The effectiveness of Solar Tracker Use on Solar Panels to The Output of The Generated Electricity Power

Arnold Edward1, Tresna Dewi2, Rusdianasari3*

1Applied Master of Renewable Energy Engineering, Politeknik Negeri Sriwijaya, Jalan Srijaya Negara, Palembang, 30139, Indonesia
email: arnold.edward@pertamina.com
2Electrical Engineering Department, Politeknik Negeri Sriwijaya, Jalan Srijaya Negara, Palembang, 30139, Indonesia
email: tresna_dewi@polsri.ac.id
3Chemical Engineering Department, Politeknik Negeri Sriwijaya, Jalan Srijaya Negara, Palembang, 30139, Indonesia
*Corresponding author: rusdianasari@polsri.ac.id

Abstract. With the aim of optimizing the electrical power output of the solar panels, the solar panels are installed facing perpendicular to the sunlight, then solar panels that can be moved automatically to follow the direction of the sun position. A solar tracker is made PT. Pertamina Plaju RU-3, using 3 units of Solar Power Plant (PLTS) equipped with Solar Tracker, using an actuator that moves solar panels facing the direction from sunrise to sunset. The effectiveness test of the solar tracker on the output power of solar panels is done by adjusting the position 3 unit PLTS against the sunlight, namely at Tracking and Static (Fixed) Position. Arrangements were made in several combinations of positions and measurement of the electrical power output. From the measurement results, obtained a graph that describes the characteristics of changes in output power that are not affected. This is caused by the electrical energy generated by the solar panels only occur optimally from 10 AM until 2 PM. When heading east before 10 AM and west after 2 PM, solar panels absorb solar energy very low. Solar tracker does not increase the efficiency of solar panel power output. Thus the Solar Panel installed in an area close to the equator does not require a Solar Tracker, and it would be better if the solar panel is positioned statically or fixed, with the position of the solar panel facing upright perpendicular to the direction of the sun coming at 12 AM.

1. Introduction

Based on the astronomic location, Indonesia would be between 6° N - 11° S and 95° E - 141° E, traversed by the equator so that the gain of sunlight on average 10 hours/day, therefore Indonesia has the potential to harness the energy of sunlight [1-3]. The potential of solar energy in Indonesia is very large, about 112,000 GWp, but has been utilized only around 10 MWp, meaning solar power technology development potential. But unfortunately, this time in Indonesia photovoltaic industry (PV) has been able to do in the downstream stages, namely producing modules / solar panels.

It has been quite a lot of solar cell panels that have been used by a company or society, but the problem is how to install solar panels to obtain the optimum electrical output. In general, the solar cell panel mounted parallel to the ground and facing straight up so that when the solar panel perpendicular field will get the maximum solar radiation by a factor Cosθ, but radiation from the sun will be the smaller position of the sun was not straight anymore.
1.1. Solar Energy
The energy emitted by the sun is only received by the earth at 69% of the total solar emission. The supply of solar energy to the earth reaches 3x10^24 joules/year. This energy is equivalent to 2 x 10^17 W. That amount of energy is equivalent to 10,000 times the energy consumption in the world today [4].

1.2. New and Renewable Energy
According to the National Energy Policy, it is estimated that in 2020 the projection of petroleum consumption will begin to decrease and only reach 25% in 2035. While the increase in primary energy by 23% [5,6].

![Figure 1. Graph of EBT supply projection and EBT contribution ratio [7]](image)

1.3. Solar Power Plant (SPP)
SPP consists of three main parts/sub-system, as follows: [8]
1. Sub-system plant, Solar Module; through the photovoltaic process, serves to transform sunlight into electricity.
2. Sub-System Storage Battery & Regulators; functioning store and regulate electrical current is generated.
3. Sub-distribution system load (LOAD), distribution panels, transmission cables, up to the load electricity were

1.4. Solar Cell
Simply, solar cells consist of semiconductor material p-type and n-type (p-n junction semiconductor) which, when exposed to the sun there will be a flow of electrons is called electricity. The process of converting solar energy into electrical energy is shown in Figure 2 [9].
Figure 2. Solar Energy Conversion Process into Electrical Energy

The main parts of energy conversion of sunlight to electricity is absorber (absorber). Electrons from the conduction band can skip to the valence band when the connection is subjected to photons with a specific energy. The resulting energy level are shown in Figure 3 [10].

Figure 3. Energy Levels Generated by p-n Connection semiconductors

1.5. Solar Module
The solar module has current characteristics against voltage, so to make it easier, an equivalent circuit model is made as shown in Figure 4. a solar module cell can be replaced with a photodiode, and the presence of light radiation will cause current to flow (photo current). The current branching towards the diode, shunt resistance (Ish) and out to the load (IL).

Figure 4. Equivalent Circuit of Solar Module Cells
1.6. Characteristics of Solar Cells
Figure 5 shows voltage and current-voltage characteristics of power and a maximum power voltage of MPP (Maximum Power Point), or the maximum power point voltage and current VMPP, IMPP [11].

![Figure 5](image)

**Figure 5.** Flow & Power Voltage As Characteristics Of Solar Cells

1.7. Solar radiation on Earth's surface
Solar radiation available outside the Earth's atmosphere or often called the solar radiation constant of 1353 W / m². The intensity of radiation is reduced by the atmosphere before reaching the earth's surface as shown in Figure 6 [12].

![Figure 6](image)

**Figure 6.** Highlights Radiation and Radiation Distribution That The Surface of The Earth

With the factors above, causing the radiation received by the earth's surface to have different intensities at all times.

1.8. The Influence of the Angle of Arrival on Radiation
The amount of radiation received by the solar cell panel is affected by the angle of incidence, i.e. the angle between the direction of the ray comes with the component perpendicular to the panel plane. The panel will get maximum solar radiation when the sun is perpendicular to the panel area. When the direction of the sun is not perpendicular to the plane of the panel or forms an angle θ as in Figure 7.
Figure 7. The Angle of Direction of the Coming Rays Towards the Solar Cell Panel.

1.9. The efficiency of The Solar Panel
To get the value of efficiency that occurs in the solar panel, it is necessary to measure the V-I curve which is then obtained by other parameters such as Isc (short circuit current), Voc (no-load voltage), fill factor (FF), efficiency (ƞ), Pm. The output characteristics of the solar panel can be seen from the performance curve; the V-I curve shows the relationship between current and voltage [13].

Figure 8. V-I Characteristic Curve

2. Materials and Methods
Research methods include tracking system/simulation, testing solar panels in a fixed position, testing the effect of the position of the solar panel following the angle of arrival of sunlight, data collection, and data analysis.

The research was conducted at PLTS Pertamina Refinery Unit 3 Plaju and carried out from September 21, 2017, to December 21, 2017, in the span of time when the sun passed on the equator and crossed the farthest distance from the equator. To make the data taken more accurate and comparable, the intensity of the sunlight is also measured.

This research uses several tools as the research object,
1) Solar Module Sky Energy Monocrystalline 250 Wp
2) Inverter Conext RL 3000E
3) Custom – GTI Solar Module Single Axis Tracking System
4) Monitoring System – Schneider Ethernet Box
2.1. Experiment Setup

The study design to the equipment of solar cell panel with a tracking system is described as shown below:

![Diagram showing the schematic design of tools for solar panels with tracking systems.]

**Figure 9.** Schematic Design of Tools for Solar Panels with Tracking Systems

2.2. Functional and Structural Design

The actuator is mounted on a pillar and solar panel frame. Step angle can be achieved by the movement of the actuator is 90°. With this kind of angle, the position of the sun that can be detected is at 8:00 to 09:00 east to the position of the sun at 16:00 to 17:00 west.

![Diagram showing actuator installation and moving direction.]

**Figure 10.** Actuator Installation and Moving Direction

2.3. Research Procedure

Research methods include tracking system/simulation, testing solar panels in a fixed position, testing the effect of the position of the solar panel following the angle of arrival of sunlight, data collection, and data analysis. The test is done by adjusting the position 3 unit PLTS against the sunlight, into the Fix and Tracker position (follow the position of the sun). Settings are made in several position combinations. In each combination of positions, measurements of the electrical power output are done at each PLTS.
When the solar panel in static / Fix, the position of the solar panel is $5^\circ$ tilted eastward to the horizontal so that the water or objects falling above the solar panel can go down. In the tracker position, the actuator is mounted on the support pole and solar panel frame. The angle of the steps that can be achieved by the actuator’s motion is $90^\circ$. With this angle, the position of the sun that can be detected is at 8:00 a.m. to 9:00 a.m. east to the position of the sun at 4:00 p.m. - 5:00 p.m. west.

3. Result and Discussion

Measurements made on PLTS # 1 Trac, PLTS # 2 Fix, PLTS # 3 Trac, shows the difference in output produced between the use of Solar Tracker and Fixed Position (Fix) at an angle of $85^\circ$. The results of the combination of Fix and tracker measurements for 3 days can be seen in Figures 11 and 12 as follows:

![Energy Generated from Fixed and Tracker Solar Panel Position](image)

In Figure 11, it can be seen that the energy from fixed photovoltaic in PLTS # 2 has a larger energy graph than the photovoltaic energy of PLTS # 1 with the tracker. Whereas PLTS # 3 is still in a maintenance condition, so the output power has not been maximized.

From the measurement results as a whole, obtained a graph of data that describes the characteristics of data changes that are not affected by the position of solar panels that use tracker or static. Electrical energy produced by solar panels occurs optimally at 10:00 AM to 14:00 PM. The use of electrical energy from solar panels used to drive the Actuator / Positioner (Solar Tracker), precisely reduces the electricity generated because it must drive the Solar Tracker. In addition, the layout of the adjacent Solar Panel will have a Shading (shadow) effect on other Solar Panels at certain hours.
Figure 12. Energy Production from Fixed and Tracker Solar Panel Position

4. Conclusions
From the research above it can be seen that the electrical energy produced by solar panels occurs optimally at 10:00 AM to 14:00 PM. However, the use of Actuator to move solar panels from East to West and vice versa actually reduces the output of electrical energy for external loads. From the study it can also be concluded, for PLTS that are installed in areas close to the equator, do not require Solar Tracking. It is recommended that the solar panel is positioned statically/fix, with the position of the solar panel facing up, a slight slope for falling water. But if you want to use Solar Tracker, you should move it from North to South with limited movement angles to adjust the position of the sun during certain seasons.

References
[1] Adler, K. H., A. C. Smith, and R. L. Longini. 1964. Introduction to Semiconductor Physics (New York : John Wiley & Sons)
[2] B.G. Yacobi, Semiconductor material; an Introduction to basic principle, Springer 2013 ISBN 0-306-47361-5, pp 1 – 3.
[3] Guarnieri, M (2015), More Light on information : “IEEE Industrial Electronic Magazine. 9 (4): 58 – 61
[4] Palz, Wolfgang (2010). Po frommer orgensen, for the World – Emergency of electricity the Sun. Belgium: Pantanford Publishing. P.6
[5] A.W. Czanderna and G.J. Jorgensen, Renewable Energy Laboratory, Golden, CO. Service Life Time Prediction for Encapsulated Photovoltaic Cells/Minimoduls.
[6] Branker, K., Phatak, M.J.M, 2011, A Review of Solar Photovoltaic Cost of Electricity. Renewable and Sustainable Energy Review. 15 (9): 4470 – 4482
[7] Alata, Mohanad, M. A. Al-Nimr, and Yousef Qaroush. 2005. “Developing a Multipurpose Sun Tracking System Using Fuzzy Control.” Energy Conversion and Management 46 (7-8): 1229–45. doi:10.1016/j.enconman.2004.06.013.
[8] Amin, Nowshad, Md Anwarul Azim, and Kamaruzzaman Sopian. 2008. “Development of Cost Effective Charge Controller with Data Acquisition Options for PV Powered Sensor Nodes.” In
Conference Record of the IEEE Photovoltaic Specialists Conference. doi:10.1109/PVSC.2008.4922822.

[9] Budi Yuwono, 2015, Optimalisation of Solar Cell Panels, Sebelas Maret University, Surakarta: Dalam penelitian ini telah dibuat sistem pelacak Panel Sel Surya dengan menggunakan pelacak berbasis Mikrokontroler.

[10] Karonis, George, 2016-09-24, How All Satellite based GPS Trackers Work, www.Lifeviewgps.com. Retrieved 2017-10-08.

[11] Martini, L, “BSCCO-2233 Multilayered Conductor”, in Superconducting for High Energy Collides, pp 173 – 181.

[12] Rizal, Yusie, Sunu Hasta Wibowo, and Feriyadi. 2013. “Application of Solar Position Algorithm for Sun-Tracking System.” Energy Procedia 32. Elsevier B.V.: 160–65. doi:10.1016/j.egypro.2013.05.021.

[13] Eke, Rustu, and Ali Senturk. 2012. “Performance Comparison of a Double-Axis Sun Tracking versus Fixed PV System.” Solar Energy 86(9): 2665–72. doi:10.1016/j.solener.2012.06.006.