Design and implementation of a solar integration in electric smart bench

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Abstract. Energy problems that hit the world have implications for savings in all fields, including lighting public spaces. However, lighting conventional public areas is an inappropriate step because the monthly electricity costs required are already very expensive. This paper proposes new solutions for alternative sources of electrical energy in open spaces. We validate this solution by implementing a solar cell in a park bench object. The experimental results show that the proposed solution has the same performance as conventional lighting. Electric park benches can operate longer by using a solar cell with an output power of 26.76 Watt-peak hours. With the enormous potential of solar power, the application of solar cells in an open environment is very suitable. With this electric bench, it is still energy efficient and green energy.

1. Introduction

Energy problems that hit the world have implications for savings in all fields [1]-[2]. Renewable energy sources continue to be developed as an alternative energy source instead of depleting fossil energy [3]. One of them is a power plant with solar cells that use solar energy heat sources [4]-[5]. One implementation of solar cells (Photovoltaic) is a source of electricity in public open space facilities that require electrical energy [6]. The problem of providing a source of electricity for facilities in the park requires a budget calculation of billions of Rupiah [7] and the use of PLN electricity is still a lot of seethes than if the electricity supply from PLN is cut off, there is no alternative source to replace. So it becomes a condition that causes an energy crisis [8]. So far, the use of solar energy has only focused on garden lighting, with a system that has not been integrated to regulate the source of electrical energy automatically [9]-[10].

Aromal, et al. [11] have designed an electric chair using solar cells. In this study, they have revealed that solar cells can generate electric power for electric chair operations. Arif, et al. [5] have revealed that solar cells can convert solar energy into light energy, which is used to produce lighting in open spaces during the day. Meanwhile, research [6] has optimized the green open space garden with renewable energy. This research is a reference development [5][6]-[11], making a park bench with photovoltaic power and implementing an automated lighting system, and adding features of a mobile phone charging station.

In this paper, we propose an alternative solution based on the design technique and prototype of a powered park bench using a solar cell. The solution a source of electricity for LED lighting systems
and mobile phone charging stations using Photovoltaics to save electrical energy. We try to develop research with a focus on adding the analysis of the power generated by solar cells to meet the electrical energy needs of each load. We then test the solution in a public open space involving a charge station and an LED light in a park bench object.

2. Methodology

This study discusses the use of solar energy as an alternative source of electrical energy to operate an open space park bench. The method we propose is to experiment with the output power of the solar cells measured under the conditions of the placement position (absorption angle) of the solar cell towards the fixed earth. Next, we describe the variables under study, current, voltage, and power, and we measure the illumination of solar radiation as is based on the variation in the time it takes [12]. We carried measurements out on July 30, 2020, at a location in Balikpapan City Three Generation Park in Figure 2c. We carried the data collection technique out by measuring using a digital AVO meter and Lux meter measuring equipment. We then include the measurement results in the experiment on the table [13]. The first step before measuring the environmental parameter variables is to make the physical structure and set-up of the solar cell electric bench by completing the electrical installation. The materials used are Polycrystalline Solar Panel 20WP 12v 1A, VRLA Battery 12V 18Ah, Step Down Regulator 12v to 9v, Solar Charger Controller 12 / 24v 10A, Arduino Uno DIP version, LCD 16X2 IIC, Relay Module 5VDC / 250VAC 10A, LDR Sensor, 12V 90mA LED strip. Then, after the entire physical building of the solar-powered park bench is completed, then we carry out the testing and measurement parameters needed in Figure 1.

![Figure 1. A flowchart diagram for our proposed method.](image)

We carry this data collection out every 10 minutes with the data taken in the form of current and voltage and power generated. We get current and voltage values using a multimeter. Meanwhile, the power calculation uses the equation \( P = V \times I \) [11], and the Lux meter is used to determine the value of light intensity. In the form of tables and graphs, we analyzed all the data, then searched the results of the experiment for the average value for each parameter produced on park bench objects by the circuit system.
3. Result and Discussion

The design of a park bench based on the solar cell in Figure 2a was designed using the Sketchup Pro 2020 application with the physical specifications for length 110 cm, width 60 cm, and height 55 cm with bench material made of iron. We store the electronic circuit Figure 2b under the solar panel in the middle and protects it using glass resistant to heavy pressure when people sit on the bench. Besides that, the electronic components are guaranteed to be sealed and safe from water when it rains. In the automation system, we use Arduino Uno to control the LED, and USB output load in Figure 2b. When the light intensity from the LDR sensor detects a value below 60 Lux, the light will automatically turn on by controlling the first Relay switch and when the battery is below 15%, the charging features and light will automatically disconnect and cannot be used by controlling the second and first Relay. Features will be reusable when the battery is charged up to 30%.

| Battery $> 15\%$ | Battery $\leq 15\%$ |
|-------------------|-------------------|
| Light $> 60$ Lux  | LED = OFF         |
| USB = ON          | LED = OFF         |
| Light $\leq 60$ Lux | LED = ON         |
| USB = ON          | USB = OFF         |

Table 1 shows the simulation results of two loads that show the battery percentage is very influential, while the LED load is affected when the battery is sufficient, and the light is less than equal to 60 Lux. From our experimental results, our proposed method shows that the LED turns on when the light intensity is below 60 Lux and off when the light intensity is above 60 Lux, then the USB will function as a charge when the battery is above 15%.

![Figure 2](image-url)  
**Figure 2.** (a) The front (b) system diagram, (c) of the smart bench, (d) part of the graphical user interface

Testing of park bench components is divided into two parts, namely solar panel testing and load circuit testing. We tested the performance of the solar cell in a park bench object for 1 hour by placing...
the object in the public space of Taman Tiga Generasi, Balikpapan City in Figure 2c. The first condition is during the day at 12:30 - 13:30, while the second condition is at 20:00 - 21:00. We collect current and voltage data every 10 minutes. The results of the experiment in Table 2 show that during the trial process, all solar cell circuits were functioning properly. This shows that performing the solar cell circuit system works well to produce current and voltage in daytime conditions, but the performance is not optimal at night. While we get the Watt value using the equation $P = V \times I$ for each take, so that the average Watt for 1 hour of testing the object is got.

### Table 2. Performance of solar cell circuit

| Time Trial     | Average Voltage value | Average Current Value | Watt   |
|----------------|-----------------------|-----------------------|--------|
| 12:30–13:30    | 13.57 V               | 1.88 A                | 26.76  |
| 20:00–21:00    | 0.12 V                | 0.01 A                | 0.0001 |

Table 2 shows the performance of solar panels with optimal conditions achieved by obtaining current and voltage parameters. The results are shown for the comparison of solar cell efficiency and battery charging characteristics as a source of electrical energy to the electrical system on the bench object. We carried our test out by connecting the solar charge controller with the 20 WP solar cell and two 12 Volt 18Ah batteries in series. The test results show the difference in Watts per time to take the efficiency value. The calculation result shows the highest value at the time (12: 30-13: 30) for daytime conditions, so the solar cell can generate electrical power. These results are in line with research [5] that solar cells function optimally during the daytime. The implication of the results of this study on saving electricity for public open spaces by integrating the object of open space facilities in this study is a park bench object. We use renewable energy sources through solar cells as an alternative energy source to replace the dwindling fossil energy. The problem of providing a power source for facilities in the park has been resolved. So it becomes a situation that can increase the efficiency of electrical energy with the support of solar cell technology which we integrate with the object of a park bench which has a dual function, namely as a source of electricity for automated lighting.

Finally, we tested the entire set of park bench objects during the day and night for 1 hour each to find the effectiveness of solar panel charging and the condition of the features on the object. The test results are presented in Tables 3 and 4, respectively.

### Table 3. Performance of the smart bench during the day (12:00 – 13:00) pm

| No | Time Trial | Voltage | Current | Battery percentage | Condition LED | Condition Charger |
|----|------------|---------|---------|--------------------|---------------|-------------------|
| 1  | 12:00      | 13.3    | 0.9     | 98                 | OFF           | ON                |
| 2  | 12:10      | 13.3    | 0.9     | 98                 | OFF           | ON                |
| 3  | 12:20      | 13.4    | 0.91    | 98                 | OFF           | ON                |
| 4  | 12:30      | 13.4    | 0.92    | 98                 | OFF           | ON                |
| 5  | 12:40      | 13.4    | 0.93    | 98                 | OFF           | ON                |
| 6  | 12:50      | 13.4    | 0.93    | 99                 | OFF           | ON                |
| 7  | 13:00      | 13.4    | 0.93    | 99                 | OFF           | ON                |

### Table 4. Performance of the smart bench at night (20:00–19.00) pm

| No | Time Trial | Voltage | Current | Battery percentage | Condition LED | Condition Charger |
|----|------------|---------|---------|--------------------|---------------|-------------------|
| 1  | 19:00      | 0.1     | 0.01    | 72                 | ON            | ON                |
| 2  | 19:10      | 0.1     | 0.01    | 72                 | ON            | ON                |
| 3  | 19:20      | 0.1     | 0.01    | 72                 | ON            | ON                |
| 4  | 19:30      | 0.1     | 0.01    | 71                 | ON            | ON                |
| 5  | 19:40      | 0.1     | 0.01    | 71                 | ON            | ON                |
| 6  | 19:50      | 0.1     | 0.01    | 71                 | ON            | ON                |
| 7  | 20:00      | 0.1     | 0.013   | 71                 | ON            | ON                |
Tables 3 and 4 show that the voltage and current at night are very inefficient for charging solar panels compared to during the day. Our experiments show that the LED works in dark lighting conditions only. While the charged condition will continue to function if the battery is above 15%. This can apply to the drastic changes in day and night lighting. However, changing this condition will not cause much error when this park bench is applied. The test results also got light intensity for daytime and nighttime conditions in Figure 2b. This shows the light sensor on the object is functioning in Figure 2d. The current and voltage values show that the solar cell is stable at low or high threshold values. Thus, the proposed park bench can handle different lighting conditions to function within a reasonable range as a dual function object.

4. Conclusion
This paper presents the basic resources needed for manufacturing solar cell-based park benches as a source of electricity in open spaces. We created the bench model with solar cell electricity for independent modification and manufacture. We showed the importance of making garden benches with solar cell electricity to identify the potential for renewable energy.

The experimental results show that the load on the solar cell electric bench depends on the percentage of the battery in the automatic system. We make garden benches out of aluminum to support electronics (cables, sensors, etc.). Also, we combined the charger station with the bench to get objects that double. In doing so, we could achieve our goal of creating a portable park bench that can serve as a charging station.

Further work could be done on improving the improved bench resistance test method to identify areas for improvement, the use of solar panels with larger peak wattages.

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