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Economic and Financial Analysis of Cofiring the Coal Fired Steam Power Plant Capacity 660 MW with Biomass (Sawdust)

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A B S T R A C T

Research on Cofiring of the Existing Coal Fired Power Plant with biomass in the form of sawdust with a mixture percentage of 5% was carried out with the main objective of pursuing the acceleration of the renewable energy mix target of 23% (Green Booster) by 2025, with minimal CAPEX costs if compared to building new hydro or solar PV plants. At the initial stage of the activity, testing and analysis of the effect of cofiring will be carried out on several main parameters of the Existing PLTU's performance, as well as its reliability. In addition, it is also at the same time to get an overview and evaluate if the cofiring plan will be implemented through technical operational evaluations, the cost of production from the aspect of fuel costs (component C) and exhaust emissions to the environment. From the results of monitoring the operating load at around 635 MW (gross) using 5% cofiring, it can be seen that critical points such as main steam temperature, main steam pressure, gas economizer outlet temperature, mill outlet temperature do not show a significant increase, meaning they are still within the operating limits, reasonable and safe. From the calculation of the cost of fuel, the coal price is IDR 594 per kg, and sawdust price of IDR 472 per kg (on site) using the SFC difference of 0.0077 kg/kwh, and the CF assumption of 80%, then with an average annual electricity production of 4,415,040,000 kwh/year, fuel savings of around IDR 35.32 billion per year will be obtained. Exhaust gas emissions to the environment for SO_2 and NOx still meet the environmental quality standard requirements according to the Minister of Environment and Forestry Regulation No.15 of 2019.

INTRODUCTION

Biomass is material derived from living organisms which includes plants, waste residue, crop residues and so on. The term biomass was first introduced by the Russian scientist, Bogorov, in 1934 in the Journal of Marine Biology Association. Biomass contains caloric value almost same as low rank coal type (around 4,200 kCal/kg) and also much less sulfur than most types of low rank coal, suppose that subbituminous and lignite.

Potential reserves of biomass in Indonesia are 32.6 GW according to the Ministry of Energy and Mineral Resources. This can be used as an alternative to support national energy sources, mixing together with Fossil fuel as Cofiring, as a source of fuel material for Coal Fired Steam Power Plant.

Biomass is scattered around the area where the power plant is located and the supply can be sustainable. This can come from agriculture, forests, plantation, and also industrial processing and utilization of wood processing. Tightening environmental regulations as a response to global climate change is also a reason to further accelerate the implementation of the use of coal and biomass cofiring in existing power plants. Changing source of fuel from coal full into cofiring biomass is expected will provide a better environmental impact.

Cofiring, the practice of supplementing a base fuel with a dissimilar fuel, is an extension of fuel blending practices common to the solid fuels community. Recently, there has been considerable emphasis on cofiring biomass opportunity fuels with coal in pulverized coal (PC) and cyclone boilers owned and operated by electricity generating utilities in order to address such issues as potential portfolio standards, voluntary actions to reduce fossil CO_2 emissions, customer service, and the generation of green power within the context of deregulation [1].

The advantages that can be obtained by implementing cofiring are that there is no need for large investments, the use of biomass can adjust to the availability of supply, reduce emissions and reduce dependence on fossil fuels. Also, it can reduce *Greenhouse Gases* (GHGs) by 70% more than coal [2].

Projections of biomass consumption in the form of firewood (95%) or charcoal (5%) in the develop countries amount 1.26 billion ton in the year of 2020 [3]. However, there are some significant barriers electricity from biomass, these are, fossil fuel subsidized, low electricity tariff and continuously biomass supply required [4].

Objectives

This research aims and objectives are to analyze the main equipment and utility, also main process parameters technically still proper when using cofiring between coal and biomass (sawdust) with mixing composition 5% sawdust, saving in fuel cost component, and also at the end, enabling power generation for more green and clean energy.

Cofiring of biomass can help improve domestic energy security as well as increasing the share of renewable biomass used in power plants initially designed for coal burning. Indonesia has released a vision for renewable energy, called Vision 25/25, in which renewable energy will meet 25% of the total energy demand in 2025 [5].

Biomass Supply

The biomass used will be taken from around the power plant site location to minimize transportation or delivery cost with caloric value same as fuel coal which already used in daily operation. The total plantation area is projected to reach approximately 13 million hectares by 2020 [6].

METHOD

Most domestic coal in Indonesia is classified as low rank coal (LRC), with a heating value near that of biomass. LRC also has a high moisture content, a low sulfur content, high reactivity, and a low calorific value [7], [8].

Biomass characteristic which will be used for Cofiring purposes must have similar characteristic with fuel Coal already used commonly. Comparation seen by ultimate analysis and proximate analysis results, tested from chemical laboratory and validated by related expert institution. There are some parameter or data taken from Ultimate Analysis comprise percentage of Carbon, Hydrogen, Nitrogen, Sulphur, and Oxygen. Parameters or data taken from Proximate Analysis comprise of percentage of Total Moisture, Ash content, volatile matter, fixed carbon, Gross Calorific Value, Hardgrove Grindability Index (HGI).

Biomass is collected from sawmills around the area/region of power plant location, economically distance no more than 50 km, by suppliers and delivered by truck to the power plant site. The unloading sawdust shelter is located at the coal yard after going through the weigh bridge.

Cofiring of biomass in a coal-fired combustor can be performed using different methods, including injection, co-milling, pre-gasification, and parallel co-firing. Injection cofiring, in which pre-milled biomass is mixed with the pulverized coal fed to the combustor, is considered to be the most feasible method, because of its relatively low capital cost and high cofiring ratio [9].

The addition of biomass in a coal-fired power plant can significantly reduce GHG emissions and reduce slagging inside the combustor. Newly-built coal fired power plants in some European countries, Japan, and China are largely co-fired, with biomass accounting for 10%–20% of output on a calorie basis [10].

Cofiring is done by mixing biomass with fuel coal directly with a percentage composition sawdust 5% and coal 95% (it around 114 tons of sawdust and 2,166 tons of coal are mixed). Total flow at 635 MW loading operation is 380 tons/hr. Then, main process parameters will be monitored for six (6) hour duration.

Mixing of biomass and coal done by manually uses excavator at coal yard after the composition amount ensured according to the coal weighing system. After mixing evenly, then pushed by bulldozer close to reclaimer area so it can be scratched and lay down above underground hopper to convey into coal bunker. At the end will be crushed and pulverized by coal mill, before feeding into the burner.

That above method does not require additional equipment for existing power plant which already operated and no need to shut down the power plant. Therefore it does not requires additional costs. Mixing can be done anytime according to arrival schedule of biomass delivery.

Data retrieval is carried out when the load is stable through monitoring operations workstation at the load setting of 635 MW. The main parameters or critical points that is observed are main steam pressure, main steam temperature, furnace exit gas temperature, mill outlet temperature, coal flow and total air flow.

Cost efficiency parameter (IDR/kWh) to determine the effect of reducing production costs from the aspect of fuel cost components can be calculated from multiplying coal fuel price by coal specific fuel consumption (SFC) factor subtracted to biomass price, (after multiplying biomass price by SFC biomass).

$$SFC = \frac{\text{Total Fuel}}{\text{kWh generated}} \tag{1}$$

Where;

SFC	: Specific Fuel Consumption	[kg/kWh]
Total Fuel	: Total Fuel Consumption	[kg]
kWh Generated	: Total electricity produced	[kWh]

RESULTS AND DISCUSSION

Biomass (sawdust) can be commercially blended with coal in various proportions ranging from 1% to 25% or more. But in this discussion we will focus on burning sawdust with 5% proportion on the pulverized coal type boiler in the existing Power plant by directly Cofiring way. Implementation of cofiring must always remain to keep the performance, efficiency and reliability of power plant stay in limit normal operated as before when using 100% coal fuel. From the data test and evaluation that shown, all main equipment able to run properly and not to be damaged or malfunction. Significant decrease in main process parameters are not occurred. Power utility usage also did not increase because it did not require additional motor or another special electrical tool/equipment [11], [12].

The table below describes main operating data uses cofiring 5% sawdust on load hold at stable condition 636.50 MW. Basically, these are no significant deviation compared to using 100% coal.

Table 1. The operating data on cofiring 5% sawdust

Load : 636.50 MW			
Parameter	**Status**	**Data value**	**Unit**
Main Steam Pressure	normal	167.26	MPa
Main Steam Temp.	normal	535.02	ºC
Gas economizer outlet Temp.	normal	395.28	ºC
Total Air Flow		2821.93	Ton/hr
Total Fuel Flow		380.65	Ton/hr
Spray Superheater Total Flow		111.45	Ton/hr

The table below is presenting characteristic comparison between typical subbituminous coal (low rank coal) and biomass (sawdust type) which obtained through laboratories analysis.

Table 2. Characteristic comparison Coal vs Sawdust

Parameter	**Coal**	**Sawdust**
Calorific value (kCal/kg)	4,199	4,294
Fixed carbon (%)	30.24	15.07
Total sulphur (%)	0.11	0.09
Ash content (%)	2.96	1.17
Volatile matter (%)	30.97	75.16
Total moisture (%)	35.84	8.60
Hargrove Grindability Index	> 45	< 32
Oxygen (%)	13.22	38.99

One of the most important function in financial management is the evaluation of capital expenditures, it is encompasses the initial investment screening and selection of the necessary projects [13]. Calculation result for operating coal fuel 100% against biomass fuel with cofiring 5% sawdust for production cost from fuel aspect (component C) obtained difference / margin as below.

$$SFC_{100\%coal} = \frac{1.540.650kg}{2.420.293kWh} = 0.6366\ kg/kWh$$

$$SFC_{5\%cofiring} = \frac{1.528.579kg}{2.430.410kWh} = 0.6289\ kg/kWh$$

Production cost (component C, Fuel cost) with 100% coal:
= Coal price x $SFC_{100\%coal}$
= IDR 594 /kg x 0.6366 kg/kWh
= IDR 378 /kWh.

Production cost (component C, Fuel cost) with 5% cofiring:
= Coal price x $SFC_{5\%cofiring}$
= [(95% x IDR 594 /kg)+(5% x IDR 472 /kg)] x 0.6289 kg/kWh
= IDR 370 /kWh.
Margin = IDR 378 /kWh – IDR 370 /kWh
= IDR 8 /kWh.

When annual total electricity power generated 4.415.040.000 kWh (CF 80% included), will be obtained cost saving amount IDR 35.32 billion per year.

Sawdust

Sawdust is a tiny piece of wood that fall as powder from wood as it is cut by a saw. In other words, sawdust is basically a waste of small particles available in saw-milling industries, pulp plant and paper industries as well as wood processing industries particularly. Sawdust is generally considered as a timber-industrial waste that pollutes the environment but can become a valuable commodity either as a raw material in manufacturing industries for wood boards, light construction materials such as shelves, notice boards, wall and roof sheeting for mobile houses, as an insulator in the refrigerating system and cold conservation of in Energy industries as fuel burned directly or indirectly. More precisely, the bulk density of sawdust could be as low as 150 - 200 kgm^{-3} [14].

Figure 1. Sawdust Texture

CONCLUSIONS

Generally as per monitoring on composition 5% biomass – coal material mixing (cofiring) applying for operational parameter coal mill, furnace and boiler temperature are safe and within normal limits. Emission of SO_2 and NOx also tends to fall and stay within the environmental requirement.

Based on calculation obtained saving in fuel cost till IDR 35.32 billion per year, with assumption difference price between coal price IDR 594 per kg and sawdust IDR 472 per kg, with SFC margin 0.0077 kg/kWh, and average CF 80% will produce electricity till 4,415 GWh/year.

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