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Effect of fresnel lens distance on the output power of the power plant solar-based electricity transistor 2N3055

Akbar Nugraha [1], Caroline [1], Ike Bayusari [1] , Rahmawati [1], Hermawati [1]
[1] Department of Electrical Engineering, Universitas Sriwijaya, Jl. Raya Palembang Prabumulih KM 32, Indralaya 30662, Indonesia

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ABSTRACT

Developments in the human life sector have progressed rapidly today, paralleled by the continuous advancement of technology. This trend is expected to significantly elevate the demand for electricity as one of the primary requirements. Currently, power plants heavily rely on petroleum as their main fuel source for electricity generation, contributing to environmental unfriendliness. In response to this, renewable energy has emerged as a viable solution to reduce dependence on petroleum fuel. One notable example of renewable energy is solar power, harnessed through Solar Power Plants. Research has been conducted to develop a transistor-based solar power plant using the 2N3055 model, with three variations in the distance of the Fresnel lens: 5 cm, 10 cm, and 20 cm over 14 days. The research yielded the highest output power, with an average voltage value of 13.868 V and a current value of 0.000038 A recorded on the 13th day. The power value reached 0.0005199 W on a prototype with a lens distance of 5 cm on the 14th day of research. This phenomenon occurs during sunny environmental conditions, leading to the transistor producing higher voltage and current due to focused light. However, different lens distances can result in improper focusing of light or even prevent light from reaching the transistors altogether, causing suboptimal electricity production or no production. Therefore, the influence of different Fresnel lens distances affects the light focusing on the transistor, consequently impacting the overall power output value.

Corresponding Author:

Caroline, Department of Electrical Engineering, Universitas Sriwijaya, Jl. Raya Palembang Prabumulih KM 32, Indralaya 30662, Indonesia
Email: caroline@ft.unsri.ac.id

1. INTRODUCTION

Developments in the human life sector have been rapidly progressing nowadays, undoubtedly followed by the continual evolution of technology, which has caused electricity to become one of the primary and increasing needs. Currently, power plants still heavily rely on crude oil as their main fuel source to produce electricity, resulting in environmental unfriendliness. Renewable energy is expected to be a solution to reduce the use of crude oil as a fuel source. One feasible solution is to create power plants that harness existing heat energy. However, the cost of solar power plants, in the form of solar panels, is still relatively high to purchase at the moment. One alternative that can be considered is building a power plant using the 2N3055 transistor, which is readily available and more affordable than solar panels. Several studies have been conducted on the creation of power plants using transistors [1] [4] [7]. However, the results obtained from the constructed power plant can still be optimized with supporting components. Based on these findings, the author aims to further develop the research by incorporating Fresnel lenses to better harness solar energy in the form of heat and light, with the goal of generating greater energy output.

The structure of this paper is as follows: Section 2 provides a method. Then, Section 4 outlines the results and discussion. Finally, the conclusion is summarized in the last section.

2. METHODS

The location chosen for the design, manufacturing, testing, and data collection on the equipment was the Energy Conversion Laboratory, Electrical Engineering Department, Universitas Sriwijaya. The research spanned from September 2022 to March 2023, involving the initial stages of research planning and conceptualization. This was followed by literature studies in books and journals, proposal writing, tool design, tool fabrication, data collection, analysis, and drawing conclusions (Fig. 1).

2.1 Research Flow Diagram

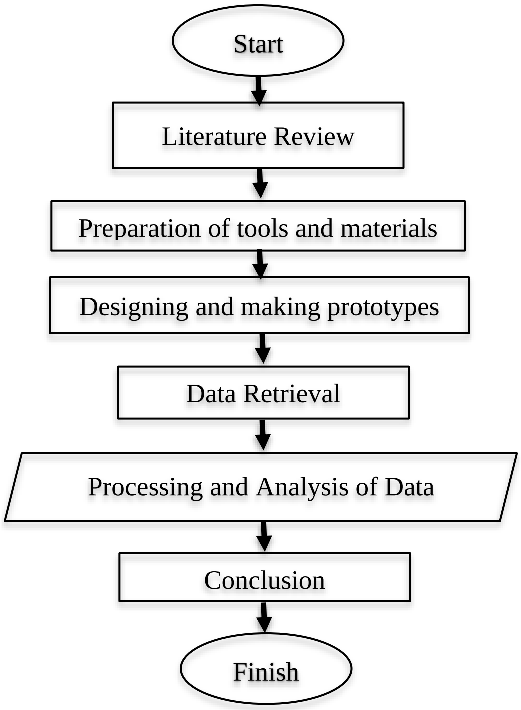

Fig. 1. Research flow diagram

2.2 Research Tool Design

In the design of a solar power plant intended for use in a sterilization machine, polycrystalline solar panels are employed (Fig. 2). Solar cells are technological components used to convert energy in the form of solar radiation into electrical energy [2]. Currently, solar cell technology is widely employed in various fields, including electricity generation, battery charging, and street lighting. These solar cells consist of two types of semiconductor links: type P (positive) and type N (negative), working together to create and produce an electric field.

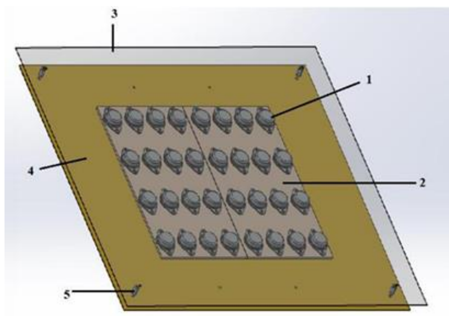

Fig. 2. Research tool design

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2.3 Data Retrieval Scheme

It can be seen in Fig. 3. The following is a research data collection scheme. As shown in Fig 3, 1 represents fresnel lens, 2 is transistor circuit, and 3 is multimeter. A transistor is a semiconductor component with p and n-type properties, resembling two diodes combined, and equipped with three pins or legs: Emitter (E), Base (B), and Collector (C) [3]. Classified based on the type of electrically conducting charge, there are now only two types of transistors: unipolar and bipolar. Electric charge in a bipolar transistor is transported through the movement of electrons and holes. Bipolar transistors come in two varieties, NPN and PNP, depending on the composition of the materials used [4]. The PNP transistor, one of the two types of bipolar transistors, operates when bias is applied to the emitter-base and collector-base sections. Forward bias at the VEE terminal allows most of the current to flow through the P-type semiconductor (holes), progressing through the junction to the collector. A smaller portion of the N-type semiconductor's regular current (electron entry) is carried to the collector and base junction due to the reverse bias at the VCC terminal. This type of bipolar transistor, denoted by the letters N and P, is used to indicate charge carriers in different regions within the transistor. NPN is a frequently used transistor type because the movement of electrons inside a semiconductor is much higher than the movement of holes, enabling it to operate at high currents and speeds

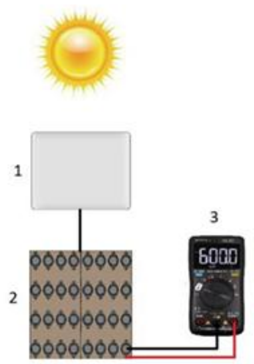

Fig. 3. Test scheme

Transistor works when there is no external bias voltage applied to the transistor terminals, no current will flow, and all current values will be zero. Similar to the diode connection, both the connection between the emitter and the base and the connection between the base and the collector have depletion regions. If the barrier voltage at each connection is observed. The 2N3055 transistor is an NPN-type transistor that is commonly used in amplifiers, especially in final reinforcement, and it can also generate electrical energy when exposed to light. The working principle of the 2N3055 transistor in electricity generation is similar to solar cells in general, which utilize sunlight with an average voltage of 0.4 - 0.6 Volts [5]. This voltage is higher than that of the MJ2955 transistor, which only produces 0.1 - 0.2 V [6]. The 2N3055 transistor, being an NPN bipolar transistor with type N and type N material links, serves as a simple semiconductor link, similar to the working principles of general solar panels.

Another component needed in the test scheme in Fresnel lenses. They are plastic lenses with a focal point made of plastic material, possessing a geometric structure capable of focusing light. Currently, the use of Fresnel lenses is often the preferred choice for concentrating solar energy. Plastic Fresnel lenses offer several advantages, being stable polymers with optical properties similar to glass, clear, lightweight, highly producible, cost-effective, and efficient in increasing energy density [7]. Specifically, the Fresnel lens made from plastic, commonly known as PMMA (polymethylmethacrylate), exhibits a refractive index of 1.49, comparable to glass. This material ensures stable temperatures of at least 80°C and is resistant to sunlight [8].

The purpose of using the Fresnel lens is to optimize the light entering the solar panel. Several studies have proven that the use of Fresnel lenses can increase the concentration of incoming light, resulting in enhanced output from solar panels. For instance, in research conducted by Subandi using Fresnel lenses, the power produced on the solar panels increased [4]. Refraction conditions in lenses occur at the surface, with the thickness of the material not affecting refraction [9].

The prototype installation process involves the following steps:

1. Install 32 2N3055 transistors in acrylic using spacers.
2. Connect the 32 2N3055 transistors with a positive base and negative emitter to obtain greater power.
3. Once the circuit is complete, attach the transistor circuit to acrylic as the base.
4. Create 3 PLTS prototypes based on the 2N3055 transistor.

5. Attach the Fresnel lens to the top of the 2N3055 transistor-based PLTS using spacers at distances of 5 cm, 10 cm, and 20 cm.

In this study, there are three electric power, measured in watts, is the amount of energy created, absorbed, or produced in a device's electric circuit per unit of time. The three different types of electric power are active power, reactive power, and apparent power. Active power, also known as real power, is the average power adjusted to the actual power transmitted or consumed by the load. This type of power is associated with useful work such as heat, light, mechanical energy, and other forms. Active power can be formulated as follows:

$$P = V.\ I \cos \varphi \tag{1}$$

where P is active power (Watts), I is current (Ampere), and Cos φ is power factor.
Then,apparent power is the product of multiplying voltage and current. The equation for apparent power is given by the formula:

$$S = V \times I \tag{2}$$

where S is apparent power (VA), V is the voltage (V), and I is the electric current (A). Lastly, reactive power is the amount of power required for the formation of a magnetic field. Reactive power can be expressed with the following equation:

$$Q = V.\ I.\ \sin \varphi \tag{3}$$

where Q is reactive power (VAR), I is current (amperes), and φ is the phase angle [3].

3. RESULTS AND DISCUSSION

3.1. Measurement Result Data

The collection and research carried out had a duration of 14 days, the data measurement time started at 11.00 WIB until 15.00 WIB. The data collection process is carried out by measuring the voltage and current from a transistor-based solar power plant with varying Fresnel lens distances. Voltage and current measurements use a multimeter and current measurements use a resistor as the load. After obtaining the values from the prototype, calculations are carried out to obtain the average values of voltage and current. To find the average value of the prototype, that is by adding the output values obtained and then divide the value by the amount of data obtained in one day of data collection from 11.00 to 15.00 with a collection time once every hour (Table 1).

Table 1. Data from Measurement and Calculation

Day	Voltage			Current (A)			Power (W)		
to	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm
1	12,54	9,946	9,386	0,000022	0,000014	0,00001	0,0002634	0,0001422	0,00009386
2	12,974	11,526	11,122	0,000024	0,000024	0,000022	0,0002672	0,0002786	0,00024802
3	12,966	11,292	11,21	0,000028	0,00002	0,000014	0,0003244	0,0002342	0,00015906
4	12,638	11,332	10,682	0,000036	0,00002	0,00001	0,000335	0,0002273	0,00010682
5	13,052	11,454	11,158	0,000032	0,000018	0,000018	0,000401	0,000209	0,00020656
6	12,116	10,986	10,642	0,000022	0,000016	0,000016	0,0002758	0,0001808	0,0001739
7	12,916	11,116	10,898	0,00003	0,000022	0,000022	0,0003823	0,0002602	0,00025538
8	12,332	10,694	10,298	0,00003	0,00002	0,000022	0,0003529	0,0002325	0,00024998
9	13,616	11,726	11,406	0,000036	0,000018	0,000018	0,0004731	0,0002145	0,00020838
10	11,58	10,804	10,444	0,000022	0,000014	0,000014	0,000252	0,0001538	0,0001510
11	10,564	9,372	8,718	0,000016	0,000010	0,00001	0,0001291	0,0000937	0,0000872
12	13,114	11,582	10,592	0,000034	0,000022	0,000016	0,0004049	0,0002659	0,00017492
13	13,868	11,776	11,326	0,000036	0,000022	0,00002	0,0004175	0,000263	0,00023108
14	13,46	12,37	11,664	0,000038	0,000022	0,000024	0,0005199	0,000271	0,00028238

After conducting research and analyzing data from three prototypes with different lens distances over 14 days (refer to Fig. 4, Fig. 5, and Fig. 6), the obtained measurements include voltage and current values displayed in graphs depicting average voltage, average current, and average power.

Analyzing the experimental data, we observe consistent output values (voltage, current, and power) from devices with the same research duration (14 days) and under similar measurement conditions. However, there are notable variations in voltage and current output daily.

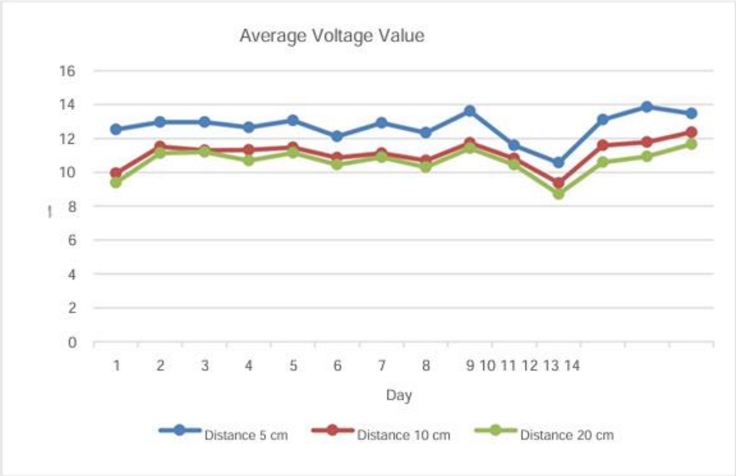

Fig. 4. Average voltage value

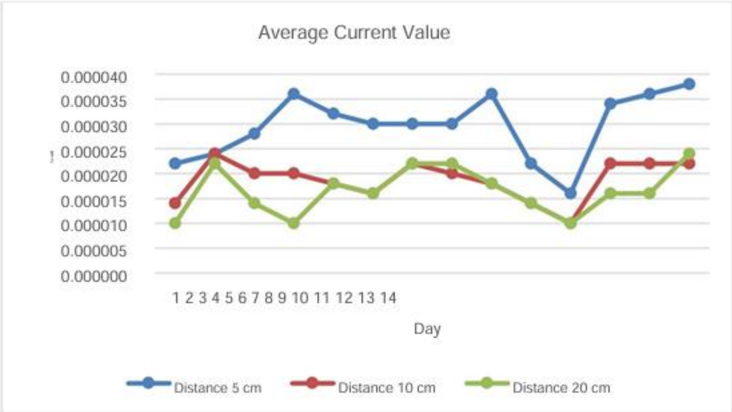

Fig. 5. Average current value

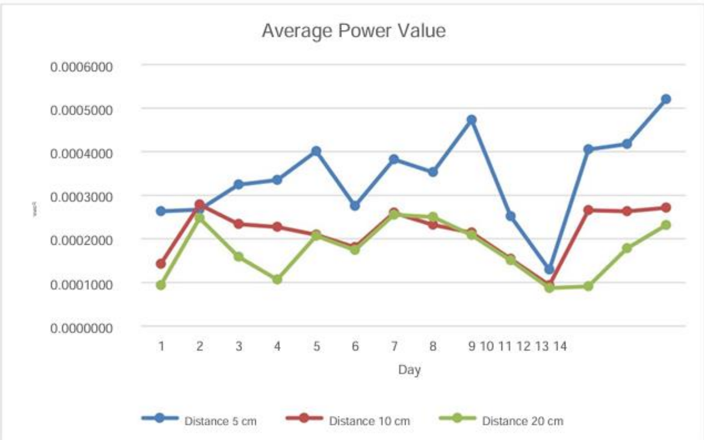

Fig. 6. Average power value

Considering the data, the prototype with a 5 cm Fresnel lens distance exhibits the highest average voltage at 13.868 V, and the highest average current at 0.000038 A. Conversely, the prototype with a 20 cm Fresnel lens distance shows the lowest average voltage at 8.718 V, and the lowest average current at 0.000010 A (observed for both 10 cm and 20 cm Fresnel lens distances). These variations are attributed to differences in light hitting the transistor.

The average power generated by the solar power generator prototype based on the 2N355 transistor varies with different Fresnel lens distances. The 5 cm Fresnel lens distance produces the highest power at 0.0005199 W, while the prototype with a 20 cm Fresnel lens distance produces the lowest power at 0.0000872 W. The disparity in power generation is a consequence of varying light focusing on the transistor.

As known, the transistor converts sunlight into electrical energy, and optimal conditions occur when the light is focused on the transistor. Bright conditions result in higher voltage and current production. However, inconsistent Fresnel lens distances lead to inaccurate light focusing or insufficient light hitting the transistor, diminishing its electricity production. The impact of different Fresnel lens distances on light focusing affects the output power value, resulting in suboptimal power generation at certain distances.

4. CONCLUSION

The research involved the design and testing of a prototype solar power generator incorporating the 2N3055 transistor with an added Fresnel lens, aimed at producing direct current electrical energy. The results revealed distinct variations in output influenced by different Fresnel lens distances. Specifically, the prototype demonstrated an average highest voltage of 13.868 V at a Fresnel lens distance of 5 cm, accompanied by an average highest current of 0.000038 A at the same distance. Conversely, the prototype with a 20 cm Fresnel lens distance exhibited an average lowest voltage of 8.718 V, and the lowest current of 0.000010 A was observed for both 10 cm and 20 cm Fresnel lens distances. These discrepancies in output were attributed to the diverse light hitting the transistor. Additionally, the average power output of the solar power generator prototype, based on the 2N355 transistor, varied with different Fresnel lens distances. The highest power output, recorded at 0.0005199 W, occurred with a Fresnel lens distance of 5 cm, while the prototype with a Fresnel lens distance of 20 cm yielded the lowest power output at 0.0000872 W. These findings highlight the impact of varying Fresnel lens distances on power generation, emphasizing the need for precise light exposure for optimal electricity production.

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BIOGRAPHY OF AUTHORS

Akbar Nugraha was born in Lahat, Sumatera Selatan, Indonesia, in 2001. He received a B.S. degree in electrical engineering from the University of Sriwijaya, Indonesia, in 2023. His research interests include energy conversion. He can be contacted at nugrahaakbar827@gmail.com.

Caroline was born in Muara Enim in 1977. She received her B.S. degree in Electrical Engineering from Universitas Sriwijaya and her M.E. degree in Chemical Engineering in 2011 from Universitas Sriwijaya. Her research interest is in energy conversion. She can be contacted at caroline@ft.unsri.ac.id.

Ike Bayusari was born in Koba in 1970. She received her B.S. degree in Electrical Engineering from Universitas Sriwijaya and her M.E. degree in Chemical Engineering in 2003 from Universitas Sriwijaya. Her research interest is in energy conversion. She can be contacted at ikebayusari@ft.unsri.ac.id

Rahmawati was born in Palembang in 1977. She received her B.S. degree in Electrical Engineering from Universitas Sriwijaya and her M.E. degree in Chemical Engineering in 2009 from Universitas Sriwijaya. Her research interest is in energy conversion. She can be contacted at rahmawati@ft.unsri.ac.id

Hermawati was born in Kota Negara in 1977. She received her B.S. degree in Electrical Engineering from Universitas Sriwijaya and her M.E. degree in Chemical Engineering in 2011 from Universitas Sriwijaya. Her research interest is in energy conversion. She can be contacted at hermawati@ft.unsri.ac.id