Automatic Grain Dryer Using Solar Power Plant Backup

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ABSTRACT: *Grain drying is a crucial stage in the rice post-harvest process, which aims to reduce the moisture content to a level that is safe for storage and milling. This research aims to design and develop an automatic grain dryer system equipped with a solar power plant (PLTS) as a backup energy source. The system is designed to ensure an efficient, stable grain drying process that can meet premium quality standards according to SNI 1628:2015, which sets a maximum grain moisture content of 14%. This automatic grain dryer uses sensors to regulate temperature and humidity, assisted also using DC motors and blowers to accelerate drying, so as to optimize the drying process and produce the best quality grain. By utilizing solar energy as a backup power source, the system is able to operate sustainably even in the event of a power outage from the main grid. In addition, the use of solar power is proven to be effective in providing stable backup energy, thereby increasing energy efficiency and reducing dependence on conventional power grids. From the test results, the maximum power generated by the solar panel is 17.08 Watts with the efficiency obtained by the solar panel reaching 12.24%. The need for a tool to turn on for 6 hours requires 126.24 Wh of energy so that a battery with a capacity of about 1,130 mAh is needed and the duration of charging to full is approximately 7.65 hours. To meet the power requirement of 126.24 Wh with a battery autonomy of 1 day, the solar panel module is 0.009618 ≈ 10 Wp.*

KEYWORDS: *Blower, ESP32, Grain, Moisture, DC Motor, Soil moisture*

I. INTRODUCTION

Grain drying is one of the important stages in the rice postharvest process. This process aims to reduce the moisture content of the grain to a level that is safe for long-term storage. Grain moisture content according to SNI 6128:2015 is 14% for dry grain with premium quality. Traditional drying methods, such as sun drying, often face weather constraints and require a long time and large area. Conventional grain drying is highly dependent on weather conditions as rain or high humidity can hinder the drying process, resulting in an increased risk of spoilage or damage to the grain. The natural drying process takes a relatively long time which can hamper the rice harvesting and processing cycle. Drying requires a large amount of land to accommodate large amounts of grain which may not always be available especially in areas with high population density. The use of automatic dryers usually requires a stable and reliable source of electrical energy. In some areas, limited access to electricity is a significant obstacle [1].

Based on previous research related to this research, most of them still use electricity sources from PLN completely. Therefore, an innovation was designed, namely an automatic grain dryer that utilizes a Solar Power Plant (PLTS) as a backup so that farmers can continue to operate the grain dryer even though there is a power outage. In addition to using PLTS, this tool also uses a DC motor as a driver of the grain container so that the grain dries evenly and speeds up the drying process [1][2][3].

II. OVERVIEW

A. SOLAR POWER PLANT

Solar Power Plant is a power generation system sourced from solar radiation through photovoltaic cell conversion. The higher the electrical power to be generated, the greater the intensity of solar radiation must be. By using Photovoltaic technology to produce DC (Direct Current) electrical energy, which can be converted into AC (Alternating Current) electricity if needed.

1) Calculation of Solar Panel Module Requirements

To get the energy needed by the load, the average daily cost energy of the circuit must be added to the energy lost in the system by 24% and the average daily cost energy STC (Solar Thermal Component). To calculate Module Power, equation 1 is used as follows [4]:

$$Module\ Power\ (\,Wp\,) = \frac{24\%\ x\ energy\ needs\ (KWH)}{Radiation\ Energy\ (4{,}5KWH/m^2)\times 1/Radiation(1KW/m^2)\times system\ loss} \quad (1)$$

To determine the number of modules required for autonomy time equation 2 as follows [4].

$$module\ count = \frac{Otonomi \times module\ power}{module\ power} \quad (2)$$

Description:
Autonomy :Days without charging from sunlight
module power :Solar panel power capacity (W)
2) Solar Panel Power Calculation

Calculations on solar panels that are used usually include:

a) Solar panel power

Solar panel power can be determined by multiplying the maximum current and maximum voltage obtained from the output of the solar panel or according to the following equation 3 [7]:

$$p = v \times I \qquad (3)$$

Description:
p : Power (W)
v : Voltage *(volt)*
I : Current *(ampere)*

b) Solar Panel Efficiency

Solar panel efficiency is a measure of how much solar energy can be converted by solar panels into usable electrical energy. In reality the performance of solar panels has several losses, namely reflection losses, excess light, dust, series or parallel resistance and temperature. This can affect the performance of solar cells which is expressed in efficiency [6]. Efficiency can be calculated using equation 4 below [5].

$$\eta = \frac{V\ X\ I}{P \times A} = 100 \qquad (4)$$

Description:
P : Solar radiation intensity (Watt/m2)
I : Current (I)
h : Solar Cell Efficiency (%)
V : Solar panel voltage (V)
A : Solar panel area (m2)

B. SCC (SOLAR CHARGE CONTROLLER)

Solar Charge Controller or commonly abbreviated as SCC is one of the components in the solar power generation system whose function is to regulate the incoming electric current (current controller) from the PV panel and the load current that comes out or is used [8]. SCC is usually used to regulate the voltage and current from solar panels to the battery, which when the battery voltage is low, the SCC will automatically cut off the use of the battery to the load. This goal is done to keep the battery from over-draining the battery power which will result in shorter battery life [7].

C. LCD (LIQUID CRYSTAL DISPLAY) 16X2

Liquid Crystal Display (LCD) is an electronic circuit used to display information or indicators given to the microcontroller. One of the LCD applications used is a dot matrix LCD with a 2 x 16 character size [9].

D. MODUL RELAY

5V relays with single channel output are used for electronic switches as controllers of electrical devices that require high voltage and current. This device pairs well with most microcontrollers especially the ESP32. This relay requires at least 15-20mA of current to control each channel. A high current relay is included so that a 250V 10A AC device can be connected. If using a microcontroller with an operating voltage of 3.3 V, it can still use this relay by removing the JD-VCC jumper and by connecting JD-VCC with another 5V external power [9].

E. BATTERY

A battery is a device consisting of an array of electrochemical cells that convert the chemical energy stored in the battery into electrical energy. Each cell has a positive pole (cathode) and a negative pole or (anode), the positive pole indicates that it has higher potential energy than the negative pole. The negative marked pole is a source of electrons, which when connected to an external circuit will flow electric current and will provide energy to the enternal equipment. Which when the battery is connected to an external circuit, the electrolyte can move as ions in it so that there is a chemical reaction at both poles. The transfer of ions in this battery causes the flow of electric current to the external circuit [11].

Calculations to Determine Battery Requirements. In the Solar Power Plant (PLTS) system, the battery functions as a store of electrical energy obtained from solar panels. To calculate the battery requirements needed from the existing power (expressed in watt-hour, Wh). Using the following equation 5 [12]:

$$battery\ requirements = \frac{V_s \times A_h battery}{W} \qquad (5)$$

Description:
V_s : Battery Voltage
$A_h battery$: Battery Capacity(Ah)
W : Tool load (Wh)

After the battery needs are known, then the capacity calculation is carried out on the battery. The level of use or drain on the battery or often referred to as DOD (Deep Of Discharge) is usually only 80%, cannot be spent up to 100% of the battery capacity because in order not to damage the battery because it will shorten the battery life. As for determining the battery capacity can be determined using equation 6 as follows: [5]

$$C_{battery}(Ah) = Q_{battery}\ \frac{t_{otonomi}}{DOD\ battery} = Ah \qquad (6)$$

Description :
Q = Battery charge (Ah)
C = Battery capacity (Ah)
$t_{otonomi}$ = Ability to supply load without sunlight (Hours)
DOD baterai = Battery discharge level (80%)
V_{op} = Operating voltage (Volts)
Wh = Daily electrical energy requirements (Wh)

Batteries in automatic grain dryers are filled using solar panels, to find out the length of time it takes to charge a lead acid battery with a capacity of 9 Ah 12

VDC so that it is fully charged can be found through equation 7 as follows:

$$Estimated\ Charge\ Time = \frac{Battery\ Capacity}{Efisiensi\ x\ solar\ panel\ current} = Hours \quad (7)$$

F. POWER SUPPLY

A power supply, better known as a power supply, is an electronic device that functions to supply electrical energy to one or more electrical loads. The working principle of a power supply involves the use of a wave rectifier circuit that aims to convert alternating electric current (AC) into direct electric current (DC). Based on its type, this rectifier circuit can be divided into two: half-wave rectifier and full-wave rectifier, both of which utilize diodes for the current rectification process [13].

G. NODEMCU ESP32

The NodeMcu ESP32 microcontroller, is a development of the ESP8266 microcontroller. Due to its complete specifications like the ESP32, this 32 bit microcontroller is perfect for applications related to the Internet of Things (IoT). It can communicate via WiFi, Bluetooth, and BLE [14].

H. MOTOR DC

Direct current motor or electric motor is a type of electric motor whose function is to convert electrical energy with direct current into mechanical energy. The form of energy it produces is rotation. The working principle of this direct current motor is the result of the interaction between the two magnetic fluxes in the motor called the field coil and the anchor coil [15].

I. PTC (POSITIVE TEMPERATURE COEFFICIENT) AIR HEATER

A positive temperature coefficient heating element (PTC heating element), or self-regulating heater, is an electrical resistance heater whose resistance increases significantly with temperature. The name self-regulating heater comes from the tendency of such heating elements to maintain a constant temperature when supplied with a certain voltage. PTC heating elements are a type of thermistor

Heaters with a positive temperature coefficient (PTC) consist of a special heating disk manufactured from advanced ceramic materials. These safe, robust and energy-efficient heaters allow for exceptional heat production and transfer even in the smallest spaces. [16]

J. TEMPERATURE SENSOR DS18B20

The DS18B20 temperature sensor is a sensor for measuring temperature that can be attached to a microcontroller. This sensor has a digital output, so it does not use an ADC circuit, this temperature sensor has an accuracy and measurement speed that is more stable and better than other temperature sensors. [17]

K. SOIL MOISTURE SENSOR

A soil moisture sensor is a type of sensor whose job is to measure water content, in general, its working principle is to detect the moisture of the water around it. This sensor has two wires that run current through the soil to be measured for moisture, and then the sensor will read the resistance value to read the soil moisture. The more water content in the soil, the higher the resistance value, and conversely the lower the water content in the soil, the lower the resistance. The soil moisture sensor in the application requires a 5V voltage source and an output voltage of 04.2V [18].

III. METHOD

A. BLOCK DIAGRAM OF TOOL DESIGN

The design of the tool begins with making a program related to changes in temperature and moisture content contained in the grain, which will be tested before being uploaded to the microcontroller. The process can be seen in the block diagram in Fig 1. below:

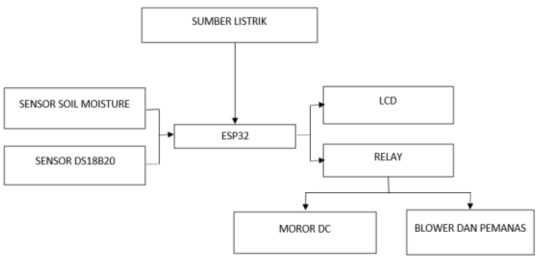

Fig 1. Indicator and Control diagram

In Fig 1. the design system of the grain dryer with PLTS backup is used one microcontroller, namely ESP32, where ESP32 is used as a control system and also designs a source of electricity from solar panels stored in batteries. The design of this prototype is divided into 2 parts, namely software design and hardware design. The charge module and battery which has an important role as a microcontroller power supply are arranged to get a good incoming and outgoing voltage setting of 5V DC.

Then the control system design uses an ESP32 microcontroller which functions as a processor and controller of the entire system.

The moisture sensor located in the tube room functions to send commands to the microcontroller so that it can provide indicators of the temperature state and the moisture content contained in the grain. Next is the DC motor which is used as a driver of the grain dryer tube room so that drying can work evenly and more efficiently, which works automatically, depending on the value of the moisture content in the grain.

Then there is a blower that functions as a grain dryer, which also works automatically, depending on the value of the water content in the grain.

LCD display is used as a viewer for temperature conditions and moisture content in the grain in the room. As for the power source used in this tool, namely, by utilizing solar energy sources (solar panels) as a backup so that this tool can be operated when there is a power outage, so it does not depend on conventional power sources.

B. Overall Equipment Network Design

The design of the entire tool circuit is a combination of each design that has been explained and explained in the previous subchapters. The design of the entire tool includes the design of PLTS as backup energy, the design of a series of sensors to check grain moisture, and the design of an LCD (Liquid Crystal Display) circuit to display grain moisture information. Furthermore, several designs are combined into one overall circuit for an automatic grain dryer system. Thus, the unification of these various elements produces a system that can be understood and effective as an automatic grain dryer. To find out more clearly about the overall circuit design of the automatic grain dryer can be seen in Fig 2. below:

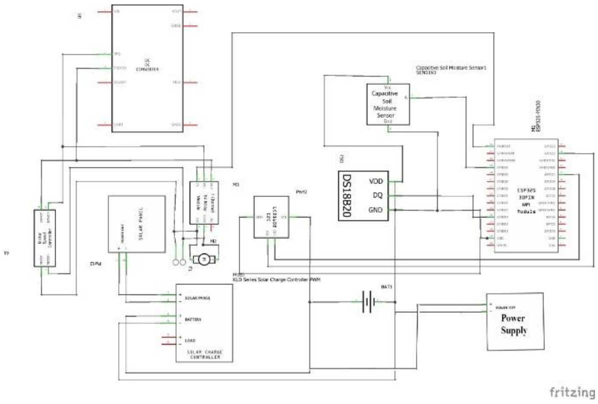

Fig 2. Overall Design of the Tool

C. Overall Prototype Design

The overall circuit design is a combination of all designs from each design that has been discussed on the previous page which is assembled into a system in the design of an automatic grain dryer.

The overall prototype design can be seen in Fig 3. below:

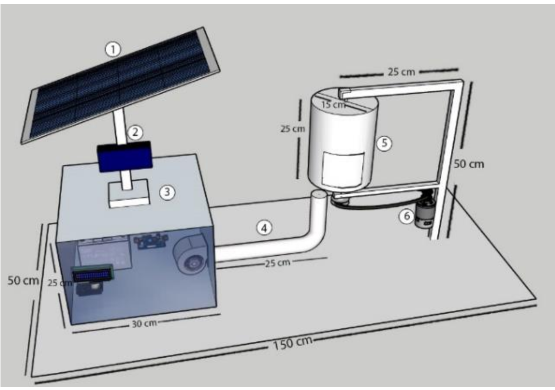

Fig 3. Overall Prototype Design

The components needed in designing the overall prototype are as follows:

1) Solar Panel
2) Solar Charge Control (SCC)
3) Component Box
   a. One battery
   b. One blower
   c. Two Step down modules
   d. One ESP32 microcontroller board
   e. One DS18b20 sensor (temperature sensor)
   f. One Capasitive Soil Moisture V1.2 (moisture sensor)
   g. One relay module
4) Wind Pipe
5) Dryer Tube
6) DC motor

IV. Results and Discussion

A. Power Supply Testing

a. Testing

Tests were carried out on the 220VAC - 12VDC power supply output to ascertain whether the voltage produced had met the needs or not. This test was carried out ten times both in conditions without a load and with a connected load. The test results are shown in Tbl 1. below:

Tbl 1. Power Supply Testing

No.	Testing	No Burden (VDC)	To Load (VDC)
1.	To-1	11,95	11,80
2.	To -2	11,94	11,79
3.	To -3	11,95	11,80
4.	To -4	11,94	11,79
5.	To -5	11,95	11,80
6.	To -6	11,94	11,79
7.	To -7	11,95	11,80
8.	To -8	11,95	11,80
9.	To -9	11,95	11,80
10.	To -10	11,94	11,79

b. Analysis

From Tbl 1. above shows the measurement results on the power supply obtained an average voltage of 11.946 Volts DC. While the working voltage is 12 Volts DC. Then when the power supply is loaded, there is a decrease in the average voltage to 11.796 Volts DC. So that from the test results as much as 10 times each trial the output voltage from the power supply is in accordance with the specifications and does not experience a significant decrease.

B. Testing And Analysis Of Voltage And Current Sources

a. Testing

Components that generate power are solar panels and batteries. This analysis is carried out on the source of voltage and electric current generated by solar panels that will be used to charge the battery. From the results of measurements using a multimeter where experiments were carried out for 3 (three) days, with 10 measurements per day.

The following is a table of current and voltage measurements that have been carried out on solar panels, the results of which can be seen in table 2. below:

Tbl 2. Results of measuring voltage, current and power generated by solar panels on the first day

Hours (WIB)	Voltage DC (V)	Current (A)	Power (Watt)	weather
09:00	12,81	0,5	6,41	Cloudy
09:30	12,86	0,5	6,43	Cloudy
10:00	12,62	0,3	3,79	Cloudy
10:30	12,59	0,3	3,78	Overcast
11:00	12,57	0,3	3,78	Overcast
11:30	12,59	0,3	3,78	Overcast
12:00	12,57	0,3	3,77	Overcast
12:30	12,55	0,2	2,51	Overcast
13:00	12,52	0,2	2,5	Overcast
13:30	12,53	0,2	2,51	Overcast

From the measurements taken on the solar panel, it produces the most or maximum power of 6.43 watts at 09:30, and has decreased at 13:00 which produces 2.5 watts of power. This happens because

Various factors, namely due to the intensity of sunlight that dims as the transition from daytime to evening or the possibility of weather factors either cloudy or cloudy sky conditions.

From the measurements taken on the second day, the results of current and voltage measurements on solar panels carried out on the second day can be seen in table 3. below:

Tabel 3. Results of Measurement of Voltage, Current and Power Generated by Solar Panels on the Second Day

Hours (WIB)	Voltage DC (V)	Curr ent (A)	Power (Watt)	Heath er
09:00	17,7	0,99	17,52	Hot
09:30	17,5	0,72	12,6	Hot
10:00	17,3	0.62	10,73	Hot
10:30	17,2	0,5	8,6	Hot
11:00	17,5	0,72	12,6	Hot
11:30	17,4	0,7	12,18	Hot
12:00	16,1	0,4	6,44	Hot
12:30	17,7	0,99	17,52	Hot
13:00	16,4	0,4	6,56	Hot
13:30	17,5	0,72	12,6	Hot

From the results of measurements taken on the second day, the solar panel obtained a peak or maximum power of 17.52 watts at 12:30, then the lowest power at 12:00 which amounted to 6.44 watts. For the second day of testing the weather was hot and sunny so that it got more power than the first day.

Next is the measurement of the voltage and current obtained from the solar panel on the third day, the resulting measurements are as shown in table 4 below:

Tbl 4. Results of Measurement of Voltage, Current and Power Generated by Solar Panels on the Third Day

Hours (WIB)	Voltage DC (V)	Current (A)	Power (Watt)	Heather
09:00	12,55	0,2	2,51	Cloudy
09:30	12,52	0,2	2,5	Cloudy
10:00	12,53	0,2	2,51	Cloudy
10:30	16,1	0,4	6,44	Hot
11:00	17,6	0,8	14,08	Hot
11:30	17,4	0,7	12,18	Hot
12:00	17,8	1	17,8	Hot
12:30	16,7	0,6	10,02	Hot
13:00	16,3	0,4	6,52	Hot
13:30	15,7	0,4	6,28	Hot

Measurements taken on the third day, the solar panel produces a peak or maximum power of 14.08 watts at 11:00, then gets the lowest power because the sky is still cloudy because of rain in the early morning at 09:30 which is 2.5 watts.

From the measurement of the electrical power obtained by solar panels on the first day to the third day can be depicted on a graph, the following is a graph of the measurement results of the power generated from solar panels on the first day to the third day shown in Fig 4. the following:

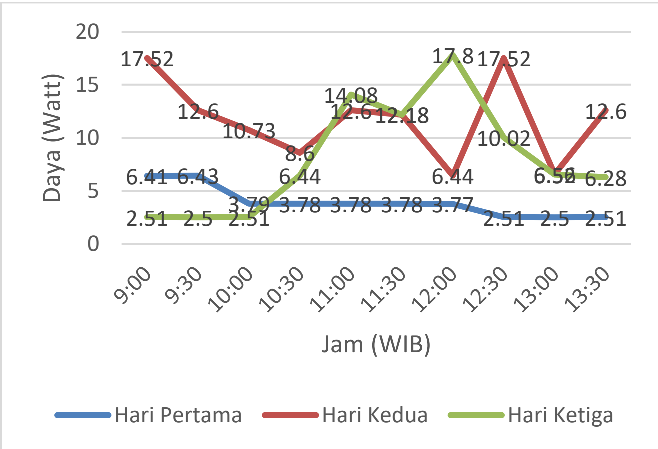

Fig 4. Comparison Chart of Power Generated by Solar Panels from Day 1 to Day 3

From the measurement results of the first day to the third day carried out at 09.00 to 13.30 the highest power generated by the solar panel is on the 3rd day at 12.00 amounting to 17.8 Watts because the sky is very bright and the sunlight is not blocked by clouds and the lowest power is on the first day at 13.00 and the 3rd day at 09.30 amounting to 2.5 Watts because the sky is cloudy so that the sunlight becomes dim covered by clouds.

1. Solar panel power

The power generated in testing tables 2. to 4. above can be calculated using equation 3:

P = V x I
P = 17,8 V X 1 A
P = 17,8 Watt

Then the power obtained on the solar panel is 17.8 Watts.

2. Energy conversion efficiency

Conversion efficiency on solar panels uses the following equation 4.

$$\eta = \frac{VxI}{p \times A} x100\ \%$$

$$\eta = \frac{18\,V\ x\ 0{,}68}{1000 \times 0{,}1} x100\ \%$$

$$\eta = \frac{12{,}24}{100} x100\ \%$$

$$\eta = 12{,}24\ \%$$

Then the efficiency of the solar panel is 12.24%.

a. Analysis

The time used is 6 hours, so to find out the total energy must calculate the power x time.
For loads in this design can be seen in Tbl 5. as follows:

Tbl 5. Total Load Requirement

No	Component	Power (Watt)	Energy (Wh)
1	ESP32	0,33	1,98
2	Motor DC	9,6	57,6
3	*Blower*	10,8	64,8
4	*Soil Moisture Sensor*	0,16	0,96
5	Sensor DS18B20	0,04	0,24
6	LCD	0,11	0,66
Total		21,04 Watt	126,24

In Tbl 5. the load requirement used is 6 hours during the day, the total energy required for this prototype is 126.24 Wh.

To meet the load requirements for 6 hours requires a sufficient battery, therefore it can be calculated using the following equation 5:

$\text{Kebutuhan baterai} = \frac{V_s \times A_h baterai}{W}$ Maka dapat ditentukan

$$\text{Kebutuhan baterai} = \frac{12 \text{ x } 9}{126{,}24}$$

$$= 0{,}85\text{Ah}$$

To determine the capacity of the battery to be used, it has previously been determined from the total battery capacity that can be used, which is 0.85 Ah with an autonomy time of 1 day. Autonomy time is the time or state where the battery is able to supply electrical power to the system when there is no sunlight, which is generally used 1 day. The level of use or drain on the battery or often referred to as DOD (Deep Of Discharge) is usually only 80%, cannot be spent up to 100% of the battery capacity because in order not to damage the battery because it will shorten the battery life. With equation 6, the way to determine the number of batteries needed is:

$$C_{battery} = \frac{Q_{battery} \text{ x } t_{otonomi}}{\text{DOD battery}}$$

$$C_{battery} = \frac{0{,}85 \text{ Ah x 1 Day}}{0{,}8}$$

$$C_{battery} = \frac{0{,}85 \text{ Ah x 24 Hours}}{0{,}8}$$

=25,5 Ah

Previously it was determined from the number of batteries needed to supply a load of 21.04 Watts with an additional autonomy time of 1 day, it requires a battery with a capacity of 1.13 Ah 12 Volt DC. However, in the design of this automatic grain dryer, the type of battery chosen in this grain dryer system is a 9Ah 12 Volt deep cycle VRLA battery type totaling 1 piece.

The length of time to charge the battery has several factors, namely the capacity of the battery used and also the current entering the battery. In accordance with the calculation of the system design design, the battery capacity used is 9 Ah with 80% efficiency and according to the specifications of the solar panel used, it is capable of producing a maximum current of 0.68 A. So, for the calculation of the estimated time needed to charge the battery can be known by using the following equation 7:

$$Estimated\ charge\ time = \frac{\text{Battery Capacity}}{\text{Efisiensi x solar panel current}}$$

$$\text{Estimated Charge Time} = \frac{9 \text{ Ah}}{80\% \text{ x } 0{,}68 \text{ A}}$$

$$= 7{,}65\ Hours$$

In general, the intensity of sunlight absorbed by solar panels in Indonesia is optimal for 4-5 hours. To calculate the need for the number of solar panels to be used, then from the specifications of solar panels in table 1. able to produce average electrical energy is calculated through the following equation 1:

$$\text{Module Power} = \frac{\text{lost energy replenishment x energy needs (Kwh)}}{\text{daily intensity x Solar Panel intensity x system loss}}$$

$$\text{Module Power} = \frac{24\% \text{ x } 0{,}12624}{4{,}5 \text{ kwh/m}^2 \text{x} 1 \text{kw/m}^2 \text{x} 0{,}7}$$

$$\text{Module Power} = \frac{0{,}0302976}{3{,}150} = 0{,}009618 \approx 10 \text{ Wp}$$

It is assumed that the length of time required to charge the battery in no-load conditions is one day. Then, the number of modules used to supply 10 Wh load requirements with an autonomy time of 1 day can be known using equation 2 as follows:

$$\text{number of modules (N)} = \frac{\text{otonomi x Module Power}}{\text{Module Power}}$$

$$number\ of\ modules\ (N) = \frac{1\ \text{Day}\ \ x\ 10\ \text{Wp}}{10\ \text{Wp}}$$

= 1 Module

So, to meet the needs of the total installed load of 10.52 Watts with a total energy of 126.24 Wh with an autonomy time of 1 day, it requires 1 solar panel module with a capacity of 10 Wp.

C. TESTING AND ANALYSIS ESP32

a. Testing

Voltage testing on the ESP32 pin to determine the voltage that comes out when ESP32 turns on and performs drying commands, voltage measurements are taken when the tool turns on and when performing drying commands automatically. Here are the results of the measurements that can be seen in Tbl 6. following:

Tbl 6. Testing Voltage

Experiment	Component	Operating Voltage (VDC)	output voltage (VDC)
1	ESP32	5	5,03
2		5	5,01
3		5	5,03
4		5	5,04
5		5	5,02
6		5	5,01
7		5	5,02
8		5	5,03
9		5	5
10		5	5,01
Average		5,02	

b. Analysis

From Tbl 6. above shows the results of measuring the input voltage (VDC) on the ESP32 obtained an average voltage of 5.02 Volts DC. While the working voltage is 5 Volts DC. So that ESP32 can operate properly because the working voltage rating is 3.3-5 volts DC in accordance with the ESP32 data sheet.

D. TESTING AND ANALYSIS SENSOR

a. Testing

This test is to determine the voltage on the soil moisture sensor and DS18B20 sensor

1) Soil moisture sensor

In testing the soil moisture sensor, this has the aim of knowing the voltage value on the sensor in working condition and not. The test data results can be seen in table 7. following:.

Tbl 7. Soil Moisture Sensor Test Results Off Condition

Experi ment to	Device	Sensor Condition (*Off*)	*Voltage on Soil Moisture Sensor* (Vdc)
1	Sensor *Soil Moisture* 5 Volt	*Off*	5,06
2	Sensor *Soil Moisture* 5 Volt	*Off*	5,06
3	Sensor *Soil Moisture* 5 Volt	*Off*	5,06
4	Sensor *Soil Moisture* 5 Volt	*Off*	5,06
5	Sensor *Soil Moisture* 5 Volt	*Off*	5,06
	Average		5,06

b. Analysis

From the test results in Tbl 7. above is a test on the soil moisture sensor when it is off or when the sensor is not working and shows a good reading in accordance with its function, which shows an average value of 5.06VDC and is appropriate because the components that run in the grain dryer automatically the value is definitely 5.06VDC because the power source itself has a capacity of 5VDC 3A, because this soil moisture sensor will work if the minimum voltage is 3.3 VDC.

To see the results of testing the soil moisture sensor with a load can be seen in Tbl 8. following:

Tbl 8. Soil moisture sensor test results under loaded conditions

No.	Device	Humidity	Voltage (VDC)
1.	**Sensor *Soil Moisture***	26%	2,7VDC
2.		20%	2,9VDC
3.		17%	2,96VDC
4.		14%	3,07VDC

From the test results in Tbl 8. above is a test on the soil moisture sensor when it is on or when the sensor is working and shows that when the grain becomes wetter, the capacitance increases, and this can cause a lower output voltage. Next is the test of the level of accuracy of the moisture sensor which will be measured with the object of freshly harvested grain so that the accuracy of the tool assessment can be in accordance with the actual conditions in 5 trials and in the first trial to the third trial the grain was measured in wet conditions then the fourth and fifth trials the grain was dry or humidity less than or equal to 14% its function is to find out whether the sensor used can read humidity properly, the following is the test result data can be seen in Tbl 9. below:

Tbl 9. Soil moisture sensor accuracy test results

Experiment	Sensor *Soil Moisture*	condition of rice
1	26%	Moist
2	24%	Moist
3	24%	Moist
4	14%	Dry
5	14%	Dry

In the test in Tbl 9. this is to show the accuracy of the soil moisture sensor, the results are obtained in the form of humidity values in the condition of the 1st to 3rd experimental grain in wet conditions and the 4th to 5th experimental grain in dry conditions.

1) DS18B20 Temperature Sensor

The measurement of the voltage source from the DS18B20 temperature sensor is shown in Tbl 10. below:

Tbl 10. Testing the temperature sensor voltage source in off condition

Experiment	Device	Sensor Condition (*Off*)	Voltage on Temperature Sensor (Vdc)
1	Temperature 5V	*Off*	5,06
2	Temperature 5V	*Off*	5,06
3	Temperature 5V	*Off*	5,06
4	Temperature 5V	*Off*	5,06
5	Temperature 5V	*Off*	5,06
	Average		5,06

From the test results in Tbl 10. above is a test on the temperature sensor when in the off condition or when the sensor is not working and shows a good reading according to its function, namely showing an average value of 5.06VDC and is appropriate because the components that run in the automatic rice dryer must have a value of 5.06VDC because the power source itself has a capacity of 5VDC 3A, because this temperature sensor will work if the minimum voltage is 3.3 VDC. Testing when the sensor is working can be seen in Tbl 11.

Tbl 11. Testing the temperature sensor voltage source with load

No.	Device	Temperature	Voltage (VDC)
1.	Sensor DS18B20	26,50°C	2,7VDC
2.		30°C	2,9VDC
3.		39,40°C	2,96VDC
4.		50,03°C	3,07VDC

From the test results in Tbl 11. above is a test on the temperature sensor when in the on condition or when the sensor is loaded and shows the lowest voltage reading of 2.7VDC when the temperature is 26.50°C. in this test according to the datasheet because the output voltage is 0-3.3VDC.

E. Draying Speed Testing

a. Testing

This test is to determine how much speed affects the automatic rice dryer. The measuring instrument used to measure the speed of the DC motor uses a Tacho Meter. The test results can be seen in Tbl 12. below:

Tabel 12. Drying Speed Testing

No.	Moist(%)	Temperature (°C)	Speed (Rpm)	Dry (%)	Hours (Minute)
1.	26%	26,50°C	171	14%	60
			229		53
			319		50
2.	26%	30°C	171	14%	25
			229		21
			319		19
3.	26%	50,03°C	171	14%	9
			229		8,3
			319		7,5

b. Analysis

From the test results in Tbl 12. above, because the purpose of using a DC motor is only to flatten the grain in the storage tube, the speed does not significantly affect the drying of this grain dryer. What affects drying is the temperature, when the grain moisture reaches 14% in just 7.5 minutes at a temperature of 50.03°C and a speed of 319 rpm.

V. CONCLUSION

Based on the results of the testing and discussion of the automatic rice dryer that has been carried out in this research, the following conclusions can be drawn from the tool that has been created:

1) For measurements on the power supply without load and with load, the results did not experience a significant decrease, which means it is still in

accordance with the specifications.
2) On the solar panel that has been measured for five consecutive days, namely by measuring the voltage (V) and current (I) produced, so as to obtain the maximum power produced by the solar panel (P = V × I), the maximum power produced by the solar panel is on the 3rd day at 12.00 of 17.08 Watts because the sky is very bright and the sunlight is not blocked by clouds with the efficiency obtained by the solar panel reaching 12.24%.
3) The need for the tool to turn on for 6 hours requires energy of 126.24 Wh so that a battery with a capacity of around 1,130 mAh is needed and the charging duration to full is approximately 7.65 hours. Taking into account the battery autonomy conditions for 1 day with a DoD level of 80%.
4) To obtain the number of solar panel modules needed to meet the power requirement of 126.24 Wh with a battery autonomy of 1 day, the solar panel module is "0.009618 ≈10 Wp".
5) The test results of the voltage of each component provide a voltage value that matches the maximum working voltage, this proves that the system and components on the device have worked according to the datasheet.
6) Drying rice using an automatic rice dryer is fairly effective because it can reach a humidity value of 14% with an average time of approximately 7 minutes because the temperature emitted by the rice dryer is an average of 51.03 °.

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