Solar Cell Outdoor Bench Design In Open Public Space For Gadged Charging Station

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***Abstract*—The increase in electrical energy is increasing in tandem with rapidly developing technological needs. However, on the other hand, electricity technology also produces negative impacts such as air and noise pollution caused by power plants. Electrical energy generation is still mostly generated from fossil fuels. A solution that can overcome this problem is to switch to more environmentally friendly electricity technology, such as solar panels. This solar powet plant can be used as an option as a charging energy source in a smart furniture. This research aims to make Solar Cell Powered Outdoor Charging Bench technology. This bench has several important components, namely: Solar Panel, Solar Charging Controller (SSC), inverter, and battery. This Outdoor Bench is placed in an open place such as a park, Public Open Space and so on which will be used as a charging place for cellphones or laptops. The way this bench works starts with the absorption of solar heat by solar panels on the roof of the bench which is converted into low-voltage electrical energy, then this energy is stored in a dry battery (battery) through SSC, low-voltage electricity is converted through an inverter, and this inverter channels electricity to the socket, so that the charging bench can be used properly**.

Keywords - Electrical technology, Solar panel, Outdoor Charging Bench

I. Introduction

It's very difficult to eliminate the use of devices or gadgets by the public. Almost for every minute, people will need a terminal to charge their device whether it is a cellphone, tablet, or laptop. However, device charging facilities are very minimal in open spaces.

Urban areas in tropical countries such as Indonesia have enormous solar energy potential, but its utilization is still not maximized [1]. The potential of solar energy can be used by Public Open Space, especially in urban areas such as in Banyuwangi.

Public Open Space is one of the facilities managed by the local government. That is one ofthe urban facilities that must be owned by every region, even almost every region in other countries also have it. With the mention of "Open Public Space", Thats in each location has the same function and purpose [2].

Open space is a shared location that is used publicly. Whether with strangers, friends, or colleagues. It is also a space that can be used for politics, religion, sports, or other needs. The existence of open space can be used to support the needs of daily life in urban areas [3].

The purpose of open space is among others as a medium that provides air and lighting, reduces density, recreational facilities, as an ecological function, and shapes the physical city [4]. In Indonesia, the use of public spaces is usually utilized for recreation and ecological functions to accentuate the impression of "public" in an area [5]. Solar powet plant (SPT) itself is an application tool for utilizing solar energy as renewable electrical energy, namely solar cell technology (photovoltaic) which is used as a power plant [6].

Important components that are installed in this setup so that solar powet plant can function optimally. The components used are: a) Solar panels that convert sunlight into electricity which is an important component that must be present in the solar power plant system. (b) Solar Charge Controller, an electronic device placed between the solar module and the battery. This tool regulates the battery charging power from the output power of the solar module so that the battery does not overcharge [7]. (c) Battery is a component that stores energy generated by solar panels. During battery charging, depth of discharge (DOD) refers to how much battery power can be transmitted to the load through the inverter. Battery power cannot be fully charged until the battery is about 80% empty, which reduces battery life [8]. d) An inverter is a device used to convert direct current (DC) into alternating current (AC). The design of solar panels requires the main components, namely power and charging time, inverter power, solar panel power and battery current [9]. solar power plant produces maximum power depending on the intensity of the incoming light every day, weather is the main disturbance that can interfere with the absorption of light intensity processed by solar panels into electricity [10]. Based on its installation, solar power plant is divided into two parts, namely off-grid system and grid connected system. Off-grid solar power plant is also called a stand-alone system, and on-grid solar power plant is solar power plant connected to a utility network or connected to the PLN network [11]. The total load planned in making this tool is 2 plugs for charging Gadged which has a specification of
0.7 A with a voltage of 220 V and 1 lamp 0.025 A with a voltage of 220 V.

In this research, the author aims to create a gagged charging station using an environmentally friendly off-grid. The required energy can be generated from the gadged charging station itself, without PLN power.

II. Methods

A. Type of Research Method

The research method uses design, with steps of literature study, design, assembly, testing, and analysis. Prototype design is used to create an ergonomic bench design, then assembly of solar panels and testing to see the success of the product and then analysis. With the design method, the design, manufacture, and testing steps are carried out systematically. The first stage begins with assembling the bench frame and continues with the installation of electrical components.

The bench frame is made of hollow iron and wood as a seat and backrest. Furthermore, the installation of electrical components such as solar panels, batteries, inverters, outlets, and others is carried out after the bench frame has been completed.

Before the components are installed on the bench, the electrical components are tested first. After testing is

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complete, the components are ready to be installed on the bench frame.

After the bench frame and electrical components have been installed, further analysis and observations are carried out in different weather conditions to determine the power and ability of solar panels in each weather variation.

The following is the flowchart carried out in the assembly of the solar cell-powered outdoor charging bench.Methods section covers the methodology of the research, including any materials needed.

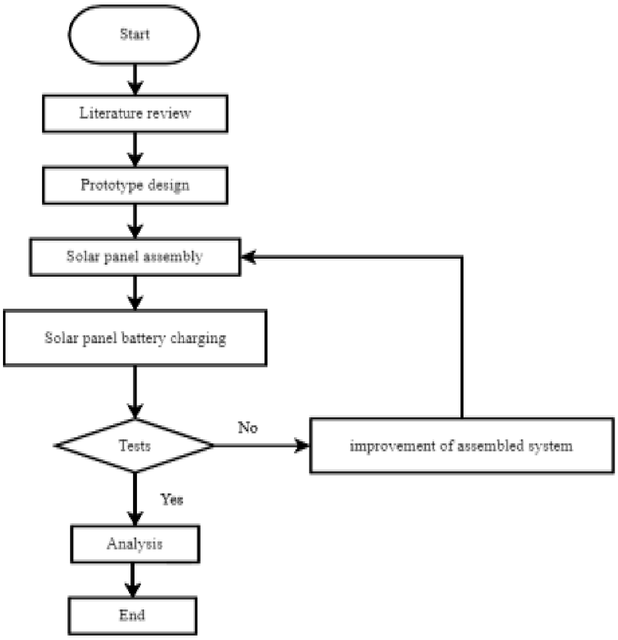

Fig.1 Flowchart of bench design

The design of solar cell-powered outdoor charging benchs uses a number of components, including a 100WP Solar Panel (solar cell), which functions to capture solar heat energy and convert it into electrical energy, which is one of the most important parts in the design of solar cell-powered outdoor charging benchs. Solar Charge Controller (SCC) which is used to store and deliver low voltage electrical energy from solar panels to batteries. 12V 45Ah battery is used as a storage medium to supply electrical energy obtained from solar panels. 150Watt inverter which functions to convert low voltage electricity (DC) into 220 Volt AC voltage. Power outlets will be placed on both parts of the bench armrest to be used as charging terminals in general.

The design of this solar cell-powered outdoor charging bench uses 2 solar panels placed on the top of the bench and assembled in parallel. The parallel circuit is done to maximize the output of electric current. The solar panels that have been installed will be connected to an inverter that functions to convert DC current into AC for the purposes of charging devices by users.

B. . Design of Bench Framework Design

The design of the bench frame uses 4x4 and 4x2 hollow iron. The framework entirely uses holow iron and the total dimensions of the bench frame are p x l x t (1.7 x 1.6 x 2) meters. The bench frame consists of a seat, backrest, armrest, and panel container at the top of the bench seat.

Wood is used as the base of the seat and backrest on the bench which is installed after the iron frame has been completed. At the bottom of the bench there are also 2 boxes, each containing a battery and an inverter as a conductor of electricity for the user when charging the device. The inverter storage box measures p x l x t (20 x 30 x 12) centimeters, and the battery storage box measures p x l x t (30 x 40 x 15) centimeters.

C. Solar panel container roof design

For the roof as well as the solar panel container using angle iron as a framework and spandex as a panel container. The bottom of the panel container is coated with Polycarbonate material to give a neat impression to the bench. The roof of the bench has a dimension of p x l (62.5 x 50.5) cm which is enough to accommodate two solar panels.

III. Results and Discussion

A. Hardware Design Results

The hardware components shown in figure Number 1 shows the 100 wp solar panel. Number 2 is the lighting lamp. Number 3 is the spandex roof. Number 4 is a power outlet. Number 5 is the battery box Number 6 is the electrical panel box.

Fig 2. Features and components of outdoor charging bench

Testing on this solar panel system is to determine the batteries are charged or not, and to find out how long it takes to fully charge the batteries. Table 1 below shows the specifications that solar panels have

Table 1. Solar Panel Specifications

Solar Panel Specifications	
Peak power / Pmax	100W
Power Tolerance Range	3%
Open Circuit Voltage / Voc	22.1V
Rated Voltage / Vmp(V)	18.3V
Short Circuit Current / Isc	6.00A
Rated Current / Imp	5.49A
Max. System Voltage	800Vdc
Series Fuse Rating	10A

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Table 2. **F**irst **S**olar **P**anel **D**ata **O**f **S**ystem **M**easurement

NO	Output Panel				Output solar charge controller					
	Time (hour)	Temperature	condition	Out (V) is not connected solar charge controller	Out (V) connected solar charge controller	I Out (A)	P (Watts)	V out (V)	I Out (V)	P (Watts)
1	10.00	37	Sunny	18,99	13,5	6,5	87,75	13,2	7,1	93,72
2	11.00	40	Sunny	21,5	14,1	7,7	108,57	13,6	6,4	87,04
3	12.00	40	Sunny	20,45	13,7	7,5	102,75	13,1	6,9	90,39
4	13.00	38	Sunny	21,1	13,5	7,1	95,85	13,4	6,3	84,42
5	14.00	39	Sunny	19,6	13,8	6,2	85,56	13,2	7,2	95,04

Table 3. Second Solar Panel Data Of System Measurement

NO	Output Panel				Output solar charge controller					
	Time (hour)	Temperature	condition	Out (V) is not connected solar charge controller	Out (V) connected solar charge controller	I Out (A)	P (Watts)	V out (V)	I Out (V)	P (Watts)
1	10.00	37	Sunny	19.02	13,3	6,7	89,11	13,1	6,9	90,39
2	11.00	40	Sunny	20,85	13,9	7,2	100,08	13,5	6,6	89,1
3	12.00	40	Sunny	21,4	14,4	7,4	106,56	13,9	7,1	98,69
4	13.00	38	Sunny	20,45	14,2	6,9	97,98	13,8	6,6	91,08
5	14.00	39	Sunny	19,47	13,6	6,3	85,68	13,5	6,8	91,8

Tables 2 and 3 show data from the measurement of the solar panel system. The solar panels used are 2 pieces that are installed in parallel in order to get a heterogeneous output power value, the value is obtained from the intensity of the sun's heat hitting the solar panel. Solar panels are not covered by anything because this can affect the value of the voltage and current of the solar panel.

The relationship between solar heat intensity is directly proportional to the current produced by solar panels. That is, the higher the intensity of solar heat captured, the greater the voltage and current produced by the solar panel.According to [6] the battery charging time can be formulated with the equation:

$$T1 = (C / I) + \Phi (C / 1) \quad \text{..............................} (1)[6]$$

Description:

I = Charging Current (A)
C = Battery capacity (Ah)
T = Charging Time
(Hour) Φ = % Deeficiency
(20%)

The calculation of charging time using equation (1) is:

$$\begin{aligned} T1 &= (C / I) + \Phi (C / 1) \\ &= (45\ Ah / 6{,}78\ Ampere) + 20\% (45\ Ah / 6{,}78\ Ampere) \\ &= (6{,}6\ h + 1{,}3\ h) \\ &= 7{,}9\ hours \end{aligned}$$

Since this bench SOLAR POWER PLANTuses 2 solar panels, the time required for charging the battery is 7.9 : 2 = 3.95 hours.

It Can be concluded that the time required for battery recharging is 3.95 hours with an average current of 6.78 A when the weather is sunny. The amount of current generated by solar panels affects the length of time the battery takes to charge.

B. Inverter Load Testing

The inverter is used as a tool to convert DC (direct) voltage into AC (alternating) voltage. The inverter load test is carried out to find out whether the inverter is functioning properly according to the maximum capacity of the inventer's power.

Tabel 4. Test Data On Inverter Loads

INVERTER LOAD TESTING	INPUT DC			OUTPUT AC		
	V (volt)	I (ampere)	P (watts)	V (volt)	I (ampere)	P (watt)
No Load	12.5	0,2	2,5	219	0	0
Charging 2 mobile phones (130 Watts)	12,1	5,4	130,68	207	0,60	124,2

In table 4 the DC input section without load shows the inverter power consumption of 2.5 watts, this is because the inverter has several components that require electricity to be operated. When the inverter is given a load of 130 watts, the battery experiences a voltage drop from 12.5 V to 12.1 V, then the inverter output experiences a decrease in voltage value from 219 V to 207 V, because the inverter only requires a current of 0.60 A, this affects the decrease in power value to 124.2 watts. As a result of the load working below the value of 207 V causes the load power value to decrease. However, the inverter as a voltage converter from DC to AC still functions optimally.

C. *Battery Testing for Mobile Phone Charging*

Battery testing for charging hp aims to determine the estimated time required to charge the hp battery until it is fully charged and how much electrical energy is absorbed by the inverter to charge the hp battery. The tested hp battery capacity is 5000 mAh

Tabel 5. Test result data of mobile phone battery charging

CHARGING 2 MOBILE PHONES				
Time (Minutes)	V in (Volt)	I in (Ampere)	P (Watts)	Energy (wh)
0	11,59	11,30	130,96	20
30	11,9	10,8	128,26	63
60	12,1	10,5	133,58	118,5
90	11,7	11,2	131,04	191,7
120	11,3	11	124,3	251,18

Table 5 is the result of testing the length of timecharging 2 hp batteries measured using a wattmeter, where the data above is taken based on the display of measurement results from a wattmeter installed after the battery and before the inverter. From the data, the voltage value of the SOLAR POWER PLANTbattery has decreased because it is used by the inverter to charge the hp battery from an empty condition (3 V) to a full condition (3.7 V) where battery condition testing is carried out separately from the initial and final time conditions when the battery is full, this full condition is known through the mobile phone screen on and reads the battery is full and the electrical energy used continues to increase from 10 - 251.18 Wh, where the energy usage is 251.18 Wh the mobile phone screen is on which shows the battery is full with an estimated charging time of 120 minutes.

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The capacity of the 12 V 45 Ah battery (540 Wh) minus 251.18 Wh remains 288.82 Wh or approximately 54% left. The battery condition is full, then the SOLAR POWER PLANTbattery can be used to charge 2 hp batteries as much as 1x charging and can be added to charge 1 hp battery again as much as 1x charging only, because SOLAR POWER PLANTbattery power cannot be used all until the battery is empty, this will affect the quality and lifespan.

IV. Conclusion

Based on the test results, it is found that the solar panels used have been working normally, especially when the weather is sunny. The panel installation has also been arranged in parallel to maximize the absorption of heat energy from the sun.

From the observation results, two solar panels require a long time to fully charge the battery for 3.95 hours with an average current of 6.78A. The inverter test measurement results also show optimal function.

The design of this bench is done to provide convenience for users to charge their devices in open spaces. Battery testing for charging is done by testing two Smartphones with each battery capacity of 5000 mAh. The charging terminal of the solar cell-powered outdoor charging bench can be used to charge 2 Smartphones for 120 minutes for one charge. The charging starts when the Smartphon battery is empty until it is fully charged. This outdoor bench battery can still be used to charge one more Smartphone calculated from the battery capacity after charging 2 smartphones before. but it is not recommended to use it when the solar bench battery indicator is below 10%.

Suggestions that can be given are the need for testing solar panel systems in other weather conditions. This research only tests the solar panel system during sunny weather, so it is not certain whether the panel will work optimally when the weather is cloudy or rainy.

In addition, charging tests on other devices such as tablets and laptops are also needed to improve the quality of outdoor charging benchs.

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