when the world oil price continued to increase and consequently increase of subsidies that the government had to pay. Utilization of alternative energy source using locally available resources such as biomass and other renewable energies can be one of the options to increase the accessibility of energy.

South Sumatera is the one of agricultural regions in Indonesia which has abundant biomass source. Approximately 33.5% of land used in this province is used for plantations and agriculture (BPS, 2009). The major commodities are palm oil and rubber. Based on agriculture economic structure, South Sumatera has been identified as the potential region for penetration of renewable energy from biomass. Despite the fact that its potential is enormous, the utilization of biomass energy in south Sumatera still not yet been developed, especially from agriculture residue and plantation. With respect to the biomass residue, it has been reported that a considerable amount of biomass residue has a great potential to be substituted for fossil fuels. The most significant potential sources of biomass residue for energy is palm oil residue where the development of oil palm plantation is growing rapidly (Agricultural Department, 2009).

2. POTENTIAL OF PALM OIL RESIDUE

In recent years, palm oil is the most promising commodity in South Sumatra which is produced significantly compared to other commodities. The production of oil palm reached 2 million tons in 2009 with total area of plantation reached 775,503 Ha. Based on data from South Sumatra crops estate agencies during 2006 to 2009 there was an increasing of land area for oil palm plantation as much as 10-12 %/year. Therefore the optimal utilization of biomass residue from oil palm as a potential source of energy production can move forward by using appropriate technology.

At present fiber and shell as residues of palm oil processing in South Sumatra are used as a fuel for boiler to meet electricity need in the plant besides using diesel engine for electricity generation. The composition of fiber and shell as fuel is 85:15; this composition is aimed to prevent breakage of boiler due to high silica content in shell. In general 60% of Fiber and shell are used as a fuel and it can be directly feed into boiler; it doesn't need further treatment because the moisture content of fiber and shell are sufficient for boiler fuel. The cogeneration technology has been used in most of palm oil mill in south Sumatera. The high pressure steam around 18-20 kg/cm^2 that is produced from the boiler is utilized to drive turbine and generate electricity. The electricity requirement for plant with capacity 60 ton FFB/hour is as much as 850 KW. The back pressure steam with a pressure of 3 kg/cm^2 is used for heating process. During peak production of palm oil, the availability of fiber and shell are plentiful, and sometimes be sold to other factory (Kurnia, 2009).

Residue to product ratio of fiber, shell and EFB based on site survey are taken as 0.119, 0.069 and 0.244 at moisture content 23%, 20% and 60% respectively. The characteristics of solid waste from oil palm processing are summarized in the Table 1.

Table 1. Characteristic of solid waste from oil palm processing

Parameter	Fiber	Shell	EFB
RPR	0.119	0.069	0.244
Moisture content (%)	23	20	60
Surplus availability factor	0	0	0.7
Energy Use Factor	0.85	0.65	0.03
Oil content (%)	7	-	1.2
LHV (MJ/kg)	10.11	15.23	3

Meanwhile for EFB because of its high moisture content (±60%), it can not be used directly for boiler fuel. It needs further treatment to use it as a fuel. Only 3% of EFB is used for boiler fuel, therefore the energy use factor for EFB is taken to be 0.03. Traditionally, 10% of EFB is used as animal feed and 20% as fertilizer and organic mulch in plantation to reduce consumption of synthetic fertilizer. It is claimed that production of FFB also increases up to 10 to 20% by using EFB as fertilizer due to its potassium content. It will decompose naturally in aerobic condition after 6 month to several years and release the nutrition for soil fertility. Oil palm is one of agriculture crop that requires heavy demand on nutrient. However, the decomposition of EFB as an aerobic fermentation can generates methane gas, which contributes to the environmental problem due to its stability as green house gas in the atmosphere. More over, the transportation cost for delivering EFB to the plantation is also an emerging issue for the owner of POM to apply it as mulch or fertilizer. With thousand hectares of palm oil plantation, it is not economically viable due to the cost of transportation and other disposal issues onto plantation, such as application of inappropriate EFB mulch can lead to the growth of oil palm pest in the area of plantation (Kurnia, 2009).

Table 2. Characteristic of waste water from oil palm processing*

Parameter	Range
pH	4.0-4.6
Temperature (^oC)	60-80
Total Solid (mg/L)	30,000-60,000
Total Dissolve Solid (mg/L)	15,000-30,000
BOD (mg/L)	20,000-40,000
COD (mg/L)	40,000-70,000

*Kurnia, 2009

Other disposal issue of palm oil plantation is waste water discharge. The waste water is mainly from cleaning, clarifying and sterilization process. The temperature of waste water from sterilization process is around 70^{o}C. The quantity of waste water in oil palm processing depends on type of process, capacity of plant and clarifier condition. For instance, if the plant using decanter to clarify the sludge, the waste water produced is less than using sludge centrifuge as clarifier. The characteristic of waste water in oil palm processing industry is in Table 2.

In most of the cases, POME is utilized as liquid fertilizer and pumped into the plantation after treatment by anaerobic process. The treated water is pumped into reservoir which is located in the highest place of plantation area. The liquid fertilizer is used to irrigate the land on the basis of differences on elevated area. It will flow into a lower location through channel provided for this purpose; this method is known as land application. The utilization of treated water as fertilizer is claimed to reduce fertilizer consumption by 30% / ha. However from environmental view, the weak point of this method is in the rainy season, when the soil in plantation area becomes saturated with the water and it can not hold optimally water runoff from rain as well as liquid fertilizers. As a consequence, the water will flow to the lowest part of the land and finally will go to water bodies. The BOD content of this treated water is still high in range of 3500-5000 mg/L. As a result, this might pollute to the environment (Kurnia, 2009).

The possibility to convert these residues to energy is an attractive option while the quantities are available in significant amount. Table 3 and 4 show theoretical potential as well as technical potential of palm oil solid residues and POME to energy.

Table 3. Palm Oil Solid Residue Potential

Regency	Production (Ton/year)	Energy potential (GJ Thermal /yr)	Technical Potential (MWh/yr)
Lahat	151,708	330,708	22,965.8
Pagaralam	10.1	22	1.5
Empat Lawang	0	0	0
Musi Banyuasin	486,846	1,061,274	74,699.6
Banyuasin	253,449	552,493	38,367.6
Musi Rawas	332,548	724,921	50,341.7
Lubuk Linggau	63	137	9.5
OKU	111,783	243,675	16,921.9
OKU Timur	80,843	176,229	12,238.2
OKU Selatan	36	79	5.5
OKI	376,081	819,818	56,931.8
Ogan Ilir	22,935	49,996	3,471.9
Muara Enim	216,992	473,020	32,848.6
Prabumulih	3,258	7,102	493.2
Total	2,036,553	4,439,476	308,297

Table 4. Potential of POME

Regency	Production (m3/year)	Theoretical potential (GJ thermal/yr)	Technical potential (MWh electricity/yr)
Lahat	75,854	29,491	11,207
Empat Lawang	5	2	1
Pagar Alam	0	0	0
Musi Banyuasin	243,423	94,640	35,963
Banyuasin	126,725	49,269	18,722
Musi Rawas	166,274	64,645	24,565
Lubuk Linggau	32	12	5
Ogan Komering Ulu	55,892	21,730	8,257
Ogan Komering Ulu Timur	40,422	15,715	5,972
Ogan komering Ulu Selatan	18	7	3
Ogan Komering Ilir	188,041	73,108	27,781
Ogan Ilir	11,468	4,458	1,694
Muara Enim	108,496	42,182	16,029
Prabumulih	1,629	633	241
Total	1,018,276	395,894	150,440

The total amount of oil palm residue above is coming from forty five POMs with production capacity range from 30-120 Ton FFB/hour (BPS,2009). With conversion efficiency 25%, the potential energy that can be extracted from solid residue reach 4.4 PJ/year which can generate electricity equivalent to 308 GWh/year. Whereas waste water generated reached 1 Million meter cube POME/year. This amount of POME can produce as much as 11,058 m^3 methane which is equivalent to 395,894 GJ/year and generate electricity as much as 150 GWh/year. This energy can be recovered either by using it as fuel or as a driver of gas/steam turbine to generate electricity.

This potential amount of energy indicates a plentiful biomass source which can be harnessed from palm oil residue to generate electricity or produce energy. The share of biomass based power generation might be very significant. Further research need to be done to find the viability of the project to use this residue for energy production taking into account technical, social, environmental and other factors.

3. THE PROPOSED TECHNOLOGY FOR PALM OIL RESIDUE CONVERSION

There are some scenarios of waste management that can be implemented in palm oil mill. The utilization of palm oil residue can be varied depend upon the available technology and adoptability of technology proposed and its cost effectiveness. One of the technology options is to build independent power plant where the distance between POM and the location of the power plant is taken into consideration. Than the potential site and viability of the project were analyzed with the help of GIS arcview and RETScreen Software.. The calculation of amount of heat generated from palm oil residue where taking of 10 ton/hr of FFB as basis of calculation by using parameter defined in Table 1 and 2 can be seen in Table 5.

Table 5. Heat generated from oil palm residue

Parameter	Production (t/h)	Lower Heating Value (MJ/kg)	Heat Generated (GJ)
Fiber	1.1	10.11	11.12
Shell	0.6	15.23	9.13
EFB (moisture 60%)	2.44	3	7.32
POME	5.0		
Methane	54 m^3	38.5 MJ/m^3	2.079

Based on Table 5, the feedstock needed for energy production in certain amount can be estimated. To analyze potential of site to build independent power plant, GIS Arcview and RETScreen software was used as follows:

1. Input the coordinate of each POM to GIS arcview with known capacity of FFB/hour
2. The candidate power plant location is obtained with distance 50 km from the POM
3. Define the potential site of power plant taking into account biomass availability around the site according to power plant capacity
4. Define the economical and technological potential of the selected site taking into consideration the transportation cost of EFB feedstock using RETScreen software

Step1. Input of coordinates of POM location. Figure 1 shows the POM location in south Sumatera with known capacity of ton FFB/hour.

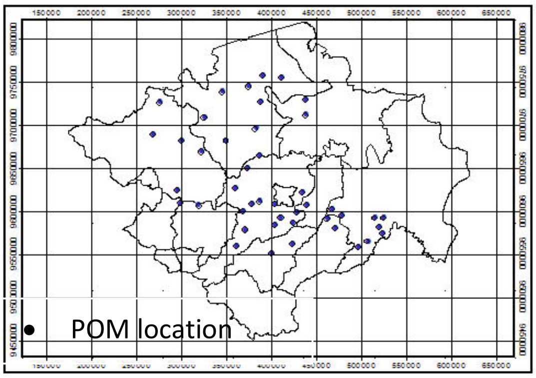

Figure 1. POM coordinate

Step2. The candidate of power plant is defined with distance 50 km (maximum) from POM location. Figure 2 shows the result of GIS for the candidates of power plant. From simulation in GIS software the potential location of the plant project can be defined by inputing the maximum allowable distance to be as much as 50 km

(Lin, 2009). The result of GIS is shown in the Figure 2.

Step 3. The potential sites with sufficient amount of feed stock from POM can be defined using GIS arcview. Based on the calculation using RET Screen to build power Plant with capacity 15 MW needs 134 kT EFB which is fulfilled by POM around the selected 50 km distance. Figure 3 shows the potential site in south Sumatera Province taking into account the transportation distance of the project to build an independent power plant and availability of EFB.

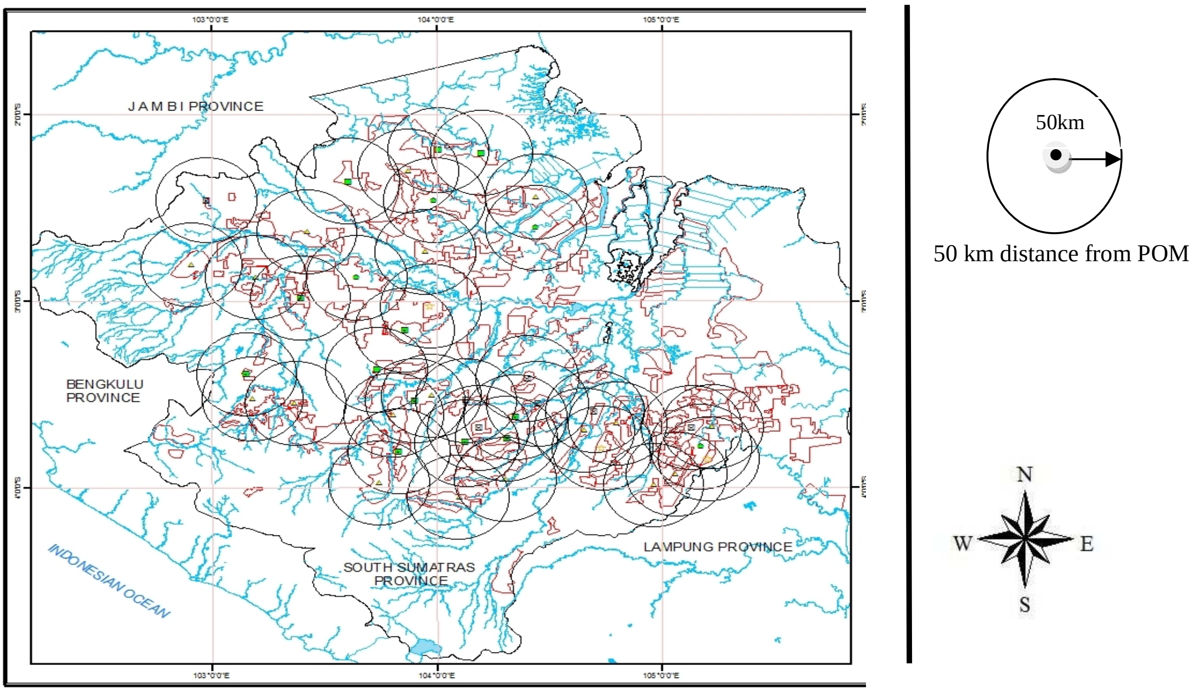

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Figure 2. Map showing the area that are within 50 km from POM

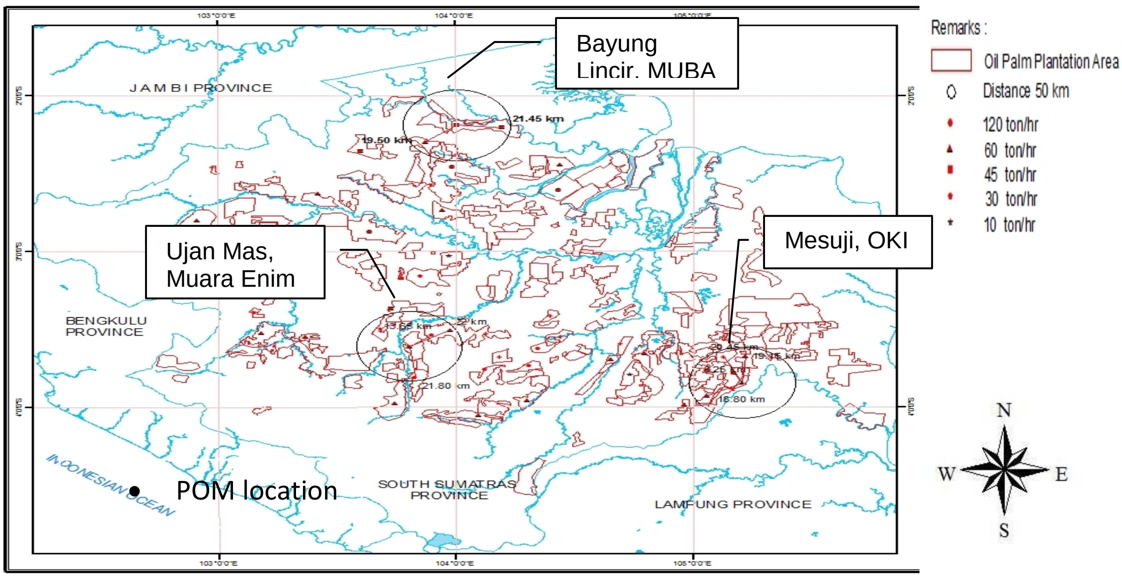

Figure 3. The potential sites for independent power plant

Step 4. Analysis of the financial viability of the potential site of the project. With respect to independent power plant, the availability of feed stock should be ensured. The production of FFB is varied seasonally during the year, and so the provision of boiler fuel should be paid attention to ensure the continuous operation of power plant for the whole year. This could be achieved by storing the residue generated during peak season. In most of the POM, shell and fiber are currently used for internal power generation in plant to meet electricity demand in the site. Thus, only EFB is in surplus condition. The moisture content of FFB being high, it needs further treatment to reduce the moisture and increase heating value by introducing drying process.

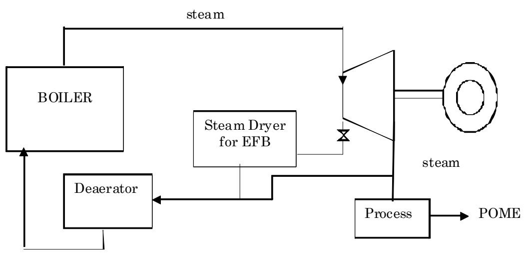

Figure 4. The scheme of EFB drying process

The scheme of drying process is shown in Figure 4 below where the steam is extracted from the turbine at certain pressure and amount for drying purpose. The suitable system for electricity generation is extraction-cum condensing type with high pressure boiler.

RETScreen software is used to identify the potential 15000 kW power plant. The system used steam turbine where the extraction type turbine is used to improve the efficiency of the system. The extraction port with 30% extraction in a pressure of 200 kPa is estimated for drying the EFB with 70% moisture.

Table 6. The project parameters

Capacity of power plant	15 MW
Operating hour	7446 h
Steam Flow	80,000 kg/hr
Operating Pressure	67 Bar
Superheated temperature	402 ^{o}C
Extraction port	15,000 kg/h
Extraction Pressure	200 kPa
Back Pressure	30kPa
Seasonal Efficiency	65%
Biomass transportation cost	0.01$/ton/km
Fuel Consumption (Ton/hr)	11 ton/hr

The amount of steam that is needed for drying purpose is calculated from the amount of moisture that should be removed from EFB. The moisture content of FFB is 70% where the heat required removing 1 kg of moisture is 3.8 MJ/kg taking into account the efficiency of 70% of drying system. The required steam for drying purpose is 14,000 kg/hour. The parameter used to implement this project is summarized in Table 6.

Table 7. Financial parameters of project

Financial parameters			
General			**Source**
Fuel cost escalation rate	%	2.0%	www.esdm.go.id
Inflation rate	%	6.3%	www.bps.go.id
Discount rate	%	6.5%	www.bps.go.id
Project life	Yr	25	PLN
Finance			
Incentives and grants	$	0	
Debt ratio	%	60.0%	www.bps.go.id
Debt	$	20,864,374	
Equity	$	13,909,582	
Debt interest rate	%	10.00%	www.bps.go.id
Debt term	Yr	10	
Debt payments	$/yr	3,395,581	
Electricity export rate	$/MWh	50	

The financial viability of the project was analyzed using the parameters shown in Table 7, and the internal rate of return of the system, payback period as well as net present value were calculated without any incentive or grants from the government.

With the input of the parameters noted above, the financial results obtained are given in Table 8.

From the financial analysis, the result for IRR is 8% which is lower than discount rate. The investment could not be attractive if IRR of the project is lower than other similar projects, Competitive IRR based on many experiences for the project should be more than 15% (Boukis et.al, 2008). Based on this IRR value, it can be seen that the project without any incentive will not be attractive.

But with application of CER sale for 7 years, the IRR of project increases significantly to 18.3% with credit rate is 20$/ton CO_2, Table 9 shows the effect of CER income to the viability of the project.

The government could play important role to set the regulation to encourage the investment on utilization of renewable energy such as feed in tariff for the electricity produced by renewable energy, Renewable Port-Folio Standards, or holiday for income tax and rebate.

Table 8. Financial Result of project

Financial viability	Units	15 MW	With CER
Pre-tax IRR – equity	%	8.0%	18.3%
Pre-tax IRR – assets	%	1.3%	4.9%
After-tax IRR – equity	%	8.0%	18.3%
After-tax IRR – assets	%	1.3%	4.9%
Simple payback	Yr	8.7	5.6
Equity payback	Yr	12.9	4.8
Net Present Value (NPV)	$	3,726,204	20,570,258
Annual life cycle savings	$/yr	305,480	1,686,380
Benefit-Cost (B-C) ratio		1.21	2.16
Debt service coverage		1.09	1.84
Energy production cost	$/MWh	47.88	38.32

Table 9. Financial results with CER income

Parameters	Unit	
Pre-tax IRR – equity	%	18.3%
Pre-tax IRR – assets	%	4.9%
After-tax IRR – equity	%	18.3%
After-tax IRR – assets	%	4.9%
Simple payback	Yr	5.6
Equity payback	Yr	4.8
Net Present Value (NPV)	$	20,570,258
Annual life cycle savings	$/yr	1,686,380
Benefit-Cost (B-C) ratio		2.16
Debt service coverage		1.84
Energy production cost	$/MWh	38.32
GHG reduction cost	$/tCO2	(12)

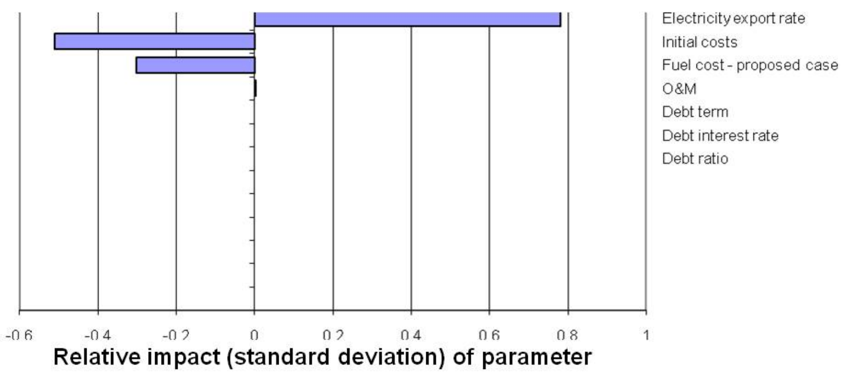

Figure 5. Risk analysis

Figure 5 shows that the electricity export rate gives greater impact to the viability of the project as well as initial cost and fuel cost. The changes of electricity tariff can be obtained if the regulation of feed in tariff is applied or the subsidies for electricity for fossil fuel are abolished, because the electricity rate is not representative the real cost. In term of initial cost, if the spare part and equipment can be procured in Indonesia, this will reduce the initial cost of investment.

Table 10. Sensitivity analysis for electricity export rate and initial cost

			Initial costs			$
Electricity export rate		39,999,090	42,221,262	44,443,434	46,665,606	48,887,777
$/MWh		-10%	-5%	0%	5%	10%
45.00	-10%	6.4%	5.3%	4.3%	3.4%	2.6%
47.50	-5%	8.5%	7.3%	6.2%	5.3%	4.4%
50.00	0%	10.4%	9.2%	**8.0%**	7.0%	6.1%
52.50	5%	12.4%	11.0%	9.8%	8.7%	7.7%
55.00	10%	14.2%	12.8%	11.4%	10.3%	9.2%

From Table 10, increasing of electricity export rate for biomass electricity generation makes the project IRR above the threshold level as well reducing initial cost of investment.

Where in case of sensitivity analysis for fuel and maintenance cost in Table 11 shows that the increasing 5% and 10% of fuel cost and operation and maintenance cost make the project is not financially feasible. The value is below the threshold level. It indicates the significant impact of increasing of fuel and maintenance cost for feasibility of project.

Table 11. Sensitivity analysis for fuel cost and Operation and Maintenance Cost

				O&M		$
Fuel cost - proposed case		68,040	71,820	75,600	79,380	83,160
$		-10%	-5%	0%	5%	10%
1,206,524	-10%	9.3%	9.3%	9.3%	9.2%	9.2%
1,273,553	-5%	8.7%	8.7%	8.7%	8.6%	8.6%
1,340,582	0%	8.1%	8.1%	**8.0%**	8.0%	7.9%
1,407,612	5%	7.4%	7.4%	7.4%	7.3%	7.3%
1,474,641	10%	6.7%	6.7%	6.7%	6.6%	6.6%

4. CONCLUSION

From the perspective of financial analysis without any incentive or income from CER, the scenario to build independent power plant as alternative to utilize the palm oil residue is not being attractive. However with the application of CER as annual additional revenue makes this entire scenario becomes financially viable.The support from the government for investment on renewable energy by introducing the financial incentive or grant or tax reduction will give significant impact to viability of the project.

South Sumatera has potential resources of palm oil residue, which can be an attractive option to develop renewable energy project where it gives significant impact to the business opportunity while also considering to the environmental aspect. GIS arcview and RETScreen software are useful tools to analyze the proper location for the proposed project taking into account the economical, technological and environmental aspect of the project.

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