# The Potential Of Biomass Co-firing In Overcoming Coal Limitation In Steam Power Plants

*Eli* Hendrik Sanjaya[1*], *Much.* Sayfulloh Alwy[1], *Abdul* Khafid Syahroni[1], *Ahmad* Atif Fikri[2], *Syamsul* Bachri[3], *Duwi* Leksono Edy[2], and *Mohd.* Fadhil MD. Din[4]

[1]Department of Chemistry, Faculty Of Matematic and Natural Science, Universitas Negeri Malang. Jl. Semarang No.5 Malang 65145, East Java, Indonesia
[2]Mechanical Engineering, Faculty Of Engineering, Universitas Negeri Malang. Jl. Semarang No.5 Malang 65145, East Java, Indonesia
[3]Department Of Geography, Faculty of Social Science, Universitas Negeri Malang. Jl. Semarang No.5 Malang 65145, East Java, Indonesia
[4]Civil and Environmental Engineering, Universiti Teknologi Malaysia Johar Bahru, Johar, Malaysia

**Abstract.** The limitations that lead to coal scarcity are interesting to study, because coal is used as the main fuel source in steam power plants (PLTU). In this study, the use of biomass made in the briquette model for biomass cofiring is offered as a substitute for coal in PLTU. The materials used in biomass cofiring here are abundant and rarely used materials, such as sugarcane waste, palm oil waste, corn waste, wood saw waste, and durian fruit waste. The results of the biomass cofiring potential are measured based on proximate testing, where the results obtained by the calorific value of the materials used are quite high, with the highest material being rice husks which have a calorific value of 6800 kcal / Kg where this calorific value is higher than the calorific value of subbituminous batubaru which is 4600-6400 kcal / Kg. so that its potential as a substitute for coal at PLTU needs to be reviewed as a step towards the continuity of electricity availability at PLTU.

## 1 Introduction

The use of tools that use electricity has grown rapidly, while the supply of electricity continues to decrease. This lack of electricity supply occurs because the main source of electricity is from steam power plants (PLTU), with the main fuel being coal. Coal in Indonesia itself is expected to run out by 2040 [1]. Efforts to overcome the limited amount of coal in steam power plants need to be assessed on the use of more environmentally friendly and available fuels continuously (renewable). One way that can be used is biomass cofiring, biomass is considered more environmentally friendly than coal, because it can reduce CO2

* Corresponding author: eli.hendrik.fmipa@um.ac.id

emissions [2]. This cofiring has even been included in Presidential Regulation 12 of 2022 concerning the Acceleration of Renewable Energy Development for Power Providers [3].
Biomass cofiring is the addition of biomass to the boiler of the PLTU [4]. Biomass combustion as a cofiring material was chosen because the material is cheap and easy to obtain, and can reduce the greenhouse effect caused by excess CO2 emissions [[5], even the dofiring process is referred to as zero CO2 emissions [6]. Biomass itself can be obtained from waste that is not so widely utilized, both from agricultural and plantation waste [7].
Some crops that can be used as biomass cofiring materials are oil palm, the area of oil palm in Indonesia in 2020 was reported to be 14.59 ha. With palm oil production of 3,723 kg/ha [8]. This is of course a concern because crude palm oil is used while empty bunches and oil palm seeds tend not to be used. In addition to oil palm, other crops used in biomass cofiring are crops with high productivity levels in Indonesia in a year, such as sugarcane 2.36 million tons [9], [9]], durian 1,582,172 tons [11], [10][11][12][12]. This is what drives these samples as the main material for biomass cofiring.
The biomass cofiring process has been carried out in Indonesia by the State Electricity Company (PLN) using biomass sources from crops grown in dry land or the cultivation of energy crops in forests such as kaliandra, gamal and lamtoro trees which produce 189 MW [13]. However, these results are not yet known about the proximate analysis of the materials used in biomass cofiring, so scientifically it is still necessary to conduct proximate tests compared to coal to determine its potential in embroidering coal shortages at coal-fired power plants.

# 2 Experimental Details

## 2.1 Equipment

The tools needed in this study include mashers, sieves, Calorimeter bombs with Parr 1341 type Oxygen Bomb Calorimeter, Furnace, Oven, Analytical balance, porcelain cup, watch glass and stopwatch.

## 2.2 Materials

Aquades, nickel wire, oil palm bunches, palm shells, coconut husks, coconut shells, rice husks, corn weevils, corn leaves, sugarcane leaves, bagasse, oil palm seeds, durian shells, durian seeds NaOH, phenolphthalein indicator, HCl, and oxygen gas.

## 2.3 Procedure

In this study, proximate testing of samples to be used in biomass cofiring, which will be compared with proximate from coal used in coal-fired power plants.

### *2.3.1 Preliminary Test Analysis Proksimat*

The sample to be used in biomass cofiring in the wind – air, then the sample weighed as much as ±6 grams using an analytical balance, then the sample was placed in a plastic clip to be used in several tests.

### *2.3.2 Calorific Value Testing*

Calorimeter value testing is carried out by measuring using an adiabatic bomb calorimeter device which is carried out by weighing as much as 1g of sample in powder form, this sample is then inserted into the sample holder, inserted into the calorimeter bomb tube, closed and flowed with oxygen gas, inserted the tube into the bomb calorimeter pool, closed the bomb pool, installed rubber, then turned on the current source, and seen the temperature change until it is found at a stable temperature. Look at the burning wire to find out the total filtration that occurred, then the bomb tube is washed and washing water is put into Erlenmeyer for titration.

#### *2.3.3 Ash Content Measurement*

Ash content measurement is carried out by weighing 3g of sample, put in a closed crucible dish, in the furnace for 2 hours with a temperature of 400oC. Turn off the tool and leave it all day, then weigh it the next day to find out the weight of ash formed.

#### *2.3.4 Moisture Measurement*

Measurement of moisture content is done using the help of an oven that is carried out by weighing the sample, the sample is then placed in an evaporation dish in the oven at a temperature of 105oC for 24 hours, then weighed to determine the weight of the sample that does not contain water.

## 3 Result and Discussion

### 3.1 Research Sample

The research samples used here are waste samples that are not too widely used and have a fairly low economic value such as bagasse, sugarcane leaves, corn weevils, corn stalks, corn leaves, durian seeds, durian skins, coconut husks, coconut shells. In addition, the samples used here are also used samples of oil palm bunches and oil palm seeds which are very abundant in Indonesia. This sample selection was chosen because of Indonesia's wide territorial coverage, in each year it always produces the types of plants used for this research sample, such as saiwt, coconut, rice, corn, durian, and sugarcane.
Indonesia has a large area, some land in Indonesia is used to produce useful crops such as oil palm, which in each year there is an increase in the area of oil palm plantations, the area of oil palm land in Indonesia in 2020 is reported to be 14.59 ha. With palm oil production of 3,723 kg/ha [8]. This is of course a concern because crude palm oil is used while empty bunches and oil palm seeds tend not to be used. In addition to oil palm, other crops used in this study were also used from crops that have high productivity in Indonesia in a year, such as sugarcane 2.36 million tons [9], Corn 878,971,000 tons [10], durian 1,582,172 tons [11], coconut 2.85 million tons, and rice reached 54,415,294.22 tons [12]. This is what drives these samples as the main material for biomass cofiring.

### 3.2 Caloric Value

Calorific value is one of the important factors in testing the quality of fuel in coal-fired power plants. Calorific value is the total heat released by a substance at the time of combustion [14]. The calorific value itself affects the quality of coal, the higher the calorific value of coal, the higher the quality of coal [15], this also applies in biomass cofiring to be used in coal-fired power plants. The results of the calorific value of several materials used in the study are as in table 1 below:

**Table 1.** Calorific value measurement results

| No | Sample | Calorific Value of Wet Sample (Kcal/g) | Calorific Value of dry sample (Kcal/g) |
|---|---|---|---|
| 1 | Fine fibers of saws | 2,721 | 2.808 |
| 2 | Bagasse | 1,266 | 1,449 |
| 3 | Corn stalks | 1,469 | 2,317 |
| 4 | Palm kernels | 6,756 | 6,808 |
| 5 | Sugarcane leaves | 2,915 | 3,032 |
| 6 | Coconut coir | 1,448 | 1,768 |
| 7 | Sawfly coarse fibers | 2,765 | 2,920 |
| 8 | Oil palm bunches | 4,713 | 2,582 |
| 9 | Coconut shell | 4,451 | 5,022 |
| 10 | Corn weevil | 2,787 | 3,237 |
| 11 | Corn leaves | 2,969 | 3,174 |
| 12 | Rice | 3,389 | 3,877 |
| 13 | Durian Husk | 0 | 4,554 |
| 14 | Durian Seeds | 1,160 | 4,447 |

In this table there are 2 calorific values, namely, the calorific value when wet, namely before drying for 24 hours at a temperature of 105°C and after drying, this is done in order to find out the difference in the quality of the biomass produced if there is still water in it and when it is completely dry. This calorific value is further compared with the calorific value of coal as the main burner in PLTU.

The calorific value in coal depends on the type of coal used, the coal used in coal-fired power plants is mostly subbituminous coal, which has the most abundant supply [16]. Subbituminous coal has a calorific value of 4600- 6400kcal/kg [16]. The results of the calorific value of samples used as biomass cofiring in most power plants have a range that is almost close to the calorific value of the sub-bituminous, this certainly makes a strong basis for the use of biomass cofiring in power plants.

### 3.3 Ash Content

Ash content is the total remaining ash residue after burning a main material [14]. Ash content has a close relationship with the ability of a material to be used as a substitute for new stone in biomass cofiring, because the higher the ash content can indicate a low calorific value [17]. So that the selection of materials to be used in biomass cofiring needs to pay attention to the ash content formed.

In this study the ash content formed varies depending on the type of material used, while the data produced is as the following table. In this table the % ash content of subbituminous coal is 2.95% [4], while the ash content of biomass cofiring material is lower than the type of subbituminous coal, so it can be said that the addition of biomass cofiring to be used in the power plant can increase the calorific value of PLTU fuel because the calorific value is inversely proportional to the ash content.

**Table 2.** Ash content measurement results

| No | Cofiring Material | Ash content (%) | % Subbituminous Coal Ash content |
|---|---|---|---|
| 1 | Rice husks | 0,312 | |
| 2 | Coconut shells | 0,266 | |
| 3 | Palm kernels | 0,298 | |
| 4 | Corn bonggoil | 0,054 | |
| 5 | Coconut coir | 0,313 | |
| 6 | Sugarcane leaves | 0,299 | |

| | | | |
|---|---|---|---|
| 7 | Palm coir | 0,137 | 2,95 |
| 8 | Corn leaves | 0,280 | |
| 9 | Corn stalks | 0,020 | |
| 10 | Bagasse | 0,031 | |
| 11 | Fine powder of wood | 0,175 | |
| 12 | Coarse sawdust of wood | 0,452 | |
| 13 | Durian seeds | 0,162 | |
| 14 | Durian Husk | 0,040 | |

### 3.4 Water Content (Mousturizer)

Water content is the total water content in coal. The content is one of the parameters in the peroximate test, which includes tests for moisture content, ash content, flying substances and tethered carbon content [14] [18]. The water content in coal itself will affect the calorific value, the higher the water content value, the lower the calorific value, which as a result will affect the quality of coal [19]. In this study, water content tests were carried out on samples to be used in biomass cofiring, and water content was produced as the following table 3.

**Table 3.** Water content measurement results

| No | Sample | Up to Air | % of air Subbituminos |
|---|---|---|---|
| 1 | Rice husks | 0,384 | 35,82 |
| 2 | Coconut shells | 0,342 | |
| 3 | Palm kernels | 0,280 | |
| 4 | Corn weevil | 0,058 | |
| 5 | Coconut coir | 0,366 | |
| 6 | Sugarcane leaves | 0,150 | |
| 7 | Palm coir | 0,126 | |
| 8 | Corn leaves | 0,241 | |
| 9 | Corn stalks | 2,000 | |
| 10 | Bagasse | 0,414 | |
| 11 | Coarse sawdust | 0,988 | |
| 12 | Fine sawdust | 1,149 | |
| 13 | Durian seeds | 1,979 | |
| 14 | Durian Husk | 2,832 | |

The moisture content data in the table is the result of conventional measurements. Conventional measurement of moisture content is carried out using the principle of evaporation carried out with the help of an oven at a temperature of 105oC for 24 hours. From these results, it can be concluded that the samples to be used in biomass cofiring have a fairly low moisture content and are suitable to be used as biomass in cofiring coal biomass PLTU.

### 3.5 Potential as Biomass Cofiring

Indonesia in meeting electricity needs in Indonesia is assisted by PLTU, where the PLTU itself requires a large enough coal supply, even in 2023 it has been explained that coal needs reach 161.15 million tons [20]. The need for coal is also seen in terms of its calorific value, because the small calorific value also affects the power of the daa issued. Such as coal which has a calorific value of 5317 kcal / kg which is able to produce 625 Mega Watt (MW) of power, with coal consumption of 0.4096 kg / kWh [16]. From this, it can be known the opportunity to use biomass cofiring as a substitute for coal in coal-fired power plants as table 4.

**Table 4.** Potential reduction in coal consumption per year

| No | Cofiring Samples | Willingness in a year ( million tons) | Calorific Value kcal/kg | Potential reduction in coal consumption (million tons / year) |
|---|---|---|---|---|
| 1 | Rice husks | 13,5 [21] | 2808 | 6,37 |
| 2 | Coconut shells | 0,342 [22] | 1449 | 0,25 |
| 3 | Palm kernels | 6,426 [23] | 2317 | 3,63 |
| 4 | Corn weevil | 2,7 [24] | 6808 | 0,76 |
| 5 | Coconut coir | 0,912 [22] | 3032 | 0,39 |
| 6 | Sugarcane leaves | 0,236 [25] | 1768 | 0,16 |
| 7 | Palm coir | 11,34 [23] | 2920 | 5,11 |
| 8 | Corn leaves | Unknown | 2582 | - |
| 9 | Corn stalks | Unknown | 5022 | - |
| 10 | Bagasse | 0,354 [25] | 3237 | 0,14 |
| 11 | Coarse sawdust | Unknown | 3174 | - |
| 12 | Fine sawdust | Unknown | 3877 | - |
| 13 | Durian seeds | 0,08 [26] | 4554 | 0,01 |
| 14 | Durian Husk | 0,96 [26] | 4447 | 0,16 |

## 4 Conclusion

Cofiring biomass from the samples used in this study has the ability to be used as embroiderer coal shortage in steam power plants, with the ability to reduce about 16 million tons per year, this result is still possible to increase according to the growth of plants used as biomass.

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