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Designing Street Lighting Using Dry Battery-Based Solar Energy Case Study: East Bogor Taqlim Council

Wawan Gunawan [1*], Lilis Cucu Sumartini [2], Irfan Fauzi [3]
Akademi Teknologi Bogor
Jl. Bina Marga No.17, RT.05/RW.08, Baranangsiang, Kec. Bogor Tim., Kota Bogor, Jawa Barat 16143, Indonesia

ABSTRACT

The use of solar panels as an alternative energy to replace generators and conventional electricity as a necessity in addition to being environmentally friendly, solar panels also do not require expensive maintenance like the use of generators. In addition, solar panels are also suitable for use in regions of Indonesia that have a tropical climate and have a hot temperature that is sufficient for the use of solar panels. Based on the description above, the purpose of the study is to find out how much electrical energy is generated from the design of street lighting using dry battery-based solar energy in the East Bogor Taqlim Assembly. The research method used is quantitative research in the form of case studies based on empirical studies by analyzing and collecting data in numerical form (numbers). The results of the study show that the higher the irradiation value of sunlight, the higher the opencircuit voltage produced. During the measurement of 19/09/2022 from the From 08.00 to 16.00, the average solar irradiation is 251 W/m2 with an average opencircuit voltage of 5.68 V. The highest solar irradiation of 705 W/m2 and the highest opencircuit voltage of 7.17 V occurred at 12.00. Meanwhile, the lowest solar irradiation of 152 W/m2 on 20/09/2022 at 15.00 and the lowest open circuit voltage of 6.00 V occurred at 10.00 on 20/09/2022. The voltage value of the open circuit is proportional to the value of solar irradiation. Solar irradiation rarely reaches 1000 W/m2 as in peak conditions, because it begins the rainy season.
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***Corresponding author:** wawan.11maret2018@gmail.com*
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Introduction

Solar energy is an energy source that will never run out of availability and this energy can also be used as an alternative energy that can be converted into electrical energy, using solar cells. Solar cells since the 1970s have changed the way we look at energy and provided a new way for humans to obtain electrical energy without the need to burn fossil fuels as in petroleum, natural gas, coal, or nuclear reactions.

Solar cells are also able to operate well in almost all parts of the earth that are illuminated by the sun without producing pollution that can damage the environment so that it is more environmentally friendly. The way solar cells work is by utilizing the theory of light as a particle, as it is known that light, both visible and invisible, has two properties, namely it can be as a wave and can be as a particle called a photon. This invention was first revealed by Einstein in 1905. Photons can be seen as energy particles or as waves of a specific wavelength and frequency.

Indonesia is on the equator which makes our archipelago illuminated by sunlight for 10 to 12 hours a day. The use of solar energy sources is very supportive in this tropical archipelago, it's just that in 10 or 12 hours not everything is in a sunny state, sometimes the weather is often unstable in the sense of cloudy, cloudy, and rainy conditions. Conditions like this optimal energy absorption in one day will not even reach the full 10 hours, therefore average data is needed and how long is the optimal maximum solar energy absorption in each day for planning the load to be installed so that the use of electricity is optimal and there is no blackout or battery discharge that is too fast due to the installed load that is too excessive.

Technological developments in a short period of time have experienced very rapid progress. Solar power technology that was once widely used by large companies is now starting to be used for housing and street lighting needs. As described above, solar power is an alternative energy that is very environmentally friendly and harmless to humans.

The use of solar panels as an alternative to replacing generators and conventional electricity as a need, in addition to being environmentally friendly, solar panels also do not require expensive maintenance like the use of generators, besides that solar panels are also suitable for use in Indonesian regions that have a tropical climate and have a sufficient hot temperature for solar panel use.

Based on the description above, the problem can be formulated, namely, how effective is the design of street lighting using dry battery-based solar energy.

The purpose of the study is to find out how much electrical energy is generated from the design of street lighting using dry battery-based solar energy in the East Bogor Taqlim Assembly.

Public street lighting is an artificial lighting that illuminates a certain area in a certain area. Public street lighting is a vital facility that is urgently needed by the community. Public Road Lighting (PJU) is needed to improve traffic safety, driving safety, especially at night with the existence of PJU can make road users more careful and feel safe on their way so that they can avoid criminal acts. Ronald V. Clark said that better lighting Will deter offenders who benefit from the cover of darkness or in Indonesian, good lighting will prevent perpetrators who take advantage of the darkness at night.

Light Emitting Diode or often abbreviated as LED is an electronic component that can emit monochromatic light when given an forward voltage. LEDs are a family of diodes made from semiconductor materials. The colors of light emitted by LEDs depend on the type of semiconductor material they use. LEDs can also emit infrared light that is invisible to the eye as we often encounter in TV Remote Control or Remote Control of other electronic devices. This project uses LED lights for the type of lighting, on the grounds that it is more energy-efficient and has a long service life so that it is suitable for solar energy-based street lighting systems. The LED lamp used is a 12V 5 Watt DC LED lamp. so that in operation there is no need for an inverter to convert the DC current from the solar cell to the current. Air conditioning that requires lights, this is done as an investment cost saving.

A solar cell is an electronic component that can convert solar energy into electrical energy in the form of direct current (DC). Solar electricity is generated by a component called a solar cell that is about 485x360x 25 mm square. This component confirms the energy from sunlight into electrical energy. Solar cells are vital components that are generally made of semiconductor materials. The electrical power produced by one solar cell is very small, so several solar cells must be combined to form a unit of components called modules.

A solar panel is a diode formed from 3 top layers of n-type silicon (silicon doping of solar cells is produced from semiconductor materials, namely silicon which acts as an insulator at low temperatures and as a conductor when there is energy and heat. A "phosphorous" solar cell), and a

silicon-type underlayer (silicondoping of "boron"). Free electrons are formed from photon millions or atomic collisions in the connecting layer (junction = 0.2-0.5 microns) causing an electric current.

Figure 1. Solar Panels

The battery used in the PJU is 12 volts. VRLA type with 7 AH. VRLA Gel or VRLA AGM type Deep Cycle Battery is a very suitable and most widely used type of battery, for solar panel systems both PJUTS (Solar Public Street Lighting), SHS (Solar Home System), Solar Power Plant (Solar Power Plant), and so on.

Figure 2. YUASA NP7-12 Battery 12V,7.0Ah

These batteries are often called sealed lead acid batteries or sealed maintenance free batteries. Physically this type of battery is protected and sealed. What appears from the outside is only positive (+) and (-) negative terminals.

Designed so that the electrolyte fluid does not decrease due to leakage or evaporation, this type of battery has a vent valve that only opens at extreme pressure for the exhaust gas resulting from the chemical reaction.

Since there is no valve to refill the electrolyte fluid, this battery is also known as a maintenance free battery. Light Dependent Resistor or abbreviated as LDR is a type of resistor whose resistance value or resistance value depends on the intensity of the light it receives. The LDR Resistance value will decrease during bright light and the Resistance value will be high if it is dark. In other words, the function of LDR (Light Dependent Resistor) is to conduct an electric current if it receives a certain amount of light intensity (Light Condition) and inhibits the electric current.

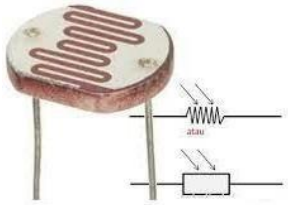

Figure 3. Light Sensor or LDR

In general, PJU poles are an important element in the structure of public street lighting, which is the place where public street lighting lights are supported. Pole is a component of the distribution of Solar Power Plant and also a component for public street lighting (PJU), both conventional (PLN) and Solar Power PJU (LPJ-TS). There are various pole models that are adjusted to specifications and needs.

Indoor panel boxes have a very important role and function because they function to maintain safety in the event of a disruption in the flow of electricity, besides that the box panel is useful for protecting the electrical panel from damage, whether it is intentional or unintentional. Indoor panel box to store and protect the Battery Charger and Solar Charger Controller from rain and the heat of the sun, therefore it is designed to be stronger and sturdier, not easily destroyed and high quality. The goal is that in its operation there are no errors and of course ensure the safety and comfort of its use.

Research Method

The method that will be used in this study is a quantitative method by conducting a case study and using the following steps:

1. Literature and literature study stage

   At this stage, the search for theoretical sources related to the design and manufacture of the system and several other literature that supports the process of working on the final project is carried out.

2. System Planning

   At this stage, a design of tools and other supporting components is carried out and a general system design is also made using a block diagram and then elaborated again in more detail.

3. System Testing and Analysis Stages

   At this stage, the system is tested based on the design that has been done previously and then continued with analysis to get the results that we process in the form of the required numerical data and to ensure that each component that is designed works well without any errors (Errors).

4. Report Creation Stage

   At this stage, the final project preparation stage and documentation are carried out starting from each stage of the process above in the form of writing a report containing theory to the final result of this research.

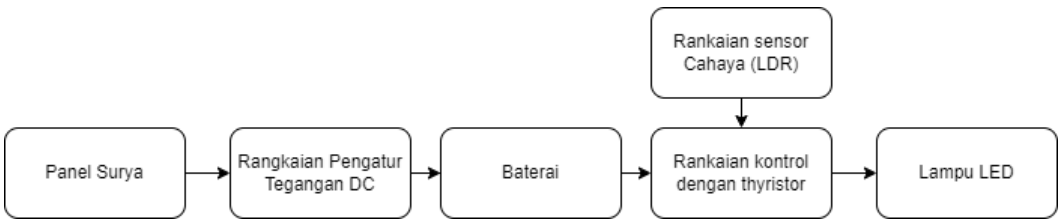

Figure 4. Installation Flow of Solar PJU Lights

Result and Discussion

The increasing demand for electricity in Indonesia must be accompanied by an increase in the electrification ratio. Indonesia's electrification ratio in 2018 was 95.15%. For the Indonesian region, based on solar irradiation data that collected from 18 different locations, solar radiation in Indonesia can be classified consecutively as follows: for the western and eastern regions of Indonesia with an irradiation distribution in the Western Region of Indonesia (KBI) of around 4.5 kWh/m2/day with a monthly variation of about 10%; and in the Eastern Region of Indonesia (KTI) around 5.1 kWh/m2/day with a monthly variation of around 4.8 kWh/m2/day with a monthly variation of around 9%.

The intensity of sunlight in the area is relatively good so that it is possible to install solar street lights. Several roads leading to the village have solar PJU lights. But according to local residents, the lights have not worked for a long time. Based on the team's observations, the standing solar PJU lamp could not work because the battery (battery) was not there.

In the design of the system, solar panels are used as a power source for charging the battery, There is a series of controllers using Thyristor (SCR) which makes the output of the solar panel stable at 13V DC, then electrical energy will be stored in a battery with a capacity of 7Ah. And there is a light sensor circuit that will detect the intensity of light in the surrounding environment, the signal from the light sensor circuit will be sent to the control circuit which will control from the load/LED lamp.

The designed device is focused on emitting light when the surroundings start to darken. Devices made using solar panels as a source of electrical energy charging, LDRs are used as the main components of light sensors and thyristors as components of control circuits, as well as led lights as loads and lighting sources. The components used are:

a. Solar Panels used on devices made using 20WP solar panels
b. Thyristor 2N3055 25A based voltage regulator circuit

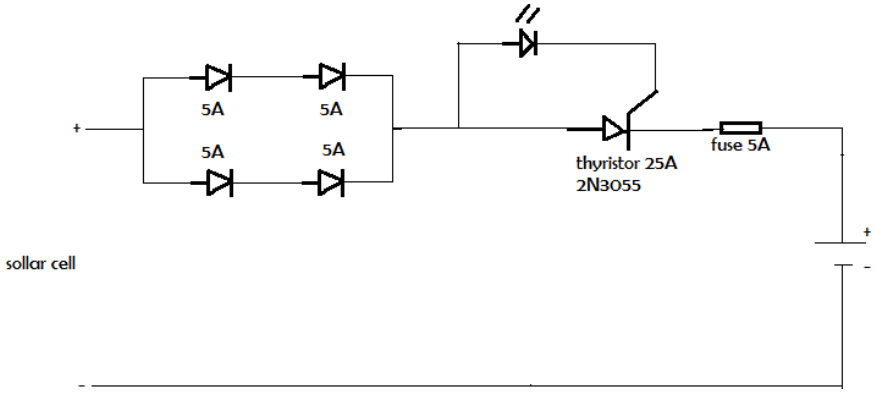

Figure 5. Thyristor 2N3055 25A based voltage introduction circuit

Component:
Diode = 5 A
Thyristor 2N3055 = 25 A
Fuse = 5A

c. Battery as a storage place for electrical energy of 9Ah
d. LDR-based light sensor range

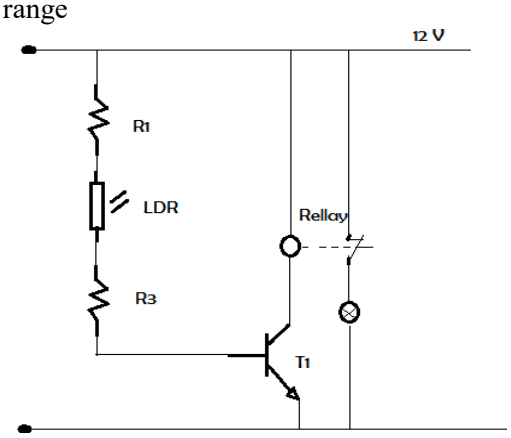

Figure 6. LDR-based light sensor range

Component:
R1 = 4.7 Kohm
R2 = LDR
R3 =4.7 Kohm
T1 =2N3055
Rellay =12 volts DC

e. 12V 5 Watt Lamp

The architectural needs of the device made consist of several electrical components that have been mentioned in chapter I as well as the object being studied, namely public street lighting. The tools needed are:

1. Solar Module with 20 WP capacity
2. Lamp LED DC 12 Volt 5 Watt
3. Lamp Case
4. Light poles and Solar Cells
5. Dry Batter 12 V/ 7 Ah
6. Box panel / Controller and cable
7. Sand cement

Technology Control/Testing Analysis can be seen in the following chart:

Figure 7. Control Analysis

The image above explains the flow diagram of how the system works. The first thing that is done is the process of absorbing sunlight by solar panels, then the electrical energy produced will be stored in the battery, then the electrical energy in the battery will also turn on a series of light sensors which will also detect the surrounding light conditions, and if the environmental conditions are bright then the control circuit will disconnect the electricity to the lamp and the lamp will turn off, on the other hand if the ambient conditions are dark the control circuit will connect the circuit electricity and lights will turn on.

Figure 8. PJUTS Structure

Figure 9. Control Panel

Figure 10. Solar Street Lighting of the East Bogor Taqlim Council

The results of the opencircuit test are shown in Table 1.

Table 1. PJUTS System Test Results

Date	Jam	Iradiasi (W/m2)	Voc (V)
19/09/2022	08.00	490	7,00
19/09/2022	09.00	492	7,11
19/09/2022	10.00	520	7,17
19/09/2022	11.00	670	7,08
19/09/2022	12.00	705	7,10
19/09/2022	13.00	534	7,07
19/09/2022	14.00	520	7,27
19/09/2022	15.00	449	6,00
19/09/2022	16.00	251	5,68
20/09/2022	08.00	499	7,00
20/09/2022	09.00	511	7,01
20/09/2022	10.00	454	6,00
20/09/2022	11.00	327	6,90
20/09/2022	12.00	340	6,95
20/09/2022	13.00	280	6,87
20/09/2022	14.00	195	6,90

20/09/2022	15.00	152	6,80
20/09/2022	16.00	155	6,70

From the table above, it can be explained that the design of dry battery-based street lighting located in the East Bogor Taqlim Assembly is considered effective, based on the data, the higher the value of solar irradiation, the higher the electrical energy produced. During the measurement on 19/09/2022 from 08.00 to 16.00, the average solar irradiation was 251 W/m2 with an average open circuit voltage of 5.68

V. The highest solar irradiation of 705 W/m2 and the highest open circuit voltage of 7.1 7 V occurred at 12.00 pm. Meanwhile, the lowest solar irradiation was 152 W/m2 on 20/09/2022 at 15.00 and the lowest open circuit voltage of 6.00 V occurred at 10.00 on 20/09/2022. The voltage value of the open circuit is proportional to the value of solar irradiation. Solar irradiation rarely reaches 1000 W/m2 as in STC conditions, because it starts the rainy season.

a. Light intensity measurement I = φ W
   I = 4500 4MI = 358.3 cd

b. Light Efficiency K= pxl h (p+l)
   K= 40 x 13 7 (40+13)
   K= 40 x 13 7 (40+13)
   K= 1.401

   So that Kmin = 1.3 and Kmax = 1.5
   So the efficiency of the table with rp = 0.7, rm = 0.1 and rw = 0.5 :ŋ= ŋmin K−Kmin Kmax−K (ŋmax − ŋmin)
   ŋ= 0.42 1.401− 1.3 1.5−1.401
   (0.48 − 0.42)
   ŋ= 0.025

   So the flux of the armature,
   $\emptyset B = \eta \; x \; \emptyset o$ = 0,025 x 4500 = 115.69 $lumen$

c. Light Efficacy K = φ P
   = 4500 43
   = 104.65 lm/watt

To get maximum results in the use of solar power, it is necessary to pay attention to various aspects, such as installation points, pole heights, and other supporting components.

A battery is said to be normal if the current stored in the battery should not be drained. more than. 25% up to DOD (deep. of discharge) = 100 % - 25 % = 75 %. Load reserve is the power reserve for the load (LED light). If the weather is cloudy in one day, when the solar cell cannot receive sunlight, it is usually made a backup for the load in one day.

Maintenance and repair of the use of PJUTS is very easy and cheap. Maintenance is only given about once every 6 months by checking the control panel or battery. The obstacle that can occur is if there is a PJUTS disturbance caused by a short connection, the peeling off of the main cable network.

Conclusion

Based on case study research conducted at the East Bogor Taqlim Council, the design of street lighting by utilizing dry battery-based solar energy can be concluded that:

- The higher the value of sunlight irradiation, the higher the voltage of the open circuit produced. During the measurement on 19/09/2022 from 08.00 to 16.00, the average solar irradiation was 251 W/m2 with an average open circuit voltage of 5.68 V. The highest solar radiation of 705 W/m2 and the highest open circuit voltage of 7.1 7 V occurred at 12.00 pm. Meanwhile, the lowest solar irradiation of 152 W/m2 on 20/09/2022 at 15.00 and the lowest open circuit voltage of 6.00 V occurred at 10.00 on 20/09/2022.
- The voltage value of the open circuit is proportional to the value of solar irradiation. Solar irradiation rarely reaches 1000 W/m2 as in STC conditions, because the rainy season begins.
- The battery is said to be normal if the stored current in the battery should not be drained by more than 25% so that the DOD (deep. of discharge) = 100 % - 25 % =75 %.
- The disturbances that arise are caused by a short circuit, peeling off the main cable network and damage to the lamp housing or other components in the PJUTS.

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