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Biomass Value Improvement and Techno-Economic Analytics in Power Plant

Rahardi Santoso[1*], *Danianto* Hendragiri[2**], *Iwa* Garniwa[3]

[1,3]Departement of Electrical Engineering, Faculty of Engineering, University of Indonesia, Depok, Indonesia
[2]Suralaya PGU, PT Indonesia Tower, Cilegon Indonesia
[*]rahardi@gmail.com
[**]danianto.hendragiri@indonesiapower.co.id

Abstract. The 23% NRE energy mix in 2025 is getting closer. An alternative fuel is needed to support the energy mix program and can improve power plant performance. Sawdust, which is the residual biomass from the furniture industry in Indonesia, has good potential to be reused as an alternative fuel and part of renewable energy. This research investigates further to improve the value of sawdust into biocharcoal as renewable energy cofiring that has a higher calorific value by pyrolysis process, and the optimum composition as a fuel mix component in coal power plant. The analysis process uses tabulation and has been validated by using SOLVER to make the cofiring composition so as to get optimization in order to get the most efficient fuel cost (cents/kWh) by setting up the calorific value target. In the economical sensitivity area, coal price has more affecting than biocharcoal price.

I. INTRODUCTION

The energy mix of 23% NRE in 2025 [1] encourages Indonesia to be able to immediately realize the use of renewable fuels and reduce mineral fuels whose availability is dwindling. An example of a fuel that is currently massively used as fuel for power generation is coal. New renewable energy sources today are actually very abundant. One of them is a material that is initially less economical because it is a residual waste from furniture production, namely sawdust which is used for making furniture. Wood waste from wood processing factories reached 49.3% [2].

The availability of sawdust can be used as an alternative fuel in Steam Power Plants. The sawdust is used as a coal mix material (cofiring) so that the coal composition is not 100% but can be reduced according to the portion of the mixed sawdust. The calorific value of coal commonly used in Indonesia is at the MRC level around 17.58MJ/kg to 19.68MJ/kg. While the calorific value of sawdust is at a value of 6.28MJ/kg to 11.30MJ/kg. The calorific value of this coal powder even though the amount is small will affect the calorific value of the mixture. In several power plants, cofiring has been tried with a mixture composition of 1%

sawdust. The impact of this sawdust mixing after being mixed in coal as cofiring, there was a decrease in the calorific value of the mixture by 0.57% compared to the pure calorific value of coal. This composition will continue to be increased in proportion to support the government's 23% NRE energy mix program. Utilization of sawdust which was originally a waste of furniture production, with the cofiring program, is now useful as a coal mixing material and as part of alternative renewable fuels. However, due to its low calorific value, the value of this sawdust is increased using the pyrolysis method so that it decomposes [3] the material into biocharcoal which has a higher calorific value of up to 24.55MJ/kg [2].
The purpose of increasing the value of sawdust into biocharcoal is to determine strategies for using biomass in the form of biocharcoal so as to increase the use of NRE. In this research, it is sought how much influence the use of biocharcoal and its economic sensitivity as quality biomass has on Power Plant operations. Sawdust is also the answer to reducing the emission content of the power plant, namely the ash content [4] and sulfur [5]. The material content is smaller than that contained in coal

II. BIOCHARCOAL AND PLANT PERFORMANCE

2.1 Pyrolysis

The process used to process sawdust into biocharcoal is using pyrolysis [6]. The calorific value resulting from the pyrolysis process is up to 24.55MJ/kg. An important process of economic consideration is how much it will cost to produce the biocharcoal. Referring to several journals that discuss the pyrolysis process [7] obtained the pattern of capital costs and operational costs.

To get biocharcoal, the basic material of sawdust must be obtained first with the commonly used price of USD34.09/ton. Referring to the weight loss (%wl) during the pyrolysis process of 74% [8] [9], the price of raw materials is (1/(1-*%wl*)) of the price of sawdust.

The capital cost to build a Biocharcoal plant [8] is shown in Fig. 1.

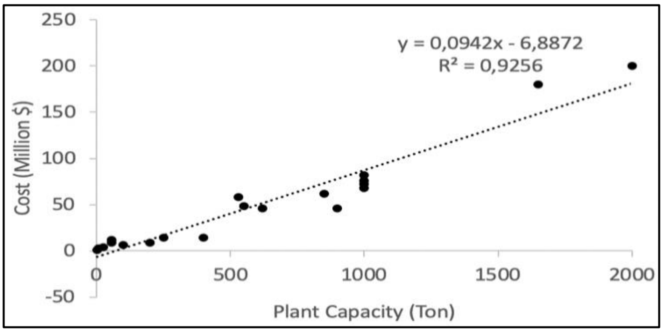

Fig. 1. Capital Cost

From the trendline of the graph obtained the capital cost in linear equation of plant capacity:

$$y_{kap} = 0,0942x - 6,8872 \qquad (1)$$

Then proceed by making a trendline of the operational costs data as below:

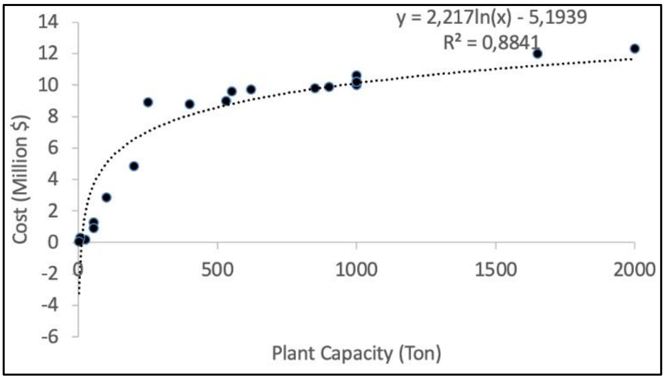

Fig. 2. Operational Cost

The equation of the Operational cost can be drawn from the trendline :

$$y_{Op} = 2{,}2170 \ln(x) - 5{,}1939 \qquad (2)$$

Then to get the overall cost by using the equation :

$$PR_{BC} = PR_{CAP} + PR_{OP} + PR_{BM} \qquad (3)$$

From the PR_{CAP} using Value-Time Money [10] by converting capital costs into depreciation costs in discrete terms, using the equation:

$$A = P\left[\frac{i.(1+i)^N}{(1+i)^N - 1}\right] \qquad (4)$$

Assuming interest and useful life of the biocharcoal plant. To get the final price of biocharcoal, all costs must be equalized to be in tons-per-day from the initial ton-per-year.

2.2 Power Plant Performance

To calculate the performance of the generator, there are several parameters used to obtain the Fuel Cost, namely Energy (MJ) and electricity production (kWh) with the following equations [11]:

$$GPHR = \frac{E}{P} \qquad (5)$$

Then to calculate the speed of coal consumption with the equation:

$$SFC = \frac{GPHR}{CV} \qquad (6)$$

So we will get several Power Plant performance parameters and fuel cost

$$Fuel\ cost = \frac{Total\ Fuel\ price}{Production} \qquad (7)$$

From these calculation components, it can then be calculated, an optimization and sensitivity research made.

III. RESULTS AND DISCUSSION

Based on the operation of one of the power plants in Indonesia with a capacity of 4x400MW. Total production in May 2021 obtained 979,707,605kWh by consuming cofiring according to the table:

Table 1. Cofiring Composition

	Unit	Coal	Sawdust
Massa	ton	538.249,41	4.577,85
CV	MJ/kg	19,02	9,83

From the mixing of the cofiring, the energy obtained is 10.280.107.534,26 MJ. Referring to (5), the GPHR is 10.51MJ/kWh.

The GPHR can be used to calculate how much coal or biocharcoal will be consumed to replace sawdust which has a low calorific value. Bicharcoal whose calorific value reaches 24.55MJ/kg, so to get the price of each kg, you can use (1), (2), (3) and (4) all of which must be converted daily.

Using (1) the total capitalization value is obtained. Needs to be converted into discrete annuals assuming certain interest and useful life. Used, i = 1.68% and the economic life is 30 years, then the annual capitalization cost with (4) becomes USD5,495,192.59/year, and simplified again to USD 10,90/ton.

For the operational cost of biocharcoal production using (2) obtained USD729.63/year and converted daily to USD 21.06/ton. As for the purchase of raw materials that have been converted to *%w*l, the material price is USD131.13/ton. So by applying (3), we get PR_{BC} USD163.09/ton.

In the period of May 2021, data on coal prices are PR_C USD55.79/ton and PR_{BM} sawdust price USD34.09/ton.

From the data processing, it can be found fuel cost. To obtain the optimum value for compliance with the calorific value standard at 19.26MJ/kg, then to replace sawdust, biocharcoal is needed whose calorific value is higher than the average coal 19.02MJ/kg.

Using SOLVER to calculate the optimization of the quantity of Biocharcoal needed to mix Coal + 1% sawdust is as much as 1346.12ton/day. The tonnage is equivalent to 9.64% of the composition of biocharcoal on coal. Obtained the fuel cost is 34.99 cents/kWh

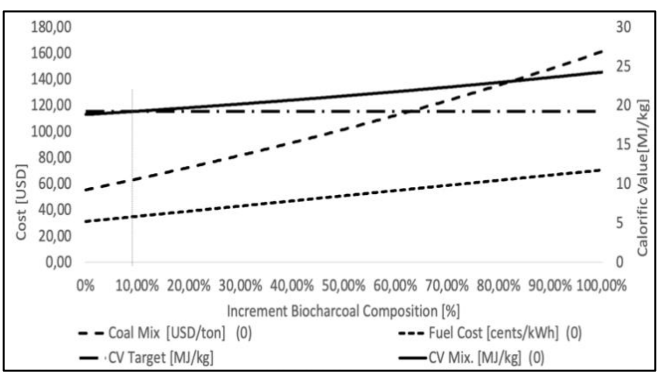

Fig. 3. Optimization of biocharcoal composition in cofiring

Meanwhile, by using a sensitivity study, the data used are the results of the previous optimization with a 9.64% biocharcoal composition, which will get the effect of price changes for each type of fuel.

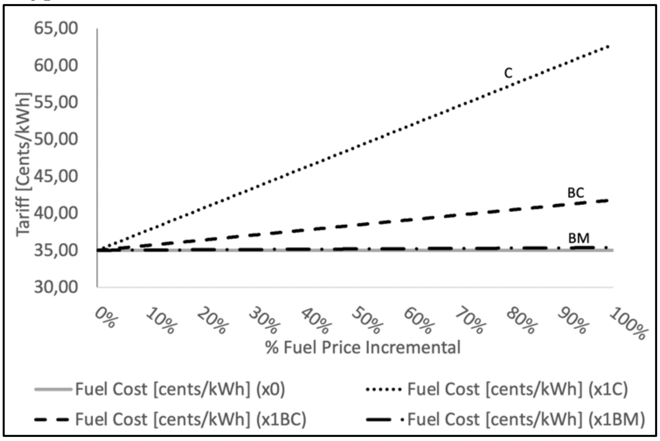

Fig. 4. The sensitivity of rising fuel prices graph

From fig. (4) it can be concluded that the increase in the price of coal has a more significant effect on changes in the price of fuel cost compared to the increase in the price of biocharcoal. This condition will remain relevant as long as the biocharcoal composition does not exceed a certain threshold.

To obtain this threshold, further studies are needed to find out the significance of the same impact between biocharcoal and coal. After doing the process, it is obtained according to the following graph:

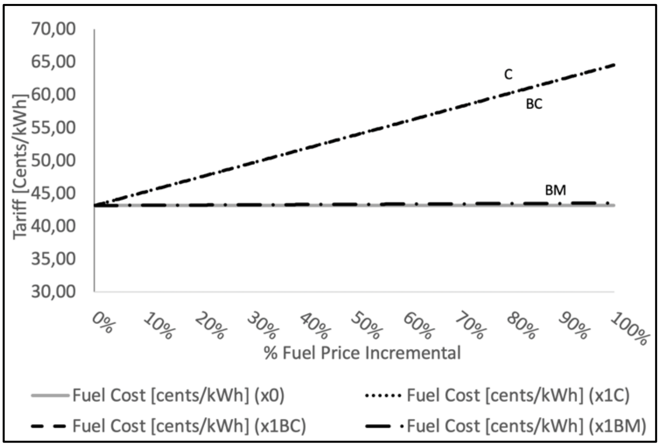

Fig. 5. Price sensitivity chart for fuel cost with the same impact either Coal (C) and Biocharcoal (BC)

So as long as the composition of biocharcoal is not more than 30.32% of coal, the effect of rising coal prices will dominate the price increase of fuel cost. So to maintain this dominance, the composition of biocharcoal remains below 30.32%.

The composition figure of 30.32% of biocharcoal as NRE has exceeded the government's target threshold of 23%, so the energy mix of 23% is still safe against the potential increase in the fuel cost.

IV. CONCLUSION

In this research, it has been illustrated that the use of Biocharcoal as a result of the waste product improvement of the wood industry has good potential as an alternative fuel to replace coal, especially as fuel for power plants. The value improvement process of sawdust into biocharcoal using the pyrolysis method to increase caloric value per mass of material. It has a high calorific value and has good potential because based on sensitivity studies it is also shown that in the composition of the biocharcoal mixture under 30.32%, coal has the potential to have a significant effect to the fuel cost. Based on this research, strategic decisions can be made regarding the energy mix program. The use of biocharcoal also has additional advantages over coal because the ash and sulfur content is lower than the content in coal so it is beneficial to the environment and the power plant itself.

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