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Preliminary study on the use of solar energy to drive biomass briquetting machines

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Abstract

Indonesia is highly potential in biomass resources. However, the use of biomass as energy resource is still limited and inefficient. One of the best strategies in optimizing biomass energy utilization is through densification methods where biomass density increases, and costs associated with transportation and storage are reduced. To carry out densification of biomass waste, reliable tools are required. Biomass waste is usually found in rural areas where inadequate transportation access and the unavailability of electricity networks are often the issues too. On the other hand, Indonesia has abundant sunlight intensity throughout the year to be utilized as a renewable energy source. This study examines opportunities for the utilization of solar energy (PV systems) to drive biomass briquette machines in the rural areas. This research was carried out through several stages including literature study, data collection on the intensity of solar radiation, and calculation and preparation of machine design. The target is to prepare a design for the briquettes pressing machine powered by solar energy. This preliminary investigation concluded that the briquette pressing machine with a production capacity of four briquettes in a single press, was able to be operated using 100 Wp solar panels equipped with a 12-volt 33Ah battery. To drive a hydraulic jack, a 12-volt DC actuator is used at low speeds. The machine is capable of producing briquettes in the form of cubical with the size of 2.5 x 2.5 x 2.5 cm.

Keywords : Biomass densification, briquettes, solar panels, presses machines, DC motor

1. Introduction

Indonesia has high intensity of sunlight throughout the year, which provides abundant potential for the source of renewable energy. Photovoltaic (PV) is one of tools capable of converting solar energy into other energy. PV, better known as solar panels, is an object made from semiconductors that can change sunlight powers into electrical energy. Photovoltaics (PV) are usually arranged into a module and placed on the roof of a house, on the wall of a building, or on a large-scale open field.

Electrical energy produced by photovoltaics can be utilized to support daily activities, especially in places where access to electrical energy from the State Electricity Company (PLN) is scarce. Areas such as plantations or rice fields, which are usually far from people's homes, may benefit from the process. The energy produced can be converted into various other forms of energies, one of which is mechanical energy [1].

Mechanical motion energy or better known as the actuator can be obtained from the rotation of a dc motor. When operating, a dc motor requires a direct voltage supply that can also be obtained through photovoltaic. This directional voltage is then applied to the field coil to create magnetic field. In addition to the field coil, the dc motor also has an anchor coil which has the function of creating an electromotive force (EF). When the current in the anchor coil meets a magnetic field, a torque (T) will arise which will rotate the dc motor [2].

Table 1 depicts the development of the use of solar energy for mechanical propulsion.

Table 1. Development of Solar Energy Utilization for Mechanical Activators

No	Description	Actuator Type	Information	Ref
1	Shrimp Pond Water Supply	Water Pump (12v dc motor)	PV 3 units x 50Wp	[3]
2	Water Reservoir Fillers	60 Watt Dc Pump	PV 1 unit 50Wp	[4]
3	Solar Mover Tracker	DC motor	10V 30mA Amorphous PV, round PV (Diameter 50mmx48mm), PV 2 units x 250Wp, PV 1 unit 50Wp, PV 1 unit 5Wp	[5], [6], [7], [8], [9]

4	Line Follower Robot	Servo Motor	PV 1 unit of 20Wp	[10]
5	Driving Boat Fishing	12V DC motor (450 w)	PV 3 units x 150 Wp	[11]
6	6WD robot	Dc motor	1 unit battery 2200mAh	[12]
7	Stadium roof automation	Dc motor	PV 1 unit 50Wp	[13]
8	Solar Water Pump	DC motor	PV 1 unit 50Wp,	[14]
9	Electric bicycle	DC Brushless Motor	PV 1 unit of 40Wp	[15]

Data in table 1 on the energy produced by solar panels highlights its capability to meet the energy needs of electric motors. This literature study also indicates that lack of study on the use of solar energy to drive briquette presses, an issue the author focusses in this study. In this discussion, the author will make a preliminary study on the use of solar energy for pressing briquettes machine made from coffee plantation waste.

In a study conducted by Mendoza Martinez et.al [16], a briquette was produced from mixing coffee residues with pine wood. The coffee residue itself consists of coffee stalks, main branches, secondary branches, and coffee skins. From the results of the density test, without being mixed with pine wood, coffee skin has the highest density level compared with other coffee residues, which is 340 kg/m^3. Based on this finding, coffee skin can potentially be used as fuel in the form of briquettes.

Briquette is a product of the biomass residues compaction process used as fuel and compacted using bonding agent. Briquettes from biomass have a high heating value. Factors affecting the briquettes qualities are the composition of the raw materials and the time of carbonization. The carbonization process in making briquettes can increase the calorific value and reduce the smoke generated from burning briquettes [17].

Briquettes consumed in any countries have their own standards for the quality. Table 2 describes several parameters that are of concern in the briquette manufacturing process of various countries [18].

Table 2. Briquettes standards parameters

Standard	water content (%)	Calorific value (Kal/g)	Density (g/cm^3)	Pressure force (Kg/cm^3)
Indonesian (SNI. 01-6235-2000)	8	5000	-	-
Japan	3,5	7289	-	-
England	6	6000-7000	-	

Table 2 shows that the quality of a briquette is determined by the level of its calorific value, the higher the calorific value, the better the quality of the briquette. The water content is usually directly proportional to the calorific value, the lower the water content, the higher the calorific value. Briquette density and compressive strength has no special standard since each type of biomass has typical characteristics. Density and compressive strength of briquettes are adjusted to the required conditions. Briquette itself has long been used for cooking purposes in people's homes, industrial needs, and trading companies that are able to replace the role of firewood without having to cut down forests. This of course can reduce the adverse effects on the environment.

Briquettes making process requires special technology and additional energy to be able to process the biomass waste directly in the plantation area without having to be brought first to a safe place. Producing briquettes directly in plantation areas can save on transportation costs. The location of the plantations is usually far from residential areas. This is due to the types of briquette raw material is still in the form of flakes or powder, which in turn requires much larger space especially when compared with the compacted briquettes.

Figure 1 shows the potential of solar energy intensity in the Northern Aceh Region, based on predictions made by World Bank Group institutions via satellite monitoring [19]. It can be seen that the peak density of solar energy occurs in June, which is 85 kWh/m^2. However, in December the lowest solar energy intensity was 50 kWh/m^2. The potential of solar energy in Aceh region is also supported by research conducted by Global Solar Atlas [19]. In Figure 2 is a graph of the intensity of sunlight in Aceh Besar district measured using lux meter. Data indicate that the average intensity in 2019 in April was 5.77 kWh/m^2/day, May was 5.96 kWh/m^2/day, and June was 5.67 kWh/m^2/day. With an average irradiation for 10 hours a day and an average temperature of 32.7 °C [20].

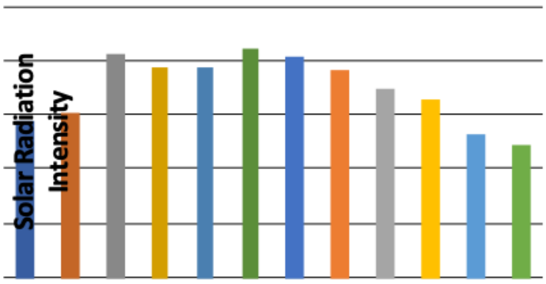


Figure 1. Solar Radiation Intensity throughout the year

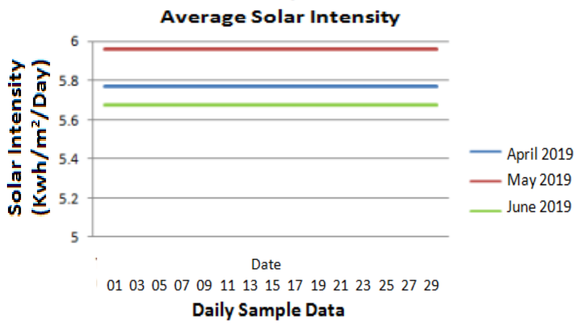


Figure 2. Solar Light Intensity in Aceh Besar District

This study aims to examine the opportunities for solar energy utilization (PV System) to drive biomass briquette pressing machine. This research also offers an optional strategy to optimize plantation residual utilization through biomass densification method. An additional benefit is gained from this coffee-agro industry residuals if the briquettes produced are of high quality and meets market requirement.

2. Research methods

Solar energy utilization as the power source for briquette presses designed in this study are shown in Figure 3. The electrical energy generated by solar panels is connected to the voltage and current regulator of the solar panels which are then stored in batteries, where the briquette press machines derive their source of power from.

To obtain the desired briquette size, a limit switch is installed which functions as a breaker and connector for the electric current. The limit switch works when a piece of equipment touches the switch, the system will automatically cut off electric current. Basically, tools and materials used in this study consist of electrical and mechanical equipment. For more details, Table 2 provides list of tool and material quantity.

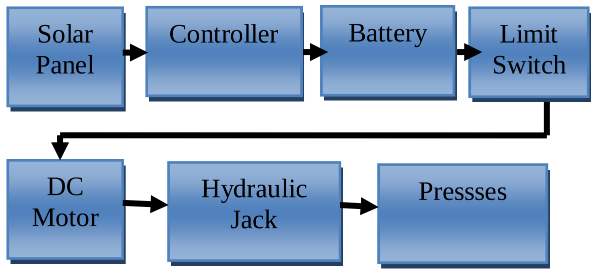


Figure 3. Basic Schema of a Briquette Press System Using Solar Energy

Table 2. Preparation of Tools & Materials

No	Tools & Materials	Total
1	Solar Panel 100 WP	1
2	Lead Acid VRLA VA 12V 33AH battery	1
3	Controller 20A	1
4	MC4	1
5	Cable	2 meters
6	12V Wiper DC Motor	1
7	Hydraulic jack	1
8	Presses machines	1
9	Multimeter	1
10	Limit Switch Sensor	1

This investigation used a 100 Wp polycrystalline solar panel type. The reasons for using this type of solar panel will be explained in the discussion section. The specifications are as follows:

Solar panel GH Solar 100 WP, 100 watts
Voltage at P_{max} : 18.3 V
Current at P_{max} : 5.47 A
Open Circuit voltage : 22.5 V
Short circuit current : 5.91 A
Size (mm) : 1020 x 670 x 30

The battery used is lead acid VRLA. The calculation of battery usage is explained in the discussion section. The specifications are as follows:
Volt / Capacity : 12V 33AH
Lenght : 195 mm
Widht : 128 mm
Height (Total Height) : 155 (180) mm
Weight : 9,68 Kg
Terminal : *Nut & Bolt*

A 20 A controller is used with the following specifications:

Rated Voltage	:12V/24V
Rated Current	: 10A & 20A
Charging Mode	: PWM
USB Output	: 5V/3A
Self-Consume	: Operating Temperature -35 ~ 60ºC
Storage Temperature	: -35 ~ 60ºC

DC motor is used with the following specifications:

Voltage	: 12 V DC
Power	: 30 Watt
No-load speed	: 60 rpm
Speed with load	: 45 rpm
No-load current	: 1.1A
Current with load	: 0.7A
Stall Torque	: 22 nm
Weight	: 1.75kg

The limit switch sensor is used to stop the briquette pressing process when the required briquette thickness has been reached. The specifications are as follows:

Type	: Micro limit switch roller 3 Pin
Dimension	: 20 x10 x 6 mm (P x L x T)
Rated Voltage	: 125V-250V
Current Rating	: 5A

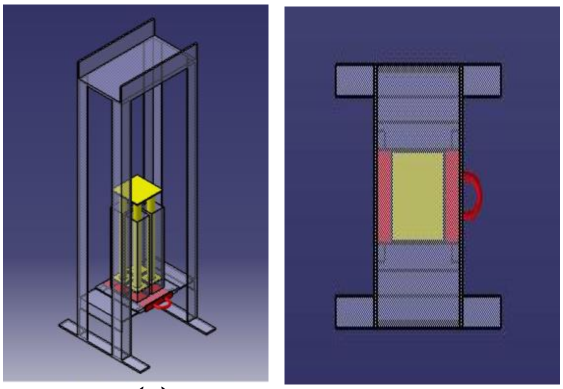
Actuators design for briquette pressing machine consists of a DC motor coupled with a hydraulic jack. This aims at converting mechanical energy into kinetic energy. This energy change produces far more power yet less power for operation. Briquette pressing machine is manufactured based on the design as shown in Figure 4 and 5. The mold is made of stainless steel to avoid corrosion due to corrosive substances presence in biomass raw material.

3. Results and Discussion

Within this study, several stages were carried out starting from designing pressing machine, selecting motors and jack as press actuators, and determining the specifications of solar panels and battery storage capacity.

3.1 Design of Pressing Tools

Presses are designed to be produce 4 (four) briquettes in one push. The cubical mold size is 2.5 x 2.5 x 2.5 cm, according to research conducted by [21]. This size is much in demand among the industry. The design is carried out with the help of the AutoDesk Inventor Student Version software. Design of the briquette press tool is displayed in Figure 4a and 4b.



(a) (b)

Figure 4: a. Assembly of Briquette Press Machine, b. Briquette extracting chamber

In Figure 4a, yellow plate indicates the location of the hydraulic jack. When the hydraulic jack is given a clockwise rotation by a dc motor until it touches the top plate of the press, then the jack also indirectly presses the bottom of the jack itself that is in direct contact with the briquette mold. After the pressing process, the briquette can be extracted at the extraction chamber as visualized in Figure 4b. This tool serves to hold the briquette during the pressing process. The surface structure of this tool is made absorbent so that it can release water or liquid that comes from plantation waste. The construction of briquetting machine are shown in Figure 5.

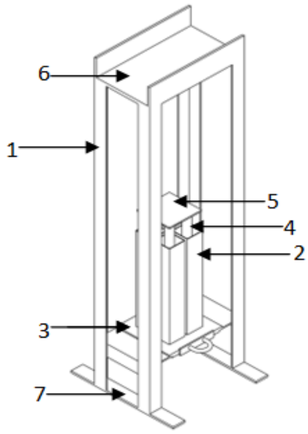


Figure 5. Pressing Machine Construction

Based on components indicated in Figure 5, the materials used for briquette pressing machine construction are as follow:

1. Iron L 50 mm x 50 mm, with a thickness of 5 mm, as the main pillar (mild steel)
2. Carbon steel hollow bar 25 mm x 25 mm, 2 mm thick, as a briquette mold
3. Stainless steel plate 300 mm x 300 mm, with a thickness of 5 mm, serves as a briquette holder

4. 12 mm in diameter stainless steel rod, as briquette pushing rod
5. Stainless steel plate 150 mm x 150 mm, with a thickness of 5 mm, as a jack holder plate.
6. UNP bar 5 mm thickness, hydrolic jack top holder (carbon steel)
7. 10 mm flat bar, as support for the lower legs (mild steel)

3.2 Motor & Jack Selection

Hydraulic jack provides an advantage of large pressure with little power operation. So that the lever on the hydraulic jack which is usually rotated manually by the user, can be replaced with a rotation on the dc motor. The jack that was used was a 2-ton hydraulic jack. The red line in Figure 6ab is where the coupling will be installed. The selection of electric motors in this study uses a 12-volt electric motor with a maximum power capacity of 100 watts.

(a) (b)

Figure 6: a) Dc Wiper Motor, b) Hydraulic Jack

The advantages of dc wiper motor include speed that is easily controlled, torque is large initially, near linear performance, the control system is relatively cheaper, dynamic response is good, and has a low power.

The dc motor and hydraulic jack are connected with a coupling that has been modified so that it can transmit mechanical energy to the hydraulic energy of the briquette pressing process.

3.3 Determination of Solar Panel & Battery

In a study conducted by [15] which uses 40 WP solar panels with 324 Watt-hour battery power, it is able to operate electric bikes as far as 54,855 Km, with a speed of 5.56 m / second. However, in that study, researcher used 3 units of batteries which is costly in operation. In this study only uses 1 solar panel which is expected to be able to supply an electric current as needed. Figure 7 is the electrical system design in this study.

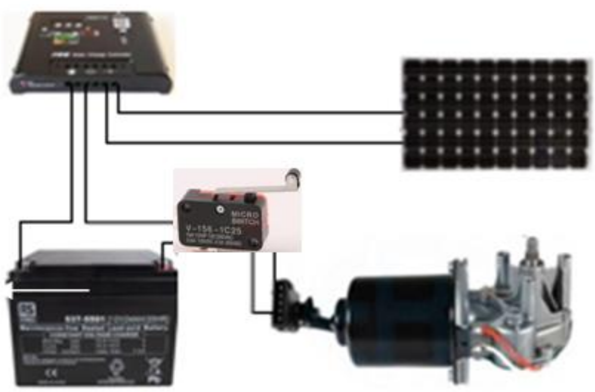


Figure 7. Electrical System Design

The beginning of the process of the formation of electrical energy can be seen in Figure 7. The solar panel is connected to the controller using the MC4 connector which is connected by cable. The positive (+) cable from the solar panel is connected to the positive (+) side of the solar charge controller, as well as the negative cable (-) connected to the negative side (-) of the controller. Then the positive (+) & negative (-) output of the controller is connected to the positive (+) & negative (-) sides of the battery. In the controller module there is an output for loading into the system, this output will flow the electric current to the limit switch sensor & dc motor.

To maximize the performance of the press, a battery is needed to function to store energy from the solar panel while the press is not operated. The battery used is a capacity of 33 AH with a voltage of 12 volts.

The selection of solar panels based on calculations of solar energy absorption is assumed for 5 hours, and the batteries used are 12 volts / 33 Ah. So the battery capacity obtained is 12 volts x 33 Ah, 396 Watt. The capacity of the solar panel is 396 Watt / 5 hours, based on these calculations, the solar panel needed is 79.2 Wp.

Taking in the possibility of energy loss and reduction, in addition to the calculation above, we will need to install PV with a capacity above 79.2 Wp. Thus, in this study using a solar panel with a capacity of 100 Wp.

Briquette presses are planned to operate for 1 hour, then the total power consumption of the 100-watt dc motor is:

Total load = 3.5 hours x 100 watts
= 350 watts
Battery capacity = 350 watts / 12volts = 29.16 Ah.

Looking from the results of the calculation of the battery capacity, the battery used for this machine must have a capacity above 29.16 Ah. Thus, in this study utilized a 12 V battery with a capacity of 33 Ah; adjusting to the available market size.

To optimize capturing of solar energy, it is necessary to install a solar charger controller, with a capacity of 20 A. In addition, to get the right briquette size, this module is equipped with a limit switch sensor to cut off the current and stops the pressing process immediately. This investigation is only focused on preliminary study of solar power potency and preparing a suitable design. The performance and design improvements will be reported in the next article.

4. Conclusion

From the experimentation and calculations made on PV usage, it can be concluded that briquette presses machine can be operated using 100Wp solar panels and 12V 33AH. One unit solar panel and one unit battery are properly enough to drive the machine. Briquette pressing machine are designed to produce four pieces of briquettes in one press with a size of 2.5 x 2.5 x 2.5 cm.

References

[1] W. Yandi, Syafii and AB Pulungan, "Three Position Solar Panel Tracker for Increasing Energy Conversion with Low Power Supply," National Journal of Electrical Engineering, vol. 6, no. 3, pp. 159-160, 2017.

[2] N. Nugroho and S. Agustina, "Analysis of DC Motor (Direct Current) As Driving Electric Cars," Mikrotiga, vol. 2, no. 1, pp. 28-34, 2015.

[3] Jalaluddin, A. Rasyid Jalil, R. Tarakka and Wardi, "Implementation of Water Pumps in Shrimp Ponds with the Utilization of Renewable Energy Sources," vol. 1, no. 1, pp. 23-32, 2018.

[4] D. Waluyo Putranto, F. Budi Antono, R. Handoko and Istiadi, "Designing an Automatic Irrigation System Using Wireless Sensor Network (WSN) Based on Solar Energy," vol. 9, no. 2, pp. 825-832, 2018.

[5] R. Syafrialdi and Wildian, "Design of Solar Tracker Based on MicrocontrollerAtMega 8535 with LDR Sensor & LCD Viewer," vol. 4, no. 2, pp. 11-20, 2015.

[6] A. Shodiqin and A. Yani, "Analysis of Charging Time of Solar Cell Systems Using Sunlight Direction Finder Complete with Light Focusing," vol. 5, no. 1, pp. 1-7, 2016.

[7] W. Yandi, Syafii and A. Basrah Pulungan, "Three Position Solar Panel Tracker for Increasing Energy Conversion with Low Power Supply," vol. 6, no. 3, pp. 159-167, 2017.

[8] H. Situngkir and M. Fadlan Siregar, "Solar Panel Runs by Following the Movement of the Sun Rate," vol. 3, no. 3, pp. 128-131, 2018.

[9] H. Ida Lailatun, R. Sabani, GM Dwi Putra and D. Ajeng Setiawati, "Photovoltaic Automation Systems for Solar Power Plants Based on Arduino Microcontroller-Based Laboratory Scale," vol. 8, no. 2, pp. 130-138, 2019.

[10] T. Rahmany Fajriah, R. Kusumanto and P. Risma, "The Effect of Reception of Light Intensity on Robot Line Follower Motion Using Solar Cells," vol. 9, no. 1, pp. 25-29, 2020.

[11] Iradiratu and B. Yan Dewantara, "Calculation of Electric Power Needs for Driving Solar Powered Fishing Boats," vol. 3, no. 1, pp. 18-21, 2020.

[12] MY Hendrayanto, IB Alit Swamardika and PA Mertasana, "Design and Build Smart Charging Systems Using Solar Panels on 6WD Robots Based on the Atmega 2560 microcontroller," vol. 17, no. 1, pp. 42-50, 2018.

[13] A. Julisman, I. Devi Sara and R. Halid Siregar, "Prototype of Solar Panel Utilization as an Energy Source in the Ball Stadium Roof Automation System," vol. 2, no. 1, pp. 35-42, 2017.

[14] Z. Iqtimal, I. Devi Sara and Syahrizal, "Application of Solar Systems as a Source of Electric Power for Water Pumps," vol. 3, no. 1, pp. 1-8, 2018.

[15] B. Nainggolan, F. Inaswara, G. Pratiwi and H. Ramadhan, "Design to Build Electric Bicycles Using Solar Panels as Battery Chargers," vol. 15, no. 3, pp. 263-272, 2016.

[16] Mendoza Martinez. Clara, Sermyagina E, Olivera Carneiro, V. Esa and C. Marcelo, “Production and Characterization of coffe-pine wood residue briquettes as an alternative fuel for local firing system in brazil.,”*Biomass and Bioenergy*, pp. 70-77, 2019

[17] Iriany, C. Carnella and C. Novita Sari, "Biobriquette Production from Palm Oil Midribs and Shells: Effects of Variation in Raw Material Composition and Carbonization Time on Briquette Quality," USU Chemical Engineering Journal, pp. 31-37, 2016.

[18] P. Djoko, “Making Palm Shell Charcoal Briquettes by Treatment of Coking Time and Concentration of Concentration.,’’Jurnal Riset Industri Hasil Hutan, Vol. 7, no. 1, pp. 1-8, 2015.

[19] Global Solar Atlas, "Global Solar Atlas," World Bank Group, 4 July 2020. [Online]. Available: https://globalsolaratlas.info/map?s=4.916521,97,000128.10. [Accessed 4 July 2020].

[20] T. Zulfadli and Muhyin, " Feasibility Study of Solar-Wind Energy (hybrid) as a Water Pump Resource for Irrigation Systems in the Greater Aceh Region," vol. 17, no. 2, pp. 61-65, 2019.

[21] A. Adhi Pratama, D. Shadewa and Muhyin, "The Effect of Base Material Composition and Variation on Adhesive Type on Heat Value, Moisture Content, Ash Content in Mixed Rice Husk and Coconut Shell Briquettes," vol. 1, no. 2, pp. 1-10, 2018.