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An Analysis Of Biomass Power Generation From Waste With Briquette

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ABSTRACT
The increasing demand for electricity and the efforts to reduce the environmental impact of waste drive the development of biomass-based power plants. This research analyzes the potential of utilizing waste as raw material for biomass briquettes to generate electricity. The waste used consists of organic materials processed into briquettes with specific characteristics, such as moisture content, calorific value, and density, to optimize combustion. The study was conducted as a case study on a small-scale biomass-based power plant. An analysis results show that waste briquettes have significant potential as a renewable energy source with relatively high conversion efficiency. Utilizing waste briquettes not only reduces the volume of waste sent to landfills but also lowers greenhouse gas emissions compared to fossil fuels. This study provides recommendations for improving briquette production technology and optimizing combustion systems to achieve better efficiency in biomass power plants.

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INTRODUCTION

In the era of the Fourth Industrial Revolution, society's demand for electrical energy is increasing, driven by population growth, economic development, and changing energy consumption patterns. This increase in demand for fossil fuels is not matched by a corresponding rise in production capacity. The declining availability of non-renewable energy, particularly fossil fuels, is one of the main causes of the global energy crisis. This phenomenon has also affected the global electricity sector, which is approaching a critical threshold since a large portion of electricity supply still comes from fossil-fuel-based power plants.

According to an analysis from the Ministry of Energy and Mineral Resources on national energy management, Indonesia's oil reserves will be depleted in approximately 18 years, natural gas in 60 years, and coal in 147 years, starting from 2006. This situation is quite ironic, given that Indonesia possesses abundant natural resources but lacks the ability to process them into finished fuel. If further precautions are not taken, Indonesia will face a prolonged energy crisis. One way to mitigate and anticipate this crisis is by using alternative energy sources.

The operation of Microbial Fuel Cells (MFCs) reactors with varying compositions of vegetable biomass, in the slurry phase over 21 days, yielded the highest voltage in reactor

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R1+, reaching 1180 mV, with an electrical current of 5.1 µA, a power output of 6.02 mW, and a power density of 462.92 mW/m². In a study on distributed generation using biomass-based power plants of the incinerator type in Medan (Safrizal, 2014), the results showed that electricity generated from biomass waste can reduce the electricity deficit by 4.99%.

Figure 1. Biomass waste yield graph

Medan City, which reaches 1,812 tons/day, can produce 21,744 MW of electricity. The potential for power generation in Pekanbaru has also been studied by Perinov (Perinov, 2016). From this study, it was concluded that the potential that can be generated by the Biomass Power Plant in Pekanbaru is around 9 MW. Some of the electricity generated can be sold to PLN. Research in West Sumatra also shows that electricity from the Biomass Power Plant, from waste or gas, can be used to help peak load conditions with economical scheduling (Monice and Syafii, 2013).

A feasibility study for the construction of a Biomass Power Plant at the Air Dingin TPA, Padang City, shows that the Air Dingin TPA has the potential to produce 28,169,259.47 KWh of electrical energy (Nofri Dodi et al., 2015). This energy is obtained from Landfill Gas (LFG) produced by the TPA (Final Disposal Site). The investment cost required to realize the establishment of a Biomass Power Plant at the Air Dingin TPA is estimated to reach Rp. 40,089,591,065.4. The studies above show that the construction of a Power Plant with energy sources from biomass and biogas can be realized by community self-reliance. The production of electricity from biomass fuel by the community is part of the People's Electricity program. The electricity produced from this type of power plant will be valuable if the construction of the power plant is carried out as much as possible. There needs to be a socialization stage to introduce this program to educational circles, such as students, lecturers, and researchers, as well as to the community. Therefore, a multimedia application is needed as a medium to introduce what is meant by a Biomass Power Plant or PLTSa and how it works in a more interesting and easier to understand way.

Literature Review

Biomass Power

Waste energy seems to be a favourite in the lives of living things. Energy does not just appear without a cause or source. The same is true for heat energy which is a form of energy. Heat energy arises due to physical changes in the energy source so that heat appears. The energy sources that are currently widely used are non-renewable energy, namely those that come from nature such as oil, coal and natural gas which if used continuously will run out,

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including encouraging the use of energy more efficiently and on target, as well as increasing technology and the availability of more complete alternative energy information, as well as saving the use of fossil fuels by using renewable energy (Soelaiman, 2013).

One effort to avoid energy dependence is the utilization of agricultural, plantation and forest waste. Where the largest waste producer comes from the agricultural sector (Lubis, 2018). According to the Head of the Communication and Information Services Division of the KLIK Office, Ministry of Energy and Mineral Resources, Indonesia has 400 GW of EBT resources and only 1 GW has been used, including the use of biomass. potential 50 GW. Referring to data from the Ministry of Energy and Mineral Resources and the EBT development program in the national energy policy, namely the addition of power generation capacity with biomass fuel by 180 MW in 2020. For this reason, the government is encouraging integration efforts in the development and improvement of research on the use of industrial, forestry and agricultural waste as alternative energy (Anam. Asroful and Muhammad Azizul Majid, 2020).

Briquetter

Briquettes are a simple alternative fuel, both in terms of the production process and the use of raw materials for making briquettes, so they have quite a lot of potential to be developed into fuel, because briquettes have a relatively high calorific value with a long burning time. The briquette production process uses a lot of raw materials from biomass. Biomass is a term to describe the type of organic material produced by the process of photosynthesis. This type of biomass energy source can be obtained from agricultural, urban, industrial and agricultural waste (Suhartoyo and Sriyanto, 2017).

Good quality briquettes based on SNI 01-6235-2000 have a calorific value above 5000 cal/gram, a maximum ash content of 8%, and a maximum water content of 8%. The characteristics of good briquettes have a burning temperature value of briquettes that lasts at a temperature of 350℃ for a long time and is flammable (Lubis et al., 2016).

Making briquettes from organic waste must of course measure the calorific value to determine the quality of the briquettes produced. This calorific value must be known to determine the quality of the briquettes produced as a requirement for use as fuel. Heat can be measured using a calorimeter. A calorimeter is an object used to measure the heat produced during a reaction or combustion of fuel. A calorimeter is a tool designed to isolate the system inside so that the heat coming out of the object is the same as the heat entering the water and its container.

The working principle of a bomb calorimeter at constant volume, namely when molecules react chemically, heat will be released or taken and the temperature change in the calorimeter fluid is measured. Since the vessel is tightly closed, its volume remains constant and no volume pressure work is done. Experiments at a constant volume are difficult to do because they require the use of a well-designed reaction vessel that can withstand the large pressure changes that occur in many chemical reactions. The principle of measuring a bomb calorimeter is based on the amount of heat measured in calories and produced when a briquette sample is completely oxidized in a bomb calorimeter (called the total energy of the briquette) (Utami et al., 2018)).

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The borm calorimeter has advantages in terms of the accuracy of the heat change results compared to using a simple calorimeter. The borm calorimeter is a specially designed tool so that the system is completely isolated. Generally used to determine changes in combustion reactions. The reaction system in the calorimeter is perfectly isolated so that the increase or decrease in temperature that occurs can be detected or measured accurately.

Various alternative energy sources that are environmentally friendly, cheaper and renewable, namely biomass in the form of using organic materials in solid fuels known as briquettes and this energy is very suitable for development in Indonesia. Therefore, the author wants to study "Analysis of the calorific value of various types of biomass briquettes by calorimeter". With this research study, it is expected to be a literature for research and can be an education for the community that the use of biomass in briquettes has great potential to minimize the national energy crisis.

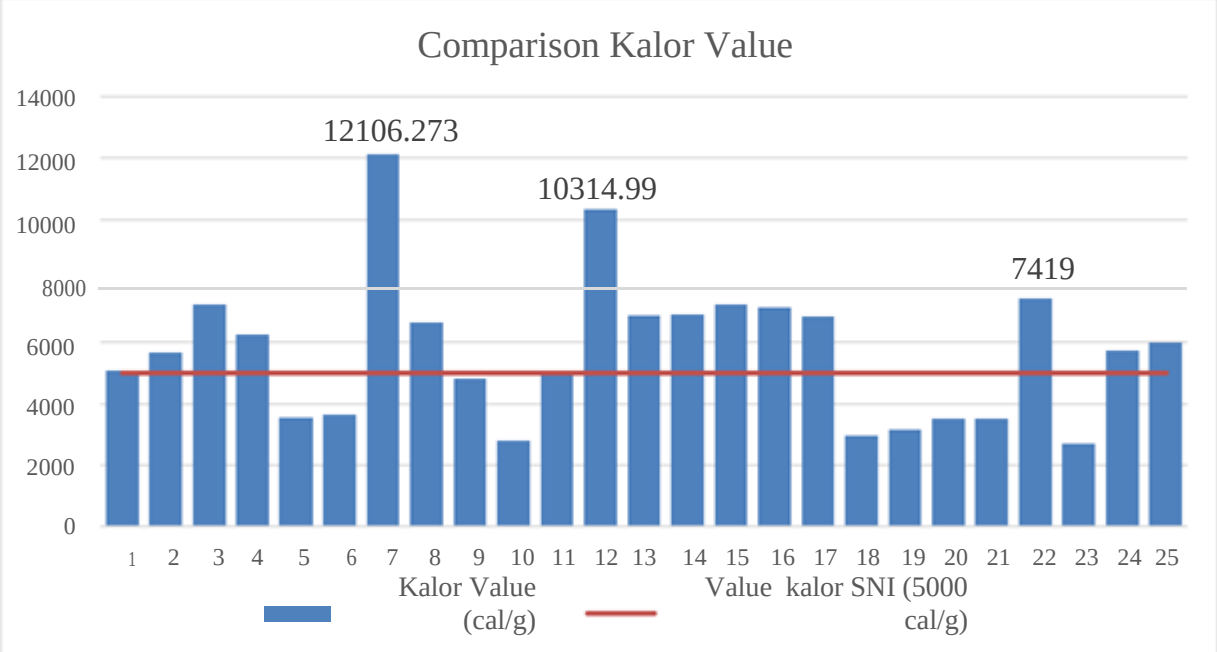

Figure 2. Graph Of Kalor Value

From the comparison of the best calorific value according to their respective compositions among several briquettes analyzed, it was found that the calorific value of the Siamese weed stem briquette: adhesive with a composition of 91: 9 with a calorific value of 12106.27 cal / g is the briquette with the best calorific value. Continued with the Coconut Shell Charcoal briquette: Tapioca Adhesive with a ratio of (70: 30) with a calorific value of 10314.99 cal / g.

Briquettes from Siamese weed stems have the highest calorific value compared to other briquette-making materials. The effect of adhesive on Siamese weed briquettes also affects the quality of the briquettes, if too much adhesive is used, it will not produce good briquettes. Other influences are also found in the water content contained in the Siamese weed charcoal briquettes, as well as the ash content produced so that it will affect the calorific value of the Siamese weed briquettes.

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Consentrated

Water content affects the quality of charcoal briquettes, the higher the water content, the more difficult it is to ignite the briquette fuel. Charcoal has the ability to absorb large amounts of water from the surrounding air. Its ability to absorb water is influenced by the surface area and pores of the charcoal and is also influenced by the level of bound carbon contained in the briquette, the smaller the level of bound carbon in the briquette, the greater the ability of the briquette to absorb water from the air.

The water content in briquettes is expected to be as low as possible in SNI ≤ 8%. Water content affects the quality of briquettes. The lower the water content in the briquettes, the better the calorific value produced. Because if the water content is high, the energy produced is largely absorbed to evaporate the water so that the calorific value will decrease. Water content greatly affects the quality of the charcoal briquettes produced. The lower the water content, the higher the calorific value and combustion power will be and vice versa, the higher the water content, the lower the calorific value and combustion power will be (Ramadiah, 2016).

Ash is the remaining part of the combustion results. The main element of ash is silica and its effect is less good on the calorific value produced because the silica content cannot be burned. The higher the ash content, the lower the quality of the briquettes produced. The remaining product of perfect combustion is ash. The main element of ash is silica, so the more silica contained in the briquette, the more ash is produced. Therefore, good briquettes are briquettes that have a low silica content so that they produce little ash. In SNI, the maximum ash content has been set at 8% (Saukani, 2019).

The type of raw material greatly influences the high and low ash content of the briquettes produced. This is because the raw materials used have different chemical compositions and amounts of minerals, resulting in different ash content of the charcoal briquettes (Hendra, 2011).

The calorific value is the most important quality parameter for briquettes. The higher the calorific value, the better the quality of the briquettes. The value is greatly influenced by the ash content and water content. Calorific value because the higher the calorific value of the briquette, the better the quality of the briquettes produced, but the quality of the briquettes is better if it must pass the specifications referring to SNI Briquette (Wibowo, 2021).

METHOD

The research used in this study is the type of (Research and Development is a method or step to produce new products or develop and improve existing products, and is used to test the effectiveness of the product (Sri Haryati, 2012). In this sub-chapter, the design of the tool will be discussed, starting from the following components.

Boileris a device used to heat water or produce steam using thermal energy. The water heated in the boiler can then be used as a power source for a turbine in a power plant. A boiler consists of several main components, including a combustion chamber, heating tubes, and a control system to regulate temperature and pressure.

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*Solar Charge Controller*is an electronic device used to regulate direct current that is charged to the battery and taken from the battery to the load. Solar charge controller regulates overcharging due to excess charging from solar panels or other sources that can produce voltage. A micro-hydro generator is a device that converts the kinetic energy of flowing water into electrical energy on a small scale. The principle of its operation involves water being directed through a turbine, which then turns the rotor on the generator to produce electricity.

A battery is a component that functions as a place to store electrical energy so that when the required energy can be used when the main source experiences a problem. Arduino is an open source tool aimed at those who want to create an interactive electronic prototype using its flexible hardware and software. The ZMPT101B voltage sensor is a module used to measure AC voltage. It has an input voltage with a measurement range of 0V to 250V AC and has an operational voltage of 5V DC. The software called Arduino IDE (Integrated Development Environment) is intended to help developers program and develop applications on Arduino boards. Arduino IDE offers a variety of functions and libraries, or libraries, that facilitate the application development process.

Developers can use the Arduino IDE to write program code using the C or C++ programming language. The code can be uploaded or uploaded to the Arduino board using a USB cable. The Arduino IDE also has features such as syntax highlighting, auto-complete, and error checking that help developers write and edit program code. In addition, various program examples (sketches) and libraries provided by the Arduino IDE can be used by developers as references when building applications. The Arduino IDE makes application development easier and more efficient because it supports various types of Arduino boards to meet developer needs. In addition, the Arduino IDE can be used to program other microcontroller boards besides Arduino, as long as the board supports the C or C++ programming language. Developers can concentrate on developing applications without worrying about technical issues such as compiling and uploading program code to the board (Shiddiqi et al., 2021). Testing techniques on each component are important to carry out in a final assignment or research project because testing helps in identifying whether the tool components have achieved the expected results

RESULT

Result Discussed

Discusses testing of the planning of the system that has been created in chapter 3. This testing is carried out to determine the performance of the system and to determine whether the system that has been created is in accordance with the planning or not. this paper had explain the main components of the tool that will be assembled and tested. Below is the hardware circuit design that the author made.

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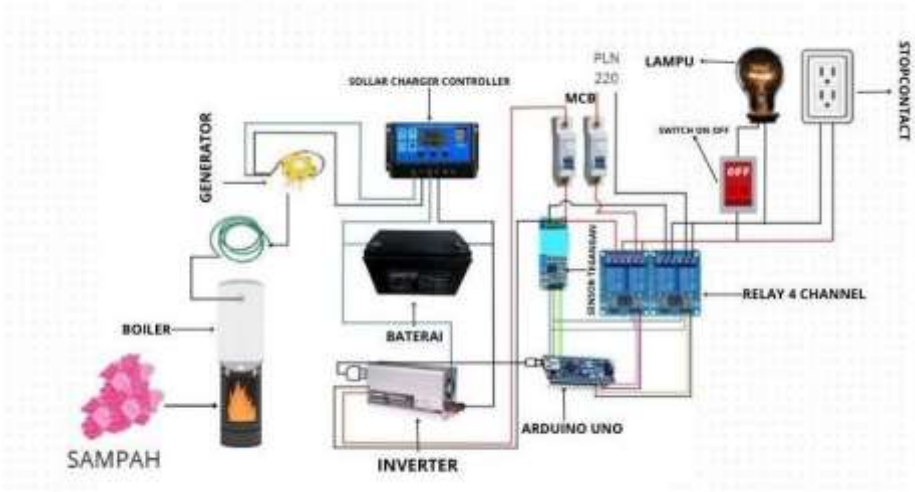

Figure 3. Working System

The waste in this tool is used as fuel which is burned in the combustion furnace where the heat generated from this combustion will heat the boiler. *Boiler*This tool is used as a tool to heat water to produce pressurized steam. The steam will drive the turbine connected to the generator.

Baseband System

The program is created using an Arduino IDE application based on the working principle of the tool system. The program created is then compiled in Arduino software. Then the program is uploaded to the microcontroller. The testing process is done by looking at the function of each port. If there is an error, a repair is needed to get the appropriate results. Testing is needed because it will greatly affect all existing component devices. Both electronic components, mechanics and application software on the computer. If it does not match the specified settings, the microcontroller device and other devices are not in sync.

In making this tool design, the Arduino nano microcontroller is an important component. This microcontroller is used for processing data and design settings so that it can work properly and appropriately. This Arduino IDE application is certainly very necessary to give commands to the tool after coding is done on the Arduino IDE application.

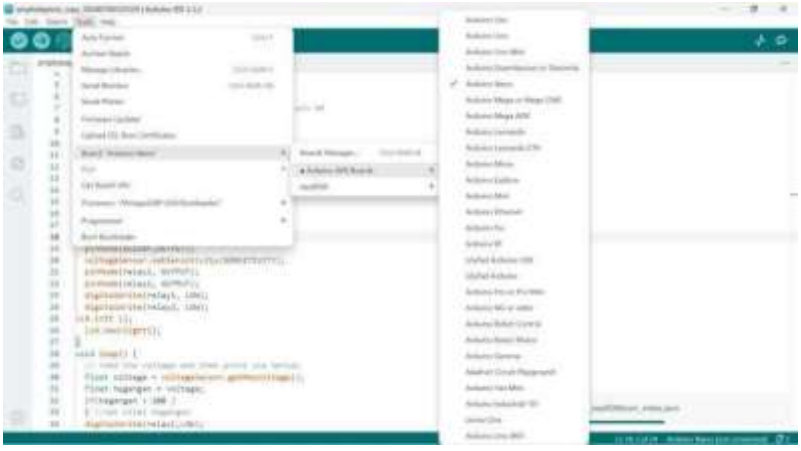

Figure 4. Arduino IDE Board Selection

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The board selection is in accordance with the one used on the hardware. In this study using Arduino Nano, so in Arduino IDE also selects the Arduino Nano board.

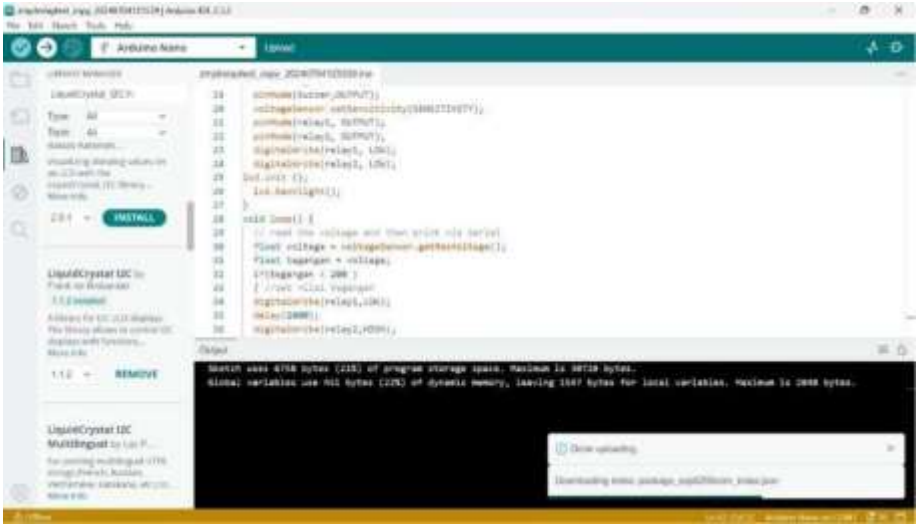

Figure 5. Compile File

After completing the coding, the next step is to compile the program to ensure that it is correct or there are still errors in the coding.

Figure 6. Upload File

If it is correct, a display will appear in the Arduino IDE application program with the words "done compiling" Analysis: From the above test, the results were obtained that the program in the Arduino IDE application works well and normally, and ready to be uploaded to the Arduino Nano board used on this tool. Testing Procedure :

1. Prepare the program that has been created previously.
2. *Compile*to find out if there are any inappropriate programs.
3. If the compilation process goes well, immediately upload the program and wait a few moments.
4. *Program* can be uploaded if it shows done *uploading*.

Testing

In this section, the author wants to test each component in the final project that was created, with the aim that this project runs as the author wants, the following are tests of

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hardware and software components: This waste testing aims to determine how long it takes for the waste to burn until the boiler produces steam.

1. Testing procedures
    a. Choose dry, flammable waste.
    b. Put the trash into the incinerator.
    c. Put a little kerosene into the furnace and light the fire with a match, wait for the fire to burn for 15-30 minutes until the boiler produces steam.
2. Measurement results

Table 1. Waste Measurement

Measurement	Mass of Waste	Time	PSI
1	2 kg	20 minutes	29 psi
2	2 kg	17 minutes	30 psi
3	2 kg	16 minutes	28 psi
4	2 kg	15 minutes	29 psi
5	2 kg	18 minutes	29 psi
	Average	17 minutes	29 psi

Analysis results

From the results of this measurement, it was found that the burning of waste in the combustion chamber takes about 17 minutes until the boiler can produce a steam pressure of 29 psi. This boiler test aims to ensure whether the boiler can produce hot steam to drive the generator to produce electricity. The results of the tests that have been carried out, it was found that the boiler can work well, namely by producing steam pressure that can drive the generator. With a boiler combustion period of about 40 minutes, it produces steam that can rotate the generator for about 10 minutes. The test on this microhydro generator aims to determine whether this generator can generate electricity from the steam pressure produced by the boiler.

1. Testing Procedure
    1) Insert the boiler outlet valve into the generator input
    2) Then open the boiler valve until it releases enough steam to turn the turbine on the generator.
    3) Then check the output results generated from the generator.

Figure 7. Generator Testing

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2. Measurement Results

Table 2. Microhydro Generator Measurement

Testing	Generator working		The voltage that produced
	Yes	No	
1	✓		12V
2	✓		12V
3	✓		12V
4	✓		12V
5	✓		12V
	Average		12V

The results of the tests that have been carried out, obtained the results that the Microhydro Generator can work well, namely with an average of 12V electricity which functions to charge the battery with an indication that the voltage is successfully distributed to the battery can be seen on the SCC screen. The test on this solar charge controller aims to determine whether the SCC can work as a control to charge the battery.

1. Testing Procedure
   1) Connect the Generator output to the SCC to see the voltage generated by the PLTSa.
   2) Connect the SCC output to the battery to see if the battery is charged or not.

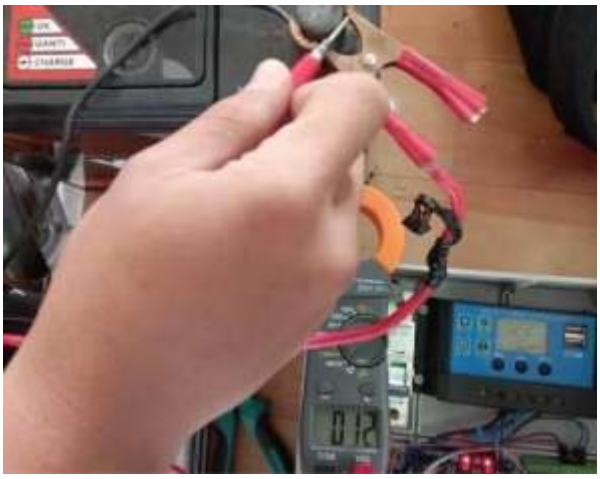

Figure 8. Solar Charge Controller TestingMeasurement results

Table 3. Solar Charge Controller Measurement

Testing	Input Voltage	Output Voltage
1	12 VDC	12.2 VDC
2	12 VDC	12.2 VDC
3	12 VDC	12 VDC
4	12VDC	12.1 VDC
5	12VDC	12 VDC
	Average	12.1 VDC

3. Analysis Results

From the test results that have been carried out, it was found that the solar charge controller can work well and there is no indication of damage with the voltage indicator produced can supply the battery. This Solar Charge Controller also displays the voltage produced accurately with an average voltage of 12.1 VDC.

CONCLUSION

From the analysis results, it can be concluded that the use of waste as a raw material for biomass briquettes has significant potential in supporting the production of more environmentally friendly electrical energy. Briquettes made from organic waste are able to produce energy with quite high efficiency and reduce dependence on fossil fuels. The use of waste briquettes not only helps reduce the volume of waste in landfills, but also contributes to reducing greenhouse gas emissions, which is in line with sustainable development goals. This study also shows that although biomass power generation technology still requires further development, especially in terms of optimizing the combustion process and increasing energy conversion efficiency, the potential for its implementation on a small to medium scale is quite promising. With the support of government policies and improvements in technological infrastructure, biomass-based power plants from waste can be an alternative solution in overcoming the upcoming energy crisis in Indonesia.

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