Economic analysis of biomass briquettes from septic tank

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Abstract. The aim of this research is to utilize slack waste into charcoal briquettes as an environmentally friendly alternative energy and minimize slack waste. The process for making briquettes is by adding polyacrylamide type adhesives with a variation of the material: adhesive ratio of 5:2 and 2:1 respectively on the slack charcoal that has been crushed, then formed into a cylinder with a press tool with pressure 85 and 105 kg/cm². Furthermore, drying is done in an oven with a temperature of 150°C with a variation of 1.5 and 2 hours drying time. From the results of the economic analysis it was found that the business of making stool briquettes with a capacity of 300 kg/day is feasible to run, where from the business a profit of Rp. 547,029,828/year where the Net Present Value (NPV), Internal Rate of Return (IRR), and Break Event Point (BEP) were Rp. 203,510,791; 21.59%; and 26.08% respectively which requires 24.41 tons of briquettes to be returned in capital in around 11.34 months with an income of Rp. 183,075,000.

1. Introduction
The increase in the human population creates many problems, one of which is human waste. Digestive waste, such as feces, can be produced as much as 125-250 grams per day by each human. The excretion of feces, if not managed properly, can become a source of serious health problems. This is because the capacity of the existing Fecal Waste Treatment Plant (FWTP) is no longer sufficient, due to the increasing population of Medan City [1].

At present (since 1995) the city of Medan has an DLW processing unit operated by Tirtanadi Regional Drinking Water Company (RDWC) Medan called the Cemara wastewater treatment plant (Cemara WTP). For four consecutive periods, the stool collected from several customers was recorded to have continued to increase. Institutionally, wastewater management in the city of Medan is carried out by the RDWC Tirtanadi and the Medan City Development Agency. The two agencies cooperate and coordinate in the technical aspects of waste water disposal and treatment supported by the regional regulations of the North Sumatra Provincial Government and the Medan City Government [2].

The development of raw material utilization technology related to alternative fuel sources is continuously being carried out to solve the problems of energy resources that are currently occurring. One of the alternative forms of fuel that is being developed today is briquettes. Briquettes are an alternative fuel that resembles charcoal and has a higher density. Briquettes are a simple alternative, both in the manufacturing process and in terms of the raw materials used, so that briquettes have a large enough potential to be developed [3].
Through the production and quality testing of briquettes, researchers are expected to be able to know the process of making fecal briquettes, and be able to determine the quality of briquettes with the right ratio between water, raw materials and adhesive materials used so as to produce quality energy/new fuel. The composition of briquettes from feces (human feces) based on SNI is shown in Table 1.

Table 1. Briquette quality standards based on SNI [4]

| Parameter            | SNI No. 1/6235/2000 |
|----------------------|----------------------|
| Water content (%)    | ≤ 8                  |
| Ash content (%)      | ≤ 8                  |
| Carbon content (%)   | ≥ 77                 |
| Calorific value (Cal/g) | ≥ 5000              |

2. Materials and methods

Biomass in the energy production industry refers to living or recently dead biological material that can be used as a fuel source or for industrial production. Biomass generally refers to plant matter that is maintained for use as biofuel, but can also include plant or animal matter used for the production of fiber, chemicals, or heat. Biomass can also include biodegradable waste which can be burned as fuel. Biomass does not include organic matter that has been transformed by geological processes into substances such as coal or petroleum [5].

Furthermore, the sludge is transported, processed to FWTP. In the case of the FWTP system, the constituent elements are not only physical processing units and FWTP flow facilities, but also include non-physical elements such as management, HR competence, information, and standard procedures for the management of the FWTP system as a whole. Briquettes are lumps made of soft, hardened material. Briquettes are an alternative fuel that has good prospects to be developed. Because apart from the easy manufacturing process, the availability of raw materials is also easy to obtain.

Materials sourced from waste can be used in making charcoal briquettes. One of these materials is plantation waste, namely rubber seed shells. In addition to rubber seed shells, the manufacture of briquettes is varied with plantation waste, namely coconut shell charcoal. To determine the good quality of the briquette charcoal produced, it can be seen from the results of chemical testing including moisture content, ash content and volatile substance content, while physical testing uses sensory testing of texture, color, and burning time. The purpose of varying coconut shell charcoal with rubber seed shells is to determine how much influence the different compositions have on the observed parameters [6].

Sources of biomass and adhesives that are generally used as raw materials for making briquettes are horse manure (feces) and starch. Dried horse manure is processed densification (made in the form of briquettes). In this study, a variation of the ratio of starch to horse manure was used 1:3 (10 grams of starch and 30 grams of horse manure); 1:5 (6 grams of starch and 30 grams of horse manure); 1:7 (4.3 grams of starch and 30 grams of horse manure); 1:10 (3 grams of starch and 30 grams of horse manure), where the briquettes are made in the shape of a cylinder with a diameter of 1.3 cm and a height of 1.5 cm, then re-dried using a solar dryer. In this study, starch only functions as an adhesive, because horse manure is very difficult to form into briquettes without any adhesive [7].

The ratio variation was chosen initially by trial and error based on the adhesiveness of starch in forming horse dung briquettes, where in this study starch functions well as an adhesive to form horse manure briquettes only up to the ratio limit of 1:10. The densification result of horse dung biomass was made for two testing processes, namely testing biomass briquettes and briquettes. The test material for briquettes is subjected to a thermolysis (pyrolysis) process on biomass briquettes using a retort (heating oven) with constant heating temperature and holding time, namely 300°C and 2 hours, and treatment with inert gas and treatment without gas. inert. The calorific value of the combustion...
was collected, and it was carried out at the end of the sample testing process using the adiabatic bomb calorimeter, where the data was collected 3 times for each test material and then the average value was taken. From the test results calculated the dry heating value (Gross dry energy, GEk) and wet calorific value (gross wet energy, GEb) of biomass briquettes [8].

In order to support the business of providing and developing energy use in rural areas, research is conducted in the field of rice husk briquettes and peanut shells as alternative fuels. One of the properties studied is the effect of pressing pressure and heating temperature on the thermophysical properties of the briquettes. This study specifically aims to determine the effect of variations in pressing pressure, the effect of heating temperature and the interaction between pressing pressure and heating temperature on the thermophysical properties of rice husk briquettes and peanut shells which include: moisture content, calorific value, density and ash content.

Briquettes are a quality alternative fuel. This fuel can be utilized with simple technology, but the heat (flame) generated is large enough, long enough and safe. This fuel is suitable for use by traders or businessmen who need combustion that continues for a long time. The advantage that can be obtained from the use of briquettes is that the cost is very cheap. The tools used in the manufacture of briquettes are quite simple and the raw materials are very cheap, you don't even need to buy them because they come from garbage, dry leaves, useless agricultural waste. The raw materials for making charcoal are generally readily available around us. Briquettes in their use a relatively small stove compared to other stoves [9].

Making briquettes as an alternative fuel to replace oil can be one of our efforts as a society to tackle and reduce waste generation, especially in the household sector. In addition, making briquettes as a substitute for oil can also be an alternative to the current energy crisis problem. The briquette analysis aims to obtain the characteristics of the briquettes that have been produced, especially to obtain the quality of these briquettes. The analysis carried out such as analyzing moisture content, briquette flame, density, and heating value consists of:

- **Water Content Analysis**
  Percent moisture content can be calculated from the percentage value of water content inversely proportional to the resulting calorific value. Good briquettes are briquettes that have low water content so that their heating value and combustion power are high.

- **Briquette Density Analysis**
  Density analysis or density analysis is a parameter in determining a good briquette. Higher density of ingredients will result in better briquette quality than lower briquette density [10].

- **Analysis of the Briquette Flame**
  The analysis of briquette flame consists of calculating the length of ignition time and the ignition time period. The length of time for burning the briquettes is calculated when the briquettes are burned to heat the water until the water is boiling, awaited until the fire in the briquettes stops burning and the briquettes turn to ashes and calculates how long the briquettes burn during the burning process.

- **Calorific Value Analysis**
  The calorific value of a biomass fuel is the amount of heat energy (kJ) that can be released for each unit weight of the fuel (kg) if it burns completely, a perfect briquette is if all of the carbon element (C) in the briquette reacts with oxygen to carbon dioxide (CO₂).

### 3. Result and Discussion

#### 3.1. Demand

So far, most of the briquette business actors are targeting the export market to market their products. This strategy was chosen by producers because the level of demand for foreign markets tends to be quite high every year, reaching 80% while domestic at 20%. Within the domestic industry, there are also many industries that use wood fuel as fuel in their production processes such as in the tofu-and-tempeh-making industry, bread making, and in several industries engaged in the textile sector [11].
Apart from industry, culinary businesses with a burnt theme are starting to develop and are mushrooming making business opportunities for briquettes made from slack (fecal sludge) are expected to increase as a substitute fuel for charcoal in the culinary business. In the future, it is necessary to conduct socialization for the use of briquettes in the country as a promotional effort so that briquettes can be more widely known to the public.

### 3.2. Target Market

Since the production of sludge briquettes has not been able to produce directly on a large scale and is just starting to produce it, the target market targeted in running this briquette business is initially around domestic industrial sectors that use firewood or briquettes as energy, culinary business that uses wood charcoal as cooking fuel, wholesalers and the general public as shown in Figure 1.

![Figure 1. Target marketing of stool briquettes](image)

### 3.3. Business Prospect

In terms of competitors in the briquette business, most of them are companies originating from abroad for foreign sales/export targets. So far, not all of the requests from abroad have been fulfilled by domestic companies’ country. Apart from industry, with the increasing number of culinary businesses with the theme of burnt, it is hoped that fecal briquettes production business opportunities will be even greater as a substitute fuel for businesses in the culinary field that use charcoal products as cooking fuel. In terms of raw materials, the availability of sludge is very much in Indonesia, especially in Medan City [12]. For four consecutive periods, the stool collected from several customers was recorded to have continued to increase. In 2017 period 4, the potential for feces in Medan reached 650,000 liters/year. Therefore, it is necessary to process the feces before they are discharged into the environment. One of the feces that RDWC Tirtanadi plans to treat is to convert the waste into fertilizer or briquettes (solid fuel). RDWC Tirtanadi Medan has thought about processing (feces) into fertilizer and briquettes. This causes the manufacture of fecal briquettes is also not too difficult with the selling price of charcoal briquettes quite cheap in the market.

### 3.4. Marketing Prospects

In fecal briquette marketing planning so that the product can be known by the public, several ways are needed so that the product can be widely marketed and have a market, including by doing promotions by placing advertisements, participating in exhibitions, and also carrying out personal selling to increase sales.

### 3.5. Technical Aspect

#### a. Location
The fecal briquette processing plant will be located in the Briquette Production section of the WTP Cemara. This factory location was chosen because of its easy access to raw material sources and a strategic location close to the main road and is one of the industrial centers [13].

b. Raw Material Availability Plan
The raw material in the form of slack (sludge) is planned to be collected from several customers and will be processed in the DLW processing unit operated by RDWC Tirtanadi Medan which is called Cemara wastewater treatment plant (WTP Cemara, Medan). In addition, the supporting raw materials in the form of adhesives (Polyacrylamide) are obtained from wholesale chemicals, Indotrading.

c. Products Produced
The resulting product is fecal briquette product sourced from slack (fecal sludge waste). The briquette shape to be made is cylindrical, 2 cm in diameter and 6 cm long. This shape was chosen because the shape that is widely traded in the market is cylindrical. The first production yield produced by the plan is around 300 kg/day with 1000 kg of dry slack as raw material. The product price will be sold at Rp7,500.00/kg cheaper than the price of other briquettes, this price is cheaper than the price of coconut shell briquettes which an average of Rp10,000 – 11,000,000,00 per kg (This price determination aims to make the product acceptable in the market).

d. Quality of Briquettes Based on SNI
Based on the quality testing that has been carried out, the characteristic values of each briquette composition are obtained which are then compared with SNI No.01-6235-2000 regarding the quality of briquettes as shown in Table 2.

| Parameter                  | Briquette Quality Standards | Best Briquette Results | Standard Type       |
|----------------------------|-----------------------------|------------------------|---------------------|
| Water content (%)          | ≤ 8                         | 7.27                   | SNI No. 01-6235-2000|
| Density (gr/cm³)           | 1.00                        | 1.06                   | America             |
| Calorific value (Cal/g)    | ≥ 5000                      | 7436.55                | SNI No. 01-6235-2000|

Based on Table 2, it is known that the parameters of moisture content and density of fecal briquettes have met the quality standards of briquettes. From the results of laboratory tests conducted, the calorific value obtained was 7436.55 Cal/g, which was obtained from the ratio of raw material: adhesive, pressure scale, and drying time respectively 5:2; 105 kg/cm²; and 120 minutes. These results meet the standard calorific value of SNI briquettes, namely ≥ 5000 Cal/g where the moisture content obtained is 7.06% smaller than the standard which should be 8% and the density in the fecal briquettes is 1.06 gr/cm³ which meets the American density, namely 1 gr/cm³.

3.6. Management Aspects
There are currently no management aspects in the fecal briquette factory, but in the future, management will be made by creating an organizational structure, clear and transparent job descriptions, and creating income and expenditure sales records. The organizational structure plan and the determination of job descriptions include leadership, secretaries, production unit employees, finishing unit employees, and marketing unit employees.

3.7. Financial Aspects
In an effort to set up a business, financial analysis is needed to find out whether the business that is being made is getting a profit or not. If in the analysis of the calculation of the business getting a profit or profit, the business is feasible to continue. The following is a fecal briquette business financial plan:
Table 3. Calculation of economic analysis on the operational process of briquette production

| No | Item                          | Justification                        | Unit | Total | Unit Price (IDR) | Price (IDR) |
|----|-------------------------------|--------------------------------------|------|-------|-----------------|-------------|
| 1  | Production Cost Per Month    |                                       |      |       |                 |             |
|    | Raw Material                 |                                       |      |       |                 |             |
| a) | Fecal Mud                    | The main raw material                | ton  | 1     | 200.000         | 200.000     |
| b) | Adhesive (Polyacrylamide)    | Supporting raw materials             | ton  | 1     | 3000            | 3000.000    |
| 2  | Electricity                  | Utilities                             | Kwh  | 350   | 1.500           | 525.000     |
| 3  | Water                        | Utilities                             | m³   | 100   | 12500           | 1.250.000   |
| 4  | Employee salary              | Factory Operations                   | person | 5    | 2.300.000       | 11.500.000  |
| 5  | Transportation costs         | Transportation                        | unit | 1     | 600.000         | 600.000     |
| 6  | Daily Worker                 | Safety and cleanliness                | person | 2    | 1.500.000       | 3000.000    |
| 7  | Depreciation expense         |                                      |      | 1     | 789.181         | 789.181     |
| 8  | Overhead costs               |                                      |      | 1     | 150.000         | 150.000     |
|    | Total                         |                                      |      |       | 21.014.181      |             |
| 1  | Income Per Month             |                                       |      |       |                 |             |
| 2  | Stool Briquettes             | Stool Briquette Production            | kg   | 7.800 | 7.500           | 58.500.000  |
| 3  | Liquid fertilizer            | WTP Production                        | m³   | 4500  | 1000            | 4.500.000   |
|    | Total                         |                                       |      |       | 63.000.000      |             |
|    | Revenue - Cost of Production |                                       |      |       | 41.985.819      |             |

In Table 3 the information on the prices listed is obtained from prices in the market in general, which are known either through direct observation or by using the internet media. In the table, it is known that the planned investment cost of equipment to support a business is Rp 261.700.000, the production cost for one month is Rp 21,014.181, with sales revenue per month from the product of Rp 63,000.000 which is divided into monthly sales of 300 kg of briquettes, namely Rp 58,500.000 and sales of 150 kg of liquid fertilizer, namely Rp 4,500.000. Meanwhile, sales of net profit after sales are deducted by production costs, the net profit for a month is Rp 41,985.819.

Table 4. Calculation of profit and loss analysis

| No | Item          | Justification  | Total | Per month (Rp) | Per year (Rp) |
|----|---------------|----------------|-------|----------------|--------------|
| 1  | Sales         | Production of   | 12    | 63,000,000     | 756,000,000  |
Based on Table 4, it is known that the monthly and per year profit and loss report plans from the results of the briquette business that will be established. It is known that the monthly sales results are Rp63,000,000 and Rp756,000,000 per year, for monthly operational costs of Rp17,414,181 and Rp208,970,172 per year, with monthly profits of Rp 45,585,819 and Rp 547,029,828 per year.

### 3.8. Net Present Value (NPV)

From the NPV calculation, the business requirements are said to be feasible if the NPV value > project cost (+) or NPV - Project Cost > 0. From the calculation with \( i = 12\% \) and project cost = Rp186,302,158, the NPV value of Rp203,510,791 is greater than the project cost value is Rp186,302,158, so the business can be said to be feasible to run.

### 3.9. Internal Rate of Return (IRR)

Internal Rate of Return is a percentage that describes the average annual interest gain from all expenses and income of the same amount. If the IRR is greater than the prevailing real interest, the factory will be profitable, but if the IRR is smaller than the prevailing real interest, the factory is considered to be losing.

From the IRR calculation with a value of \( i_1 = 18\% \), \( i_2 = 20\% \), and MARR = 15\%, the IRR results are 21.59\%. The business is considered feasible if IRR > MARR. It is assumed that MRR = 15\%, because IRR > 15\%, the business is considered profitable and feasible to run. The IRR earned is greater than the current bank loan interest, amounting to 10.50\%.

### 3.10. Break Event Point (BEP)

Break Even Point is a state of factory production capacity when the sales proceeds can only cover production costs.

\[
BEP = \frac{Fixed\ cost}{Total\ sales - variable\ costs} \times 100\%
\]

\[
BEP = \left(\frac{14,814,181}{56,800,000}\right) \times 100\%
\]
BEP = 26.08%

Production capacity at point BEP = 26.08% x 93.6 tons/year
= 24.41 tons/year

Sales value at point BEP = 26.08 % x Rp208,970.172
= Rp54,499,420.00

It is known that to get back capital, 24.41 tonnes of briquettes were needed which were sold in about 11.34 months with an income of Rp183,075,000.

**Conclusion**

The best briquettes are produced from sixteen (16) types of briquettes with the longest burning time of 613 seconds and a heating value of 7436.55 Cal/g which is obtained from the ratio of raw material: adhesive, pressure scale, and drying time respectively 5:2; 105 kg/cm²; and 120 minutes, with moisture content and density values respectively 7.27% and 1.06 gr/cm³. Where the moisture content and briquette value obtained have met SNI 01-6235-2000, namely ≥ 5000 Cal/g and 7.75%, respectively, in addition, the briquette density obtained has met the American standard, namely 1.0 gr/cm³.

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