# *ANALYSIS OF WASTE UTILIZATION OF REFUSE DERIVED FUEL (RDF) INTO BRIQUETTES FOR STEAM POWER ELECTRIC GENERATION*

**TUGAS AKHIR**

Diajukan Sebagai Salah Syarat untuk Memperoleh Gelar Sarjana Teknik
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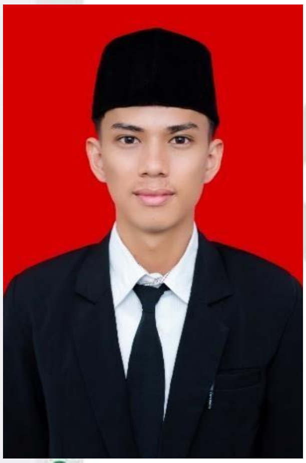

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**PEKANBARU**

**2024**

# LEMBAR PERSETUJUAN

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# Analysis of Waste Utilization of Refuse Derived Fuel (RDF) into Briquettes for Steam Power Electric Generation

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## ABSTRACT

*Waste in Indonesia reaches 65.2 million tons per year, dominated by organic and inorganic waste. Approximately 36% of the total waste is poorly managed, including 4K1P waste (paper, wood, fabric, rubber, and plastic), which can be quickly burned and turned into RDF briquettes through pyrolysis and paraffin adhesive. These briquettes will use three variations of raw materials: organic, inorganic, and mixed waste. The quality of these briquettes is compared based on calorific value, ash content, moisture content, and the fuel requirement for a 7.5 MW capacity power plant if used as fuel. The initial weight of the raw materials for each briquette is 2 kg, resulting in 10 pieces each of organic, inorganic, and mixed briquettes. Test results indicate that inorganic briquettes have the best quality with a calorific value of 8,075.92 cal/g, moisture content of 1.75%, and ash content of 10.84%, meeting the SNI-01-6235-2000 standard. The minimum fuel requirement for the power plant using RDF briquettes is inorganic briquettes, at 3.05 tons/hour or 26,205.6 tons/year. Inorganic briquettes are of the best quality and require the least fuel for use in power plants.*



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## 1. INTRODUCTION

Waste can be defined as residue or waste from an industrial, public, institutional, or human processing process [1]. All activities related to the processing of raw materials, both food and non-food, inevitably produce useless residue which creates piles of waste [2]. Based on data from the Central Statistics Agency in 2016 alone, Indonesian people produced at least 65.2 million tons of waste/year. Waste production is increasing every year. The Ministry of Environment and Forestry released data that in 2020 there was an increase in waste production of 72 million tons of waste, with details of 9 million tons of waste or the equivalent of 36% of the total waste that had not been managed properly, including 4K1P waste (paper, wood, cloth, rubber, and plastic). This waste comes from various sectors including households, industry, agencies, and the general public [3].

Waste is divided into two groups, namely organic and inorganic. Organic waste comes from living creatures and can decompose naturally, while inorganic waste comes from synthetic materials that are difficult to decompose. In Indonesia, 69% of waste is organic, consisting of 60% food waste and 9% paper. Inorganic waste is around 23%, with plastic dominating 14%, cloth 3.5%, and rubber 5.5% [4]. Waste processing is carried out through various methods, namely waste banks, compost processing, 3R TPST (Reuse, Reduce, Recycle Integrated Waste Processing Site), and PDU (Recycling Center) which focuses on recycling. In addition, TPST (Integrated Waste Processing Site) integrates various waste

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management methods, and ITF (Intermediate Treatment Facility) produces energy from waste. TPA (Final Disposal Site) is used for final disposal of waste that cannot be processed, in order to isolate its negative impacts on the environment and health [5].

Several studies have studied the 4K1P waste problem. In research by [6], processing organic waste into RDF briquettes using the chopping method resulted in a calorific value of 4,228 kcal/kg, a water content of 6.57%, an ash content of 2.25%. The research of [7] used carbonization on PET plastic waste, coconut shells, and sawdust, producing briquettes with a calorific value of 5,608 kcal/kg, water content of 5.18% and ash content of 3.55%. In research by [8] using carbonization on mixed waste, it produced a calorific value of 5,218 kcal/kg, a water content of 1.04%, and an ash content of 17.34%. In research, [9] examined a mixture of organic and inorganic waste, resulting in a calorific value of 4,819,220 kcal/kg, water content of 5.56%, and ash content of 11.64%. In research by [10], pyrolysis was used, producing a calorific value of 8,996 kcal/kg, water content of 5.5%, ash content of 4.9%, and steam content of 15.9%. The results show that 4K1P waste can be converted into type-5 RDF, namely RDF from the combustible fraction, which is compacted into pellets, slag, briquettes, and so on, with high potential for use as an alternative fuel [9, 10, 11].

The methods commonly used in processing RDF briquettes are carbonization and pyrolysis. Several studies have examined the processing of RDF into RDF briquettes using the carbonization method, namely the research of [7] used carbonization on PET plastic bottles, shell charcoal, and wood charcoal with starch adhesive, producing a calorific value of 5,608 cal/g, water content of 5.18%, ash content of 3.55%, and carbon content of 32.49%. Research [8] also uses carbonization on organic and inorganic waste, producing a calorific value of 5,218 cal/g, water content of 1.04%, and ash content of 17.34%, according to the bio briquette standard SNI 01-6235-2000. The pyrolysis method is also used to process RDF into energy, namely in research [10] on organic waste such as dry bamboo leaves and sawdust, resulting in a calorific value of 8,996 cal/g, water content of 5.5%, ash content of 4.9%, and vapor content 15.9%. As well as research [12] using pyrolysis on organic waste, producing a calorific value of 16,201 J/g, an ash content of 6.45%, and a water content of 0.92%. A comparison of the two methods shows that carbonization produces a calorific value of 5,218 -5,608 cal/g, water content of 1.04%-5.18%, and ash content of 3.55%-17.34%. Pyrolysis produces a higher heating value of up to 8,996 cal/g, water content 0.92%-5.5%, and ash content 4.9%-6.45. %. Thus, pyrolysis is more optimal for processing RDF into energy briquettes than carbonization.

Several studies have determined the optimal adhesive for making RDF briquettes, including research [8] comparing molasses, paraffin, and starch. The best results were obtained with paraffin, producing a calorific value of 5,218 cal/g. Meanwhile, research by [6] using tapioca flour in 4K1P waste produces a calorific value of 3,645 cal/g. In conclusion, paraffin adhesive produces the best quality briquettes because the calorific value is 5,218 cal/g.

RDF is considered the newest solution in waste management in Indonesia because it can be processed into various energy sources. RDF can fuel the steam power cycle in PLTUs, producing a potential electrical power of 154 MW (thermochemical) and 1.4 MW (biochemical). If applied with a biochemical cycle in a biodigester, RDF can produce 2.1 MW of power. RDF can also be used for PLTSa, and with the gasification method, it has the potential to generate 1 MW of power [13, 14]. So, from several studies that have been carried out, RDF has become a fuel for the power cycle. Steam in PLTU has more significant potential than various other energy sources.

Based on data from the Ministry of Environment and Forestry, around 36% of Indonesia's 4K1P waste, needs to be appropriately managed. This research aims to analyze the potential for flammable 4K1P waste to become type 5 RDF, namely RDF from combustible waste fractions that are compacted into briquettes [9, 10, 11]. Several studies that examine the use of 4K1P waste in RDF briquettes still focus on mixing the composition of raw materials for briquettes from 4K1P waste so that this research will compare the quality of RDF briquettes with a variety of pure organic, pure inorganic raw materials and a mixture of the two. The pyrolysis method was chosen because it produces the highest heating value and is better than other adhesives [8, 13].The quality of the briquettes will be tested using a bomb calorimeter to produce heating value, a minimum free space oven for ash content, and an ash content

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test oven for water content. The research will also analyze fuel requirements for a 7.5 MW PLTU, including calculating the heating value of the boiler and estimating fuel per hour and year [15].

## 2. RESEARCH METHOD

This research uses a quantitative approach to analyze the manufacture of RDF briquettes from organic and inorganic waste in Indonesia, which reaches 65.2 million tons/year, with 36% still being managed, including 4K1P waste. This waste will be processed into RDF briquettes, namely organic briquettes (wood and paper), inorganic briquettes (cloth, rubber, plastic), and mixed briquettes. The quality of RDF briquettes will be tested based on calorific value, water content, and ash content according to SNI 01-6235-2000 [8]. If the briquettes are used as fuel, then the RDF briquettes will be implemented in a PLTU with a capacity of 7.5 MW. Primary data was obtained from direct observation and secondary data from related journals. Research steps include literature study, preparation of tools and materials, burning, molding RDF briquettes (100 gr/piece), drying, and quality testing (heat test, water content, ash content). Data analysis will determine whether the briquettes meet applicable standards and calculate the PLTU's fuel requirements [15].

### 2.1. Raw Material

The raw materials used in this research came from 4K1P waste, namely organic and inorganic raw materials. 4K1P waste is flammable, so it has the potential to be used as RDF briquettes. So, in making RDF briquettes, the raw materials chosen are paper, wood, cloth, rubber, and plastic, with the weight of each raw material being 2 kg. The raw materials come from leftovers and waste dumped in the surrounding environment.

### 2.2. Carbon Charcoal Production

Refuse Derived Fuel is the fuel that comes from the process of separating solid waste between flammable waste and hard-to-combust waste. The waste used is flammable when making RDF briquettes. For briquettes, the RDF waste used is small, so cutting the waste into smaller pieces is required [14, 16]. In processing 4K1P waste into briquettes using the pyrolysis combustion method. The main product of the pyrolysis process is carbon charcoal [17]. The following is the process of processing 4K1P waste into carbon charcoal:

1. Collection of tools and materials
   In this research, the materials used were 4K1P waste (paper, wood, cloth, rubber/leather, and plastic) with respective weights as in Table 1 and paraffin adhesive. The equipment used was a 60 mesh sieve, digital scales, containers, and iron drums that have been modified by adding iron pipes as chimneys, mortars, stoves, spoons, pans, briquette molds, scissors, knives, and manual paper grinders.
2. Waste cutting
   The 4K1P waste collected has a variety of different sizes. To facilitate the process of making RDF briquettes and ensure the results meet the quality standards of raw materials with a high calorific value, cutting is carried out manually using scissors, knives, and a paper grinder. The pieces of waste are cut to a size of approximately ± 5 cm, except for wood, which is already in the form of sawdust.
3. Waste drying
   To maximize the combustion process, the water content in the raw material must be removed through an evaporation process until it is dry [18]. This means drying it under direct sunlight for 24 hours or until it is completely dry.
4. Burning
   Waste that has been dried will be burned using the pyrolysis combustion method. Pyrolysis is a method of decomposing material at high temperatures without air or with limited oxygen. The main products of the pyrolysis process are carbon charcoal, oil, and gas [17]. Here are the steps:

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a. A chimney is used as a combustion site to make a pyrolysis site. This chimney is designed to remove pyrolysis gases and steam produced during the burning process of raw materials. This removes gases containing hydrocarbons or other compounds from the pyrolysis system.
b. The raw material is 4K1P waste, each of which weighs 2 kg and will be put into the pyrolysis site. Then, the pyrolysis vat is closed tightly to burn with no or little oxygen in the combustion. In addition, every gap in the pyrolysis container must be considered so that no smoke comes out during combustion.
c. Burning of raw materials begins with ignition from the bottom of the pyrolysis chamber, and the combustion process continues until smoke appears from the chimney, indicating that the raw materials are starting to burn. This burning process lasts 3 hours when the raw material becomes carbon charcoal.
d. After the combustion process is complete, the resulting carbon charcoal is left for 4 hours and its weight is measured.

### 2.3. RDF Briquette Production

In the production of RDF briquettes, 4K1P waste has gone through a combustion process using the pyrolysis method which produces carbon charcoal. The carbon charcoal will be processed into RDF briquettes, the following are the stages in producing RDF briquettes.

1. Carbon charcoal sieving
   The carbon charcoal will be sifted using a 60-mesh sieve to separate the coarse particles still present into fine particles of the same size.
2. Mixing carbon charcoal
   Adding adhesive to the manufacture of RDF briquettes greatly influences pressure resistance, heating value, ash content, and water content. The adhesive must have high binding power so that the briquettes do not decompose quickly [18]. Carbon charcoal will be mixed with 20% paraffin adhesive. The following is a design for experimental variations of RDF briquettes with a weight of 100 grams each
   a. Briquettes 1 Organic (100 gr) = 80% organic carbon charcoal (40 gr paper carbon charcoal, 40 gr wood carbon charcoal) and 20% (20 gr) paraffin adhesive.
   b. Briquette 2 Inorganic (100 gr) = 80% inorganic carbon charcoal (26.7 gr plastic carbon charcoal, 26.7 gr cloth carbon charcoal, 26.7 gr rubber carbon charcoal) and 20% (20 grams) paraffin adhesive.
   c. Briquette 3 Mixture (100 gr) = 40% organic mixed carbon charcoal (20 gr paper carbon charcoal and 20 gr wood carbon charcoal) and 40% inorganic (13.33 gr plastic carbon charcoal, 13.33 gr cloth carbon charcoal and 13, 33 gr rubber carbon charcoal) 1:1 (50% organic carbon charcoal, 50% inorganic carbon charcoal) with 20% (20 gr) paraffin adhesive.
3. RDF briquette printing
   RDF briquettes will be molded using molding iron, with a diameter of 7 cm and a weight of 100 gr. Then, the carbon charcoal is compacted using a press to apply pressure to the briquettes so that they become solid.
4. Drying of RDF briquettes
   After the RDF briquettes are printed, the briquettes will be dried using the RDF briquette drying process for 48 hours under sunlight so that the resulting briquettes can dry thoroughly and to reduce the water content contained in the RDF briquettes. The surface of the briquettes should feel dry and not damp to the touch.

### 2.4. Test the Quality of RDF Briquettes

The briquettes that have been produced need to be tested to determine the quality of the briquettes according to applicable standards. Good briquette testing results will be by SNI 01-6235-2000 standards as in Table 1.

Table 1 Standard Briquette Parameters

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| Characteristics | Unit | Quality |
|---|---|---|
| Calorific Value | Kal/g | ≥ 5000 |
| Water Content | % | ≤ 8 |
| Ash Content | % | ≤ 8 |

There are parameters used in processing waste into RDF, including calorific value, water content, and ash content. Briquette testing includes:

1. Calorific Value
   Calorific value is a quantity that describes the energy value of a material. The greater the calorific value of a material, the more easily it will burn [8]. A bomb calorimeter is used to test the energy value contained in a briquette. The standard value is a minimum of 5,000 cal/g based on SNI 01-6235-2000.
2. Water Content
   It is hoped that the water content in RDF briquettes will be low so that lighting them does not require a large amount of energy, which can reduce the smoke that appears when burning them. The water content test in a briquette will be measured using a Minimum Free Space oven or MFS oven. The standard value is a minimum of 8% based on SNI 01-6235-2000.
3. Ash Content
   Ash content is the residue from the combustion process, consisting of the composition of unburned briquettes. After combustion, the remaining organic mineral content determines the ash content value of the briquettes. Ash content is measured using the Ash Content Test Oven, with a minimum standard of 8% according to SNI 01-6235-2000.

### 2.5. Fuel Requirements at PLTU

In the process of converting water into high pressure steam (steam), the boiler requires heat from burning fuel. In calculating fuel requirements for a PLTU with a capacity of 7.5 MW, initial data was obtained from previous research [15].

Table 2 Data on PLTU Boilers

| Steam Pressure | Steam Temperature | Efficiency (η) Boilers | Temp. Feed Water | Boiler Capacity |
|---|---|---|---|---|
| 3, 2 MPa | 420 °c | 90 % | 90 °c | 32 tons/hour |

The heat requirement for the boiler can be calculated by:

$$Q_{boiler} = \frac{m\,.(h_o - h_i)}{\eta} \quad (1)$$

In the equation above, the enthalpy value of the superheated steam and the enthalpy value of the feed water entering the boiler will be known from the thermodynamic periodic table of water vapor temperature and the superheated steam table. To calculate fuel requirements for a boiler, use the equation:

$$Q_{fuel} = \frac{Q_{boiler}}{calorific\ value\ of\ fuel} \quad (2)$$

The calorific value contained in different fuel types significantly affects the calculation results [15]. Then, annual fuel requirements are calculated based on usage capacity using the equation:

$$Q_{fuel} \text{ x 24 hr x 358 days} \quad (3)$$

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In 1 year the PLTU is not fully operational, it only lasts 356 days, but there are 7 days for maintenance and repairs so the effective time for a PLTU to operate is 358 days.

## 3. RESULTS AND DISCUSSION

In this research, RDF briquette products were produced with 3 samples that compared the calorific value, water content, and ash content, where each RDF briquette was composed of different raw materials. The process of processing RDF briquette raw materials into carbon charcoal can be seen in Table 3 where the raw materials can produce carbon charcoal as follows.

Table 3 Carbon Charcoal

| Type of Raw Material | Raw Material | Initial Raw Material Weight (Kg) | Weight of Carbon Charcoal Yield (Grams ) |
|---|---|---|---|
| Organic | Paper | 2 | 875 |
| | Wood | 2 | 648 |
| Inorganic | Plastic | 2 | 1.090 |
| | Cloth | 2 | 856 |
| | Rubber | 2 | 1.160 |

Table 3 shows that carbon charcoal consists of organic and inorganic raw materials and 4K1P waste raw materials. The result of burning waste in the form of carbon charcoal is that the combustion process can reduce these raw materials with a reduction percentage of paper of 57%, wood at 68%, plastic at 46%, cloth at 58%, and rubber at 42% of the total raw materials reduced.

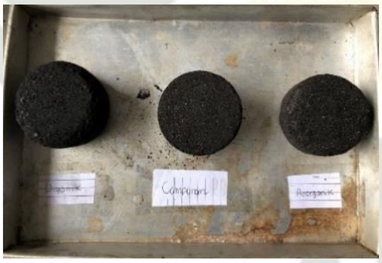

Figure 3 RDF Briquettes

Figure 3 shows the shape of the three briquette samples that have been made. The three briquette samples consist of organic briquettes, inorganic briquettes, and mixed briquettes with a weight of 100 grams each. From the carbon charcoal results for each raw material in Table 3, more than 1 RDF briquette can be produced. The following is the number of briquettes that can be produced.

Table 4 Number of Briquettes

| Types of Briquettes | Number of Briquette Pieces (100 grams/piece) |
|---|---|
| Organic | 10 |
| Inorganic | 10 |
| Mixture | 10 |

Table 4 Number of briquettes made from raw materials that have gone through the combustion process to become carbon charcoal. Each briquette weighs 100 gr/keeping using paraffin adhesive of 20% of the total briquette weight and 80% carbon charcoal from the raw material.

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### 3.1. Calorific Value Analysis

Calorific value analysis is carried out to determine the amount of energy contained in a briquette, which will affect the ignition of the fire [10]. The following are the results of the calorific value test :

Table 5 Results of Calorific Value of RDF Briquettes

| Sample Type | Calorific Value (Cal/g) | Standard Value (Cal/g) | Reference | Information |
|---|---|---|---|---|
| Organic | 6448,65 | | | Standard |
| Inorganic | 8075,92 | ≥ 5000 | SNI 01-6235-2000 | Standard |
| Mixture | 6994,51 | | | Standard |

Table 5 shows the results of the heating value of briquettes using a bomb calorimeter. The greater the calorific value of a material, the easier it is to burn [8]. The test results showed that the highest calorific value was in inorganic briquettes at 8075.92 cal/g, then mixed briquettes at 6994.51 cal/g, and organic briquettes at 6448.65 cal/g, which produced the lowest water content value. From the laboratory test results, the calorific value of the three types of RDF briquettes is by SNI, where the value has exceeded 5,000 cal/kg. This is due to the influence of different kinds of raw briquette materials and the composition ratios of the raw materials. With this calorific value, the results can be obtained that inorganic briquettes can generate more incredible energy than organic and mixed briquettes because the calorific value produced will affect the energy that can be formed from the briquettes.

This research shows that briquettes' calorific value is higher than previous research [8] due to differences in combustion methods, burning duration, and raw material composition. This research used the pyrolysis method with a burning duration of 3 hours, while previous research used the carbonization method without specifying the burning duration. In addition, the waste composition used in this research consisted of organic, inorganic, and mixed raw materials with 4K1P raw materials, whereas previous research used different raw materials.

### 3.2. Water Content Analysis

Water content values are analyzed to determine the water content in the RDF briquettes produced to measure the extent to which the briquettes can provide efficient heat during combustion [8]. The following are the results of testing the water content values:

Table 6 Results of RDF briquette water content

| Sample Type | Water content (%) | Standard Value (%) | Reference | Information |
|---|---|---|---|---|
| Organic | 1,88 | | | Standard |
| Inorganic | 1,75 | ≤ 8 | SNI 01-6235-2000 | Standard |
| Mixture | 1,82 | | | Standard |

Based on the results of testing the water content of RDF briquettes in Table 6, organic briquettes have the highest water content value of 1.88%, followed by mixed briquettes at 1.82% and inorganic briquettes with the lowest value of 1.75%. All water content values are by SNI standards, which do not

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exceed 8%. The difference in moisture content values is caused by variations in briquette raw materials, where organic waste tends to have higher moisture than inorganic waste. Pre-treatment processes such as drying raw materials also affect the water content value by reducing the mass of water that evaporates. In addition, the finer particle size in briquettes can produce a larger surface area and denser briquettes, reducing the water content.

The water content value in this study is higher than in previous research [8] with a difference of 0.71% – 0.84%. This difference could be caused by the drying process in this study, namely for 48 hours under sunlight. In contrast, in research [8], the drying process was for 24 hours under sunlight with an additional 4 hours of drying using an oven at a temperature of 105°C. Apart from that, the composition of the waste used is also different, where this research uses a mixture of organic and inorganic raw materials and 4K1P waste. In contrast, previous research only used a mixture of organic and inorganic waste in specific proportions.

### 3.3. Ash Content Analysis

Ash content analysis was carried out to determine the residue results from the combustion process of an RDF briquette. Briquettes that do not burn completely will produce combustion residue called ash. The following are the results of testing the ash content values :

Table 7 Results of Ash Content of RDF Briquettes

| Sample Type | Ash Content (%) | Standard Value (%) | Reference | Information |
|---|---|---|---|---|
| Organic | 23,17 | ≤ 8 | SNI 01-6235-2000 | Non Standard |
| Inorganic | 10,84 | | | Non Standard |
| Mixture | 18,32 | | | Non Standard |

Based on the ash content test results in Table 7, organic briquettes have the highest ash content (23.17%), followed by mixed briquettes (18.32%) and inorganic briquettes (10.84%) which have the lowest ash content. The ash content values of the three types of briquettes exceed the specified SNI standards (8%). Organic briquettes tend to have a higher ash content because the characteristics of the raw material have not been adequately carbonized, causing the presence of compounds that increase the ash content value, resulting in more significant residue in the briquettes. In addition, the ash content value is inversely proportional to the heating value, which means that the greater the ash content, the lower the heating value [19].

This research shows higher ash content than previous research [8] due to differences in waste composition, burning method, and burning duration. This research uses organic, inorganic, and mixed waste compositions with 4K1P waste as raw materials, while previous research only used a mixture of organic and inorganic waste. In addition, this study used a pyrolysis method with a burning duration of 3 hours, whereas previous research used a carbonization method without a specified burning duration. Different burning methods can affect the mineral content that does not burn completely.

### 3.4. Fuel Requirements at PLTU

In the process of calculating the fuel requirements for a PLTU with a capacity of 7.5 MW, use equation 1 using the initial data in Table 2, where this equation produces the heat requirements for the PLTU boiler so that you can find out the fuel requirements for the boiler which are calculated using equation 2 uses 3 variations of RDF briquettes, namely organic briquettes, inorganic briquettes, and mixed briquettes. The following are the results of the heat requirements for the boiler and the fuel consumption required for the PLTU.

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Volume 11, Issue 2, Oktober 2024, pp. xx-xx
ISSN 2355-5068 ; e-ISSN 2622-4852
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Table 8 PLTU Fuel Consumption

| Heat in PLTU Boiler (kCal/hour) | Sample Type | Fuel Requirements (tons/hour) | Number of Briquette Pieces (pieces/hour) | Briquette Raw Materials | Amount of Carbon Charcoal (gr/hour) | Amount of Raw Materials (gr/hour) |
|---|---|---|---|---|---|---|
| 24.679.424 | Organic | 3,8 | 38.000 | Paper | 1.520.000 | 3.474.286 |
| | | | | Wood | 1.520.000 | 4.691.358 |
| | Inorganic | 3 | 30.000 | Plastic | 799.800 | 1.467.523 |
| | | | | Cloth | 799.800 | 1.868.692 |
| | | | | Rubber | 799.800 | 1.378.966 |
| | Mixture | 3,5 | 35.000 | Paper | 700.000 | 1.600.000 |
| | | | | Wood | 700.000 | 2.160.494 |
| | | | | Plastic | 466.550 | 856.055 |
| | | | | Cloth | 466.550 | 1.090.070 |
| | | | | Rubber | 466.550 | 804.397 |

Based on Table 8, the fuel requirement for a PLTU with inorganic briquettes is 3 tons/hour, with a briquette requirement of 30,000 pieces/hour. This requires 799,800 g/hour of plastic carbon charcoal, cloth, and rubber, with plastic raw materials 1,378,276 gr/hour, 1,868,692 gr/hour of cloth, and 1,379,310 gr/hour of rubber. This is because the calorific value of inorganic briquettes is higher than that of organic and mixed briquettes. The boiler fuel requirement for this research is better than previous research, which used palm oil waste (shells) with a requirement of 5.1 tons/hour because the calorific value is higher, namely 6,448.65 to 8,075.92 cal/kg. Different types of fuel greatly influence the calculation of PLTU fuel requirements. By knowing the fuel requirement per hour, you can calculate the fuel requirement per year.

Table 9 PLTUs Fuel Consumption Per Year

| Sample Type | Fuel Requirements (ton/year) | Number of Briquette Pieces (pieces/year) | Briquette Raw Materials | Amount of Carbon Charcoal (gr/year) | Amount of Raw Materials (gr/year) |
|---|---|---|---|---|---|
| Organic | 32.649,60 | 326.496.000 | Paper | 13.060 | 29.851 |
| | | | Wood | 13.060 | 40.308 |
| Inorganic | 25.776 | 257.760.000 | Plastic | 6.872 | 12.609 |
| | | | Cloth | 6.872 | 16.056 |
| | | | Rubber | 6.872 | 11.848 |
| Mixture | 30.072 | 300.720.000 | Paper | 6.014 | 13.747 |
| | | | Wood | 6.014 | 18.563 |
| | | | Plastic | 4.009 | 7.355 |
| | | | Cloth | 4.009 | 9.366 |
| | | | Rubber | 4.009 | 6.911 |

Based on Table 9, the annual fuel consumption of PLTUs using inorganic briquettes is 25,776 tons, lower than other briquettes because the calorific value is higher. This requires 6,872 tons/year of carbon from plastic, cloth, and rubber, with raw materials of 12,609 tons of plastic, 16,056 tons of cloth, and 11,848 tons of rubber. This fuel requirement is more efficient than research [15], which shows a need for 43,819.2 tonnes/year from palm oil waste, with a difference of 40.19% greater.

## 4. CONCLUSION

From the lab test results that have been obtained, it can be seen that the best briquettes are inorganic RDF briquettes because they have the highest heating value of 8075.92 cal/kg and the lowest water

Volume 11, Issue 2, Oktober 2024, pp. xx-xx
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content value of 1.75% which meets the SNI 01-6235-2000 standard. The best results in calculating fuel requirements for PLTUs are inorganic RDF briquettes, namely 3.05 tonnes/hour with an annual requirement of 26,205.6 tonnes/year.

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# Letter of Acceptance

Dear Author(s)

Based on the results of the reviewer evaluation and the coordination meeting of the editorial board of the Jurnal Ecotipe, your article entitled:

***Analysis of Waste Utilization of Refuse Derived Fuel (RDF) into Briquettes***

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has been accepted and will be processed for publication in the **Jurnal Ecotipe** (*Electronic, Control, Telecommunication, Information, and Power Engineering*) **Volume 11 Issue 2, October 2024**. Articles with the above title may not be published in other journals. If in the future, an article with the same title above is known to have been published and plagiarism was found in another journal, then Jurnal Ecotipe is not responsible and is entirely the responsibility of the author. Your article will be published online no later than November 2024.

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