Study on Effective Utilization of Palm Oil Waste (Empty Fruit Bunch) System in Malaysia

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ABSTRACT

Malaysia has vast amounts of biomass wastes such as empty fruit bunches (EFB), fiber, and shell. With growing environmental consciousness, high petroleum prices and depleting fossil fuels, it draws country's attention to develop the potential of these palm oil wastes. It is necessary to establish an effective system to fully utilize these valuable resources. This study analyses the best combination of technology options for an area to handle EFB. Excess energy from palm oil mill is quantitatively evaluated for drying EFB. A simulation model is developed with the objective of system profit maximization using data from a set of 19 mills that located in the state of Sarawak.

1. INTRODUCTION

Malaysia is the largest palm oil producer, which contributes approximately 50% of the world palm oil production. In 2006, there is about total 42,000 km^2 of palm oil plantation, which is equivalent with 1/9 total area of Japan. Total 397 palm mills are operating in Malaysia. In the milling process, a fresh fruit bunch produces 13% of fiber, 7% of shell, and 23% of EFB. Using this ratio, total 79.7 million tonnes of fresh fruit bunch in the year of 2006, generates 18.33 million tonnes of EFB. Most of the EFB are taken back to the plantation to mulch as organic fertilizers. Some are burnt onsite with fibers and shells to produce industrial steam and electricity. Originally, Malaysia's energy policy is focused on 4 element fuel, which oil, gas, coal and hydro. In 2001, Malaysia announced Five Fuel Diversification Strategy with renewable energy fuels as the fifth component, in particular biomass. In line with this, combined heat and power (CHP) technology is being developed using EFB as main fuel to generate electricity in Malaysia. However, there are many difficulties for the realization of CHP power plants projects in Malaysia. These difficulties includes the problems of EFB supply chain, characteristic of EFB (high moisture content and bulky) that causing inefficient combustion and difficult in transporting and the location of the power plant located far away from the heat demand. This study is tried to look into the location problem of a proposed power plant that uses EFB as fuel and improve the system transporting of EFB.

2. METHODS AND ANALYSIS

2.1 Simulation

The study area is state of Sarawak that located in the borneo island of Malaysia. Total palm oil plantation area is 5914.71 sq km.

2.1.1 Database extraction using GIS (Geographical Information System)

a) Coordinate x-y palm oil mill and mesh numbers

The coordinate x-y of the nineteen mills with known annual supply of EFB in the state of Sarawak were defined. In GIS, mesh numbers with 20km spacing line were created and only buffer 50km from palm oil mill and elevation in range 0- 500 m of these mesh numbers were selected to be potential locations of proposed power plant. Total 130 mesh numbers were used (Fig.1).

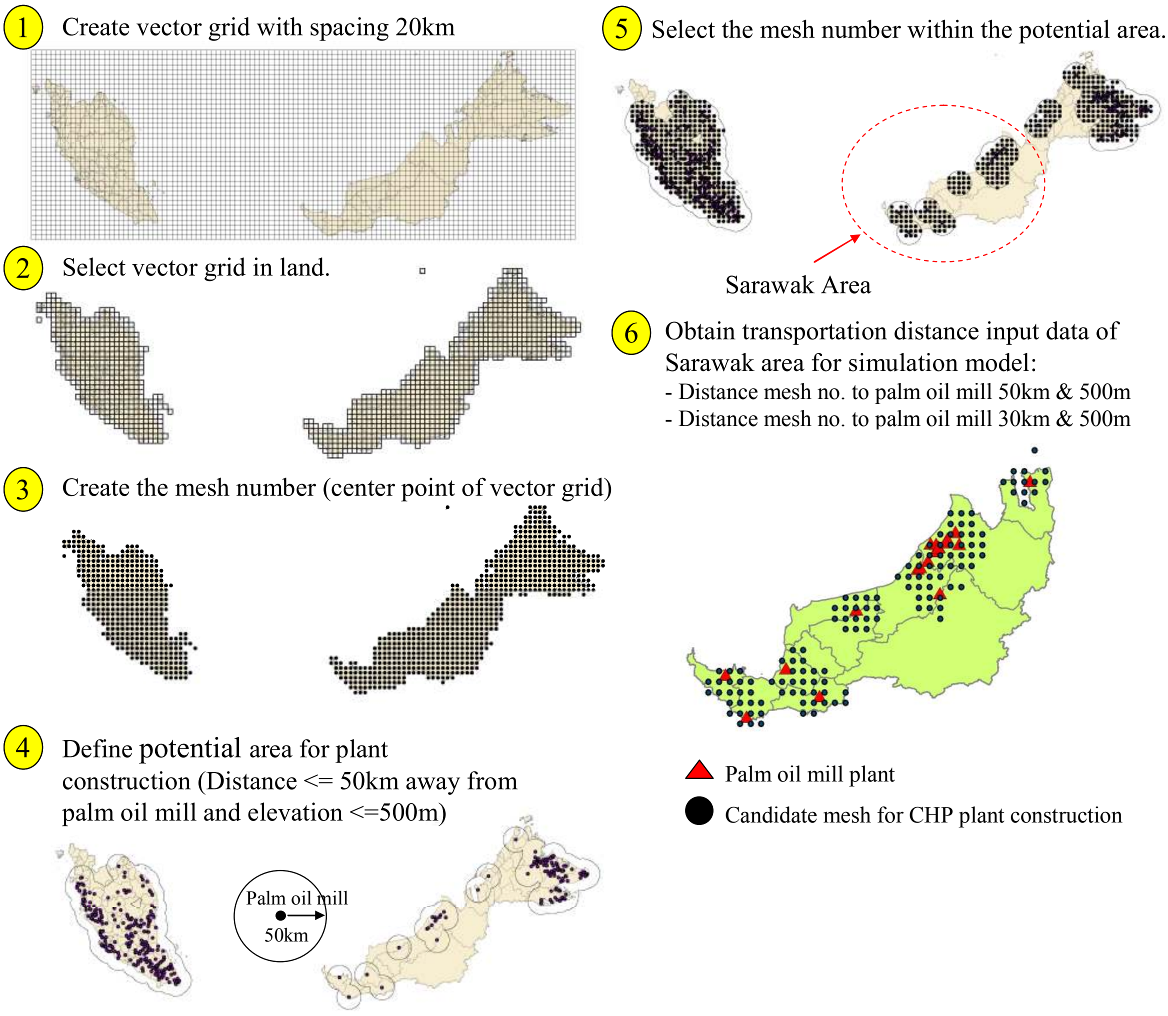

Fig.1; Data extraction of the palm oil mill and mesh numbers using GIS Location

b) Transportation Distance

Transportation distance between the palm oil mills and distance palm oil mills to power plant were measured for model input data.

2.1.2 Simulations contents

Three scenarios were considered in this model, which is a) Mulching, b) CHP power plant installed at palm oil mill, and c) Independent CHP power plant.

The model is a mixed integer program. It used branch and bound algorithm to solve this program.

There are total 8655 variables, 973 constraints and 428 of integer variables in this program. The objective function of this program is to maximize the total system profits. In the program, the number of power plant in the object area is set as parameter. Five simulations are carried out by setting different of number of power plant in the object area. To identify the optimal system, simulation also carried out without setting the numbers of power plant in the object area. Simulation result will shows the location of the proposed power plant, EFB power plant scale, technology options and also the EFB transportation map in the study area.

3. RESULTS

Fig. 2. shows the optimal results of the simulation.. Three power plant build in state of Sarawak. Two independent CHP power plants with 14 MW and 18.3 MW.. and CHP unit installed at the palm oil mill. Total 19,408 tonnes were used for mulching. It could supply 62.1 tonnes of nitrogen and 7.36 tonnes phosphorus demand of the palm oil plantation. Total system profit is 467.5 million JPY, and the CO_2 emission reduction is 3.924 Gt CO_2-eq./year (Table 1).

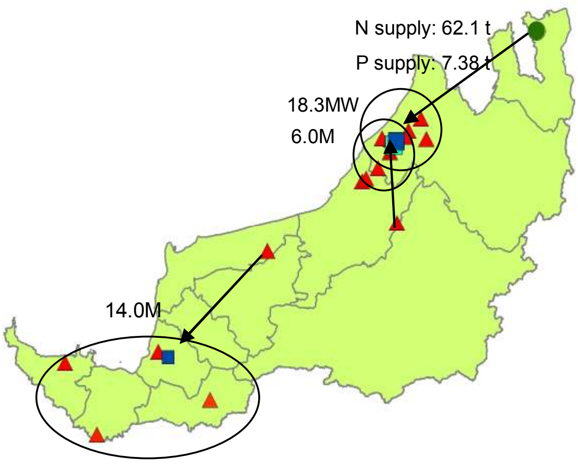

Fig.2. Optimal location of the power plant in Sarawak state

Fig. 3 shows the result of the total cost of the systems of different numbers of power plant. The transportation cost of the system is increasing when the number of power plants increasing. The system profit turned negative when the numbers power plants increase to 6 power plants. The systems profit of 6 power plants is -605.3 million JPY, mainly due to high transportation cost.

Table 1 Total cost of 3 power plant

Sarawak	Total cost (JPY/year)		
	Mulching	CHP1	CHP2
Transportation cost	-	-16,390,232	-426,090,166
Constant Cost	-	-20,908,800	-112,467,615
Variable Cost	-	-3,611,192	-19,424,458
Electricity sales revenue	-	185,566,234	998,153,487
Ash sales revenue	-	5,076,209	27,304,729
System Profit	6.19E+06	149,732,219	467,475,977
CO_2 emission (Gt CO_2-eq./yr)	1.61E-08	731	3,924

According to z. Hussain, Z.A. Zainal, M.Z.Abdullah, the energy balance in a typical palm oil mill is far from optimum. It might be an option to utilize the excess energy from palm oil mill to dry EFB, to reduce the volume of transporting EFB to increase the profit of the power plant.

In this study the effect of technical advance on boiler was considered. As a result, it was indicated that an improvement of the energy efficiency of boiler can largely contribute to the EFB volume reduction (Fig.4).

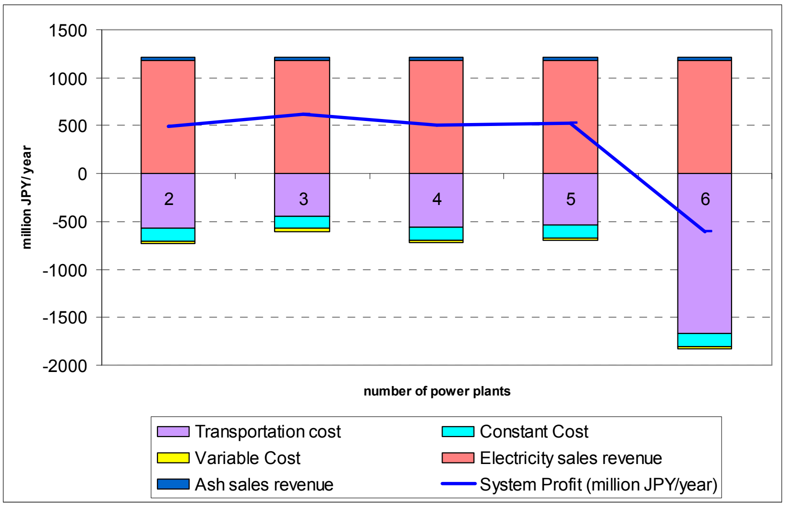

Fig.3: System total cost of different number of power plant in the state of Sarawak

4. CONCLUSION

The effective movement of EFB from palm oil mills to power plant is critical. This is because inefficient location for production will result in excess cost being incurred throughout the lifetime of the facility. In transporting massive amounts of a commodity way must be found on how to minimize the effort in getting it to its destinations. Power plants location is important to reduce the transportation cost, but we can consider another alternative. According to z. Hussain, Z.A. Zainal, M.Z.Abdullah, the energy balance in a typical palm oil mill is far from optimum. It might be an option to utilize the excess energy from palm oil mill to dry EFB, to reduce the volume of transporting EFB to increase the profit of the power plant. In this study the effect of technical advance on boiler was considered. As a result, it was indicated that an improvement of the energy efficiency of boiler can largely contribute to reduce the EFB volume.

Heat Balance Equation:

$$q(1-\varepsilon/100) = w_{EFB}\{(1-{}^{mc}\!/_{100})\int_{T_0}^{T_{Dry}} c_{EFB}dT + {}^{mc}\!/_{100}\int_{T_0}^{T_{Dry}} c_w dT + q_w(mc-x)/100\}$$

- w_{EFB}: Input Amount of EFB (kg)
- mc : Moisture Content of EFB (%)
- T_0 : Initial EFB Temperature (℃)
- T_{Dry} : Drying Temperature (℃)
- c_{EFB} : Specific Heat Capacity of EFB (kJ/kgK)
- c_w : Specific Heat Capacity of Water (kJ/kgK)
- q_w : Latent Heat of Water (kJ/kg)
- q : Supplied Heat (kJ)
- ε : Heat Loss (%)
- x : Moisture Content of EFB after Drying (%)

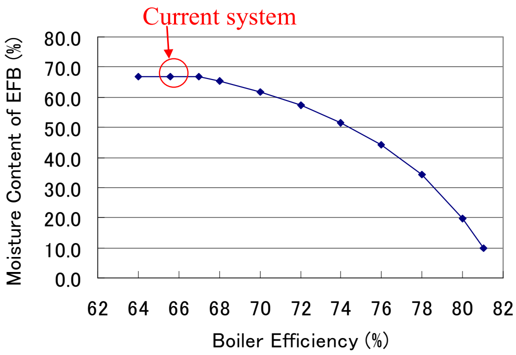

Fig.4: Relation between the energy efficiency of boiler and moisture content of EFB

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