Taikichiro Mori Memorial Research Grant Report 2014

Name of the Research Project	*Study on Cost and Performance Analysis of Biomass Power Plant Installation using Cocoa Beans Husks as Feedstock*
Name of the Research Project Leader	*Eky Yenita Ristanti (Master Program, Graduate School of Media and Government)*

Research Abstract:

Indonesia is world 3rd largest cocoa producer. After the enactment of customs exit to bulk cocoa beans in 2010, domestic cocoa grinding is growing. It leads to the increase of cocoa bean shells discharged from winnowing process. Cocoa bean husk, or also called as cocoa bean shell, is a potential biomass resource, which can be utilized for energy. This research aims to analyze cost and performance of power plant installation using cocoa beans husk as feedstock. Research was conducted at PT. Mars Symbioscience Indonesia, in Makassar, South Sulawesi Province, Indonesia. Amount of cocoa bean husk generated from entire production process in this factory in total is about 963,613 kg in year 2014. Potential energy generated per month from average 120,373 kg discharged cocoa beans husks is about 2029,52 GJ. Economically, power generation seems cheaper than combined heat-power technology (CHP). However, CHP can reduce factory expense on heat used for processing.

Research Result Report:

1. Introduction

Cocoa industry generates 11-12% of cocoa beans husks/shells from winnowing/de-shelling process. Cocoa bean husk is considered as solid waste. Some cocoa processing companies has utilized cocoa beans husks/shells as boiler feedstock to produce heat, but many companies will sell cocoa beans husks to buyers, which will use it as cattle feed or fertilizer.

This research aims to analyze cost-performance of cocoa bean husks utilization for power plant installation in cocoa processing company. Research was carried out at PT. Mars Symbioscience Indonesia, one of cocoa processing industries, which located in Makassar, South Sulawesi. The factory is located in industrial park area as shown on Figure 1. The company has utilized cocoa beans husks as boiler feedstock. The boiler produces heat, which used for production processes. There is opportunity to generate electricity from cocoa beans husks, in addition to heat generation.

Figure 1. Location of the factory and location of collector

Solid biomass conversion in Indonesia is still limited to large sugar and palm plantation. Table 1 shows feasible solid biomass conversion using CHP (combined heat and power) in rural industry in Indonesia. Saw mill with 1000 – 3000 m^3/y capacity can produce 40- 100kWe using CHP (combined heat and power) technology, while a sugar mill with 1000- 4000 TCD (total cane/day) can produce 3-10 MWe.

Industrial process mostly uses steam with pressure up to 15 bar e.g. for cane cooking in the sugar industry and to produce mechanical energy utilizing steam engines. These types of boilers represent around 66 % of the total boilers installed at sugar mills. Boilers operating above 15 bar are mostly combined with large steam turbines for electricity generation (Abdullah, 2001).

Table 1. Potential Biomass Conversion in Rural Industry

Solid Biomass Source	**Mill size**	**Capacity of CHP technology**	**Biomass potential for power generation**
Saw mills	1000-3000 m^3/y	40-100 kWe	0.6 m^3 wood waste/m^3 sawn timber ~ 130 kWh/m^3 sawn timber
Plywood mills	40 000-120 000 m^3/y	1.5 – 3 MWe	0.8 m^3 wood waste/m^3 plywood ~ 200kWh/m^3 plywood
Sugar mills	1000- 4000 TCD	3-10 MWe	0.3 t bagasse/t sugarcane ~ 100 kWh/t sugar cane
Rice mills	< 0.7 t/h >0.7 t/h	30-70 kWe 100-300 kWe	280 kg husk/t paddy ~ 120 kWh/t paddy
Palm oil mills	20- 60 t FFB/h	2-6 MWe	0.2 t EFB/t FFB 0.2 t fibre/t FFB 70 kg shells/t FFB ~160 kWh/t FFB

Indonesia's total cocoa production in 2013 is 777,500 tons harvested from 84,700 ha large estate and 1,768,200 ha smallholder estate. 70% of it is produced in Sulawesi Island, especially South Sulawesi Province and West Sulawesi Province. This amount was almost doubled from 2012 production, which is only in the range of 435,000- 450,000 tons

However, this amount has declined into 425,000 tons in 2014, even lower than 2012 (http://www.reuters.com/article/2014/04/29/cocoa-grindings-idUSL3N0NG06220140429**,** accessed on January 4th, 2015).

Figure 2. Image of cocoa beans husk

2. Research Approach

This study is based on used cost and performance analysis on biomass power plant installation.

3. Findings

Energy Potency from Cocoa Beans Husks in PT. Mars Symbioscience Indonesia

The grinding capacity of PT. Mars Symbioscience Indonesia is 50 tons per day. Input beans for production in 2012-2014 are shown on Table 2. The amount of husks is calculated on based of 12% of input beans.

Table 2. Production Input Capacity of PT. Mars Symbioscience Indonesia

Period	2012		2013		2014*)	
	Input beans (kg)	**Bean husks (12%) (kg)**	**Input beans (kg)**	**Beans husks (12%) (kg)**	**Input beans (kg)**	**Bean husks (12%) (kg)**
P1	1,467,409	176,089	0	0	846,850	101,622
P2	1,418,985	170,278	79,745	9,569	1,012,000	121,440
P3	1,400,489	168,059	1,211,002	145,320	1,170,000	140,400
P4	0	0	1,280,030	153,604	614,025	73,683
P5	90,440	10,853	1,006,346	120,762	576,775	69,213
P6	1,421,287	170,554	1,405,671	168,681	1,278,110	153,373
P7	1,422,217	170,666	1,259,357	151,123	1,358,350	163,002
P8	530,298	63,636	1,233,872	148,065	1,174,000	140,880
P9	116,075	13,929	1,110,082	133,210	NA	NA
P10	1,310,471	157,257	1,185,177	142,221	NA	NA
P11	1,147,249	137,670	1,295,445	155,453	NA	NA
P12	1,419,888	170,387	1,182,619	141,914	NA	NA
Average	**978,734**	**117,448**	**903,639**	**108,437**	**1,003,110**	**120,373**
Total	**11,744,807**	**1,409,377**	**10,843,675**	**1,301,241**	**8,030,110**	**963,613**

Energy related properties of cocoa bean husks are analyzed in Energy Laboratory, of LPPM-ITS, Surabaya (*Center of Research and Community Service, Sepuluh Nopember Institute of Technology)*. The result of energy properties of cocoa beans husks is shown on Table 3 below.

Table 3. Energy related properties of cocoa beans husks

Sample	Total Moisture (%)	Water Content (%)	Ash Content (%)	Flying Material (%)	Fix Carbon (%)	Calorific Value (cal/g)	Total Sulphur (%)
	ASTM D3302-2	ASTM D3173-02	ASTM D3174-02	ASTM D3175-02	ASTM D3172-02	ASTM D5865-03	ASTM D3177-02
Cocoa Bean Shells	7.64	5.87	8.96	76.22	8.96	4027	0.096

Potential energy generate per month (calculated as average cocoa beans husks discharged per period production) is:

120,373 kg x 4027 kcal/~~kg~~ = 484,742,071 kcal

The amount calculated is gross energy value (GCV), which is equal to 2029,52 GJ or 563,755 MWh. This amount seems very promising, however, it is a very rough calculation. To calculate net calorific value, it needs to analyze the element composition (C, H, N, S and O), which is not being conducted in this study. Therefore, net calorific value cannot be determined.

A report from Barry-Callebaut (2012), a cocoa processing company, stated that the company has utilized 64,451 GJ energy from cocoa beans husks annually or about 5,370 GJ per month. It means cocoa beans husks have high potential to be utilized for energy.

Cost-Performance Analysis

There are 2 (two) possible ways to utilize cocoa beans husks for power generation in a cocoa processing company. It can be utilized either for power generation using direct combustion technology, the most feasible technology can be applied in development country like Indonesia, or simultaneously to generate both electricity and heat (*Combine Heat-Power Generation, CHP*). In this study, cost-performance analysis is performed to compare electricity generation using direct combustion with combine heat-power generation technology.

Regarding the environmental impact and permission regulation for large-scale power plant generation, this study estimated for small-scale electric power generation (<1 MWe). The result is summarized on Table 4.

Table 4. Summary of cost and performance analysis of power generation and CHP

Items	Cost (in USD)	
	Electric Power Generation (using fire tube boiler technology)	Combined Heat-Power Generation (steam engine technology)
Investment Cost (not include installation and design) (USD/kW)	400-500	900-1,500
Operation and Maintenance (USD/kW)	Lower than CHP (around 30-40)	High (50)
Fuel cost (using cocoa beans husks) (USD)	0	0
Interest rate (%)	10	10
Efficiency (%)	~60-65	Total 75-85 (thermal 40-70; electrical 15-35)
Lifetime (year)	20	20

Economically, electric power generation is cheaper compare to combined heat power-generation, in terms of investment and maintenance cost. However, cocoa industry needs heat during production process. Application of CHP will reduce expense on heat generation.

References

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