Evaluation of cofiring application in power plant's coal combustion

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Abstract: Steam Power Plant (*PLTU*) is a power plant that uses coal as an energy source to generate electricity. Burning coal to produce energy will produce residues in the form of carbon dioxide (CO2), carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), as well as bottom ash and fly ash which is harmful to health and the environment. To reduce pollutant emissions, RS-*PLTU* has implemented a co-firing system using sawdust. After 8 months of testing, it was seen that there was a decrease in exhaust emissions which could be monitored from CEMS. The total use of sawdust was 10,313.9 tons, which was only 0.54% of the initial consumption target. While the total KWh green produced is 11,108 MWh. The sawdust used comes from the waste from the local wood industry to build the local people's economy.

1. Introduction

Using energy in Indonesia for electricity generation is still very dependent on the combustion of fossil fuels such as coal, oil and gas. From the combustion of fossil fuels, CO_x, NO_x and SO_2 gases are produced which can cause air pollution and also produce radioactive pollutants. *PLTU* is an energy producer that consumes a lot of fossil fuel. The use of coal can also impact air pollution from coal handling in addition to emissions from chimneys [1].

The increase in the amount of CO_x gas in the air due to the burning of fossil fuels will increase the greenhouse effect which can cause global warming and ultimately can affect climate change and damage to ecosystems on earth. Meanwhile, radioactive pollutants occur because coal contains natural radioactive elements trapped in coal, where when the coal is burned, it breaks down, causing the natural radioactive elements to come out together with other emission gases or are included in the ashes of combustion. The natural radioactive elements of coal consist of potassium, uranium, thorium, and decay products such as radium, radon, polonium, bismuth and lead [2].

Therefore, an alternative system for burning coal is needed as a power plant that is more environmentally friendly, inexpensive, and efficient. One type of energy that has the potential to be developed is biomass (waste and energy plantations). Based on the Paris Agreement, the government has announced the achievement of the EBT mix of up to 23% in 2025, where the achievement of the EBT energy mix in 2020 is 13.1%, and the target of Greenhouse Gases (GHG) in 2030 is 29% (equivalent to 834 million CO2) [3]. So, efforts to increase the EBT mix are carried out by implementing biomass cofiring in the combustion of *PLTU*.

Co-Firing is the process of adding biomass as a partial replacement fuel to a coal boiler. This mixing of biomass combustion with coal has been tested in all types of boilers commonly used by power plants. Only a fraction of the total boiler efficiency is lost after adjusting the combustion output by blending biomass to coal combustion. This proves that the efficiency of burning biomass on electricity will increase when combined with coal. Demonstration and testing also ensure that biomass energy can provide 30% of the total input energy by modifying the feed intake system and burner. Biomass is an alternative to reduce CO2 emissions at a high level. Co-firing coal with biomass using a Circulated Fluidized Bed (CFB) is a promising technology that can reduce CO2 emissions where emission levels can be as competitive as supercritical technology [4]. This article will discuss the evaluation of the application of cofiring in burning coal at RS-*PLTU* in Probolinggo, East Java.

2. Methodology

In this article, an 8-month cofiring trial was conducted using sawdust biomass. Sawdust is an example of an application of biomass for energy. The wood raw material referred to is the wood residue resulting from the processing of paper, furniture, and others. The *PLTU* RS uses sawdust as biomass which is mixed in the cofiring process. The sawdust supply/feedstock comes from the area around the *PLTU*. The following are the sources of supply that can meet the biomass needs of the *PLTU* in table 1.

Table 1. The Sources of sawdust feedstock.

No	Source	Location	Wood	Supply (t/d)
1	Source A	Paiton	Sengon	10
2	Source B	Condong, Gading	Sengon	24
3	Source C	Wringin	Sengon	40
4	Source D	Jember	Sengon	48
5	Source E	Wonomerto	Sengon	20
6	Source F	Lumajang	Sengon	20

As for the location of the position when viewed from the map, the image aimed at figure 1 is obtained.

Figure 1. Map of biomass feedstock location.

From figure 1, it can be seen that the supply/feedstock of Co-Firing at *PLTU* RS can be fulfilled from the area around the *PLTU* (50 km from the *PLTU*) and makes a positive contribution to the development of the people's economy around it. And obtained data on sawdust consumption, the amount of green kWh that can be generated, the amount of exhaust gas concentration, as well as sawdust supplier data. Exhaust gas emission data resulting from coal combustion is obtained from

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monitoring the levels of pollutants in the chimney or what is known as Continuous Emission Monitoring (CEMS). Prior to using CEMS, monitoring was carried out by carrying out manual monitoring where officers from the environmental laboratory took exhaust gas sampling from industrial facility chimneys then carried out the analysis in the laboratory to determine the level of pollutants including SOx, NOx, PM in the exhaust gas. In monitoring exhaust gas, it must comply with the emission standards for steam power plants (*PLTU*) in the Minister of Environment and Forestry Regulation No.15 of 2019 according to table 2 [5].

Table 2. Quality standard of the steam power plant.

Parameter	Maximum Amounts (mg/NM_3)		
	Coal	Oil	Gas
Sulfur dioxide (SO_x)	550	650	50
Nitrogen dioxide (NO_2)	550	450	320
Particulate (PM)	100	75	30
Mercury (Hg)	0.03	-	-

Then the exhaust emissions monitored by CEMS before using cofiring can be seen in table 3.

Table 3. Initial of gas emission.

Time	Parameter (mg/NM^3)		
	SOx	NOx	PM
Initial	536	424	26.82

3. Results and discussion

3.1. Sawdust consumption

Biomass Co-Firing in *RS-PLTU* currently uses wood residue (sawdust) as the Co-Firing biomass. At the same time, the main products from trees remain for several main purposes such as construction, furniture, plywood industry and pulp and paper. The amount of sawdust consumption for 8 months can be seen in figure 2 below.

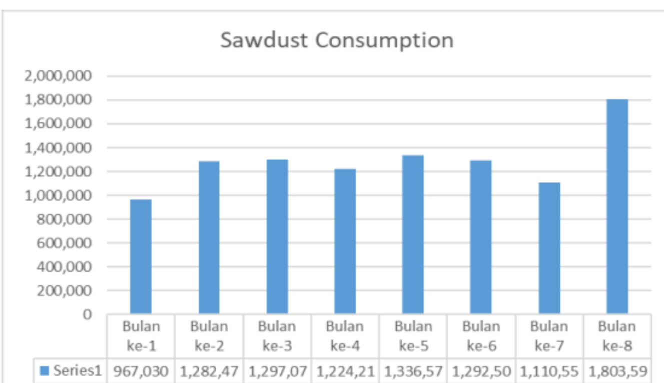

Figure 2. Sawdust consumption.

The main objective of cofiring in coal combustion is to reduce exhaust emissions and produce green kWh to pursue the target of renewable energy potential. The resulting kWh amount can be seen in figure 3.

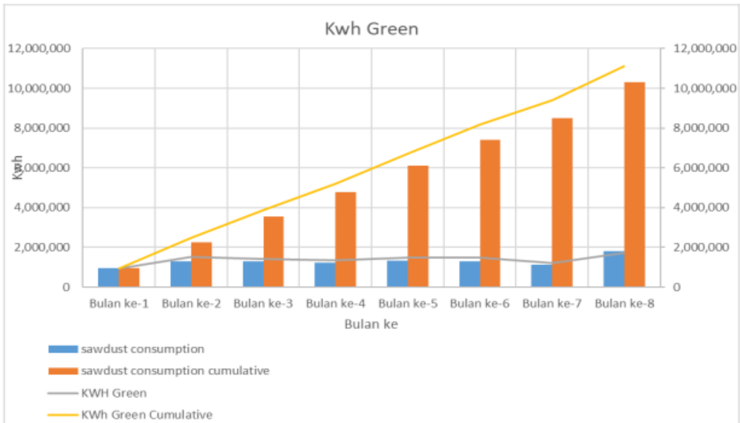

Figure 3. kWh green.

3.2. Exhaust gas emission
From monitoring through CEMS, the following data on exhaust gas emissions are obtained after using cofiring.

Table 4. Exhaust gas emission.

Time	Parameter (mg/NM^3)		
	SO_x	**NO_x**	**PM**
Before Cofiring	536	424	26.82
After Cofiring	285	267	16.82

3.3. Discussion
One of the efforts to increase the EBT mix is through the use of biomass raw materials. RS-*PLTU* is conducting a *PLTU* cofiring program by substituting a portion of coal fuel with biomass using Refused Derived Fuel (RDF) technology where the fuel comes from waste that has gone through a process of sorting and homogenizing into small grain sizes where the RS-*PLTU* uses sawdust as material RDF waste that has met the requirements of 95% of organic material [6]. The sawdust used comes from the area around the *PLTU*, where the seven suppliers can supply the sawdust demand scenario of 1200 tons/month. By providing sawdust raw materials from the surrounding areas, it is integrated to encourage the growth of local industries and pellet-making factories. Wood chip chopper can increase regional economic growth through community service [7-9].

In the 8-month trial, the total sawdust consumption was 10,313.9 tons from the initial daily consumption target of 483 tons/day, while the realization was only 42.1 tons/day or 0.54%. Then the total number of kWh Green that can be generated is 11.108 MWh, where the target is 518.3 MWh green kWh/day while the realization is only 45.3 MWh/day. So, the fore case will be carried out in the future where the use of sawdust in the cofiring process of 1200 tons/month to obtain the desired green kWh target. So, biomass cofiring is not only beneficial in increasing the economic growth of the surrounding areas but can produce kWh green optimally [10-12].

The cofiring process shows that there is a reduction in *PLTU* exhaust emissions after mixing coal with biomass of 251 mg/NM^3 at SOx, 157 mg/NM^3 at NOx, and 10 mg/NM^3 on PM and still approve by quality standards for exhaust gas emissions (*Permen KLHK No.15 of 2019*) [5].
In addition, cofiring with RDF also produces high heating values. The calorific value is the main parameter of biopelet quality and is very important in determining fuel efficiency. The calorific value in this study ranged from 4,297-4,780 Kcal/Kg. The calorific value produced in this study meets SNI 8021-2014, which requires a biopelet calorific value of more than 4,000 Kcal/Kg.

4. Conclusion
The cofiring evaluation using sawdust as RDF material has resulted in many benefits for the company, consumers, and the community around the RS-*PLTU*. Cofiring with sawdust can improve the surrounding community's economy, produce kWh Green that is safe for the community, reduce exhaust emissions, and produce high heating value.

Acknowledgement
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GENERAL COMMENTS

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