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Effect of Voltage and Efficiency on Solar Panels with Landscape or Portrait Positions at Nurul Azhar Islamic Boarding School, Bengkalis Regency

Fitriadi [a], Berlianti [b], Junaidi Asrul [b], Rahmi Berlianti [b], Taufik Rahmadinata [b]**

[a] *Electrical Engineering Department, Politeknik Negeri Padang, Indonesia*

[b] *Program of Applied Bachelor of Electrical Installation Engineering Technology, Padang State Polytechnic, Indonesia*

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A B S T R A C T

Solar Power Plant (PLTS) is one of the renewable energy solutions that are environmentally friendly. Various methods have been developed to optimize the generation of PLTS. This research discusses the effect of the voltage generated by solar panels with landscape and portrait positions and its effect on the efficiency and practicality of the system. The research method involves analyzing the performance of electricity generated from both mounting patterns, taking into account factors such as sunlight intensity and solar panel positioning. A solar power generation system with a total capacity of 1 kWp was designed to support the operation of a 1 kW AC water pump as the main requirement. The system consists of 5 solar modules of 200 Wp capacity each, a 100 A capacity MPPT charge controller, two battery units of 100 Ah each, and a 1250 watt inverter. The results show that the landscape position of the solar panel is more effective than the portrait position, because using the landscape pattern is superior in a narrow space such as on the roof of a house with high light intensity while the portrait pattern requires a large area with high sunlight intensity.

Keywords: Voltage, Efficiency, Solar Panel, Landscape, Portrait

INTRODUCTION

Indonesia's commitment at the G20 Summit will continue to strive to reduce greenhouse gases by 29% on its own or 41% with international assistance by 2030. And for Net Zero Emission (NZE) in the energy sector is targeted to be achieved by 2060 or sooner [1]. By 2025 Indonesia has announced 23% of its electricity supply from renewable energy, and 28% by 2035 [2]. Geographically, Indonesia has many potential renewable energy sources such as hydro, solar, wind, bioenergy, geothermal and marine. However, these new renewable energy potentials are still not widely developed due to high dependence on fossil energy, such as coal and petroleum. Of the several existing renewable energy sources, the most widely used energy as a source of renewable energy power generation is solar and wind energy. This is because both energy sources are available even with non-continuous conditions [3]. However, in reality, the application of renewable energy generation technology as an alternative energy is not yet economical compared to fossil-sourced power plants. This is due to the high cost of investment compared to the amount of energy generated and a very complicated control system. Researchers in various places have designed several models of renewable energy plants. With the aim that it can be utilized as alternative energy and produce high efficiency and low cost.

The need for renewable energy sources is increasing along with population growth and awareness of the importance of reducing carbon emissions. One solution that has been widely developed is Solar Power Plant (PLTS), which utilizes sunlight to generate electricity. It has advantages in terms of environmental friendliness, abundant energy availability, and its ability to be applied at various scales, ranging from households to industries. One important factor in the design of solar power plants is the mounting configuration of the solar panels. Panel mounting patterns, namely landscape and portrait, have an influence on the efficiency of the energy produced and space utilization. The portrait pattern is generally used on large areas such as flat roofs or open land. While the landscape pattern is more suitable for limited spaces such as vertical walls or roofs with high slopes. Although both patterns are commonly used, there is little research comparing the performance and advantages of each in various geographical and environmental conditions as reported by [4]. This paper examines the landscape pattern and portrait pattern for the installation of PV modules at Pondok Pesantren Nurul Azhar, Bengkalis Regency. The contribution of this research provides an overview in the selection of the optimal solar panel position to be used and the space requirements for the tropics. The implementation of the research results is expected to improve the efficiency of solar power systems and accelerate the adoption of renewable energy in various sectors.

LITERATURE REVIEW

In designing PV the tilt angle needs to be taken into account, in the tropics the optimal tilt angle on the module will be within 5-100 on both sides of the location latitude. However, PV modules installed with a minimum tilt of 100 should be regularly cleaned. The declination angle formed between the earth's equator and a line drawn from the center of the earth toward the center of the sun. The main reason for the variation in solar declination is the rotation of the Earth on an axis. The declination angle varies within the range of -23.45 degrees to + 23.45 degrees, as shown in Fig. 1. [5][6].

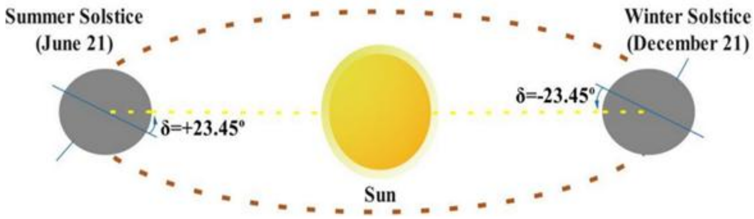


Fig. 1. Declination angle maximum and minimum value. Scientific [5].

In the research developed by [7] on the roof mouted system area to avoid the shadow of the module in the back row PV panels produce more power when arranged in a landscape configuration than in a portrait configuration, exhibiting a discrepancy of up to 1010 Wh for a modest PV system. Other researchers, namely [4] where comparing the performance of portrait and landscape patterns, two PV modules installed with portrait patterns and four PV modules installed with landscape patterns, the results of their research for PV modules installed with portrait patterns, the greater the tilt angle, the more shadows are produced on the collector field, causing the electrical energy generated to decrease, while PV modules installed with landscape patterns result in increased electrical energy production.

To calculate the solar panel or solar cell efficiency, we use the solar efficiency equation.

$P_{max} = V_{OC} \times I_{SC} \times FF$ (1)

$P_{in} = \text{Solar Irradiance} \times \text{Area Total Panel}$ (2)

Based on this equation, we can write the formula for calculating the efficiency of solar panels like this:

$\eta \text{ (Solar Panel Efficiency)} = P_{max} / P_{in} \text{ x } 100\ \%$ (3)

EXPERIMENTAL DESIGN AND METHODOLOGY

A. Material and Components

Some of the main components used in the research of installing a Solar Power Plant system include the following:

1. Solar Panel

Solar panels are tools used are monocrystalline type with a power capacity of 200 Wp as many as 5 pieces, PV modules will be connected in parallel to meet the needs of the inverter input current and voltage. To obtain energy optimization from PV modules, PV modules are installed with two patterns portrait and landscape as shown in Fig. Table 1 lists their technical and mechanical characteristics.

Table 1 - Technical and characteristics of the studied PV systems.

Characteristics	**Values**
Maximum Power (P_{max})	200Wp
Maximum Power Current (I_{mp})	10,96A
Maximum Powwer Volatge (V_{mp})	18,24V
Maximum Circuit Voltage (V_{oc})	21,8V
Characteristics	**Values**
Short Circuit Current (I_{sc})	11,62A
Maximum System Voltage	1000V
Dimensi	1290 x 760 x 35 mm
PV Technologi	Mono

2. Inverter

Inverter is an electronic device that is useful for converting DC (Direct Current) voltage into AC (Alternating Current) voltage. The inverter used in this PLTS system is a low frequency type with a power capacity of 1250 VA with a DC input voltage of 12 V and an AC output voltage of 220 Volts.

PV modul landscape

PV modul portrait

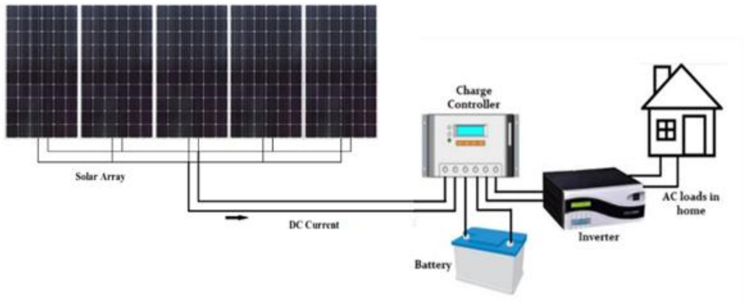


Fig. 2. Arcitecture the PV module

3. Batrays

The battery is an important component that serves to store electrical energy generated from solar panels. The type of batray used is VRLA Gel, this batray has a thick electrolyte liquid like jelly. Another term for this batray is fmaintenace free batray because there is no electrolyte liquid filling valve.

4. Solar Charge Controller (SCC)

The use of Sollar Charge Controller (SCC) is needed to be able to charge electrical energy to the battery. The electrical energy stored by the battery will make the Workstation and Automatic handwasher can still be used when the sun does not shine on the solar panel. The selection of the right SCC will be very well needed to get efficient and affordable results for the Automatic Handwasher with Workstation [8]. The SCC technology used in this research is the maximum power point tracking (MPPT) type, which is able to find the maximum power point on solar panels and optimize battery charging.

B. Methodology

In this study, an analysis was carried out on the position of PV modules with landscape and portrait patterns with a constant slope, a 1000Wp solar panel array to evaluate the maximum power generated at changes in the position of solar panels carried out. The method used is direct observation in the field with the research location at the Nurul Azhar Islamic Boarding School, Bengkalis Regency. The data collection process includes measuring the intensity of sunlight, changes in the position of solar panels (landscape and portrait), and the voltage generated by solar panels at 09.00 Wib until 15.00 Wib. The PV module installed with a portrait pattern at the Nurul Azhar Islamic Boarding School location in Bengkalis Regency can be seen in Figure 4.

Fig. 3. Installation process of Off-Grid Solar Power Plant in Nurul Azhar boarding school

4. RESULTS AND DISCUSSION

A. Hasil

Testing is one of the stages of analysis that aims to determine the intensity of solar radiation received by solar cells, the efficiency of the PLTS system. The relationship between current, voltage, power and efficiency to the intensity of solar radiation, the power generated by solar cells and inverters, the efficiency of solar cells and the PLTS system with 200 WP solar cells connected parallel as many as 5 pieces in Figure 2. In PLTS testing with landscape and portrait pattern installation, the data measured is Tilt Angle, Voltage, Solar Irradiance, Ambient Temperature. The measurement data will be analyzed to calculate the efficiency value of the PLTS system.

1. Landscape Pattern Testing

The first test of the PV array module was then installed with a portrait pattern, testing was carried out from 09.00 to 15.00 with a data interval of 30 minutes. This test was conducted on Sunday, November 10, 2024, the test results data can be seen in Table 2.

Table 2 - PV system test data with Landscape pattern

Time (***hr***)	**Tilt Angle** (***Degrees***)	**Voltage Open Circuit** (***Volt***)	**Solar Irradiance** (***W/m²***)	**Ambient Temp** (***°C***)
09.00	19,7	20,88	670	38
09.30	19,7	20,68	638	37
10.00	19,7	20,68	642	35
10.30	19,7	20,07	624	35
11.00	19,7	20,04	618	35
11.30	19,7	20,11	630	35
12.00	19,7	20,9	658	35
12.30	19,7	21,06	690	38
13.00	19,7	20,9	668	37
13.30	19,7	20,68	588	34
14.00	19,7	21,11	671	37
14.30	19,7	19,81	496	34
15.00	19,7	19,29	403	34
Mean	**19,70**	**20,48**	**615,08**	**35,69**

2. Portrait Pattern Testing

The second test of PV array modules installed with landscape patterns, testing was carried out from 09:00 to 15:00 with a data interval of once 30 minutes. This test was conducted on Monday, November 11, 2024, the test results data can be seen in Table 3.

Table 3 - PV system test data with Portrait pattern

Time (***hr***)	**Tilt Angle** (***Degrees***)	**Voltage Open Circuit** (***Volt***)	**Solar Irradiance** (***W/m²***)	**Ambient Temp** (***°C***)
09.00	19,7	20,83	671	38
09.30	19,7	20,63	640	37
10.00	19,7	20,63	642	35
10.30	19,7	19,84	471	33
11.00	19,7	19,76	470	32

11.30	19,7	19,25	410	32
12.00	19,7	20,77	658	35
12.30	19,7	20,93	680	38
13.00	19,7	20,76	668	37
13.30	19,7	20,71	588	34
14.00	19,7	20,84	671	37
14.30	19,7	19,56	465	33
15.00	19,7	19,15	396	32
Mean	**19,70**	**20,28**	**571,54**	**34,85**

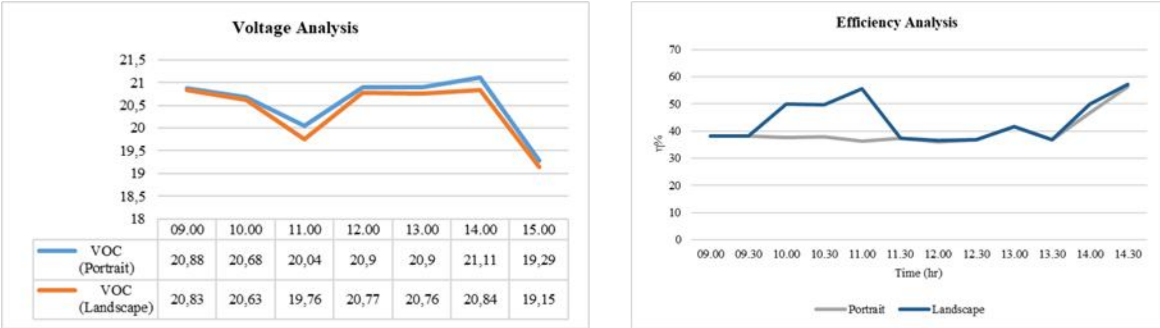
B. Discussion

Based on the results of measurements that have been made, the installation of a PV module array with a landscape pattern gets an average value of 20.48 Volts while using a portrait PV pattern gets an average value of 20.28 Volts. This is due to receiving sunlight during the day which is not the same so that the resulting voltage also varies. Based on the data in Tables 2 and 3, it can be analyzed the efficiency value of the PLTS system using two portrait and landscape installation patterns. The calculation can use equations 1, 2 and 3. For the short circuit current value taken from the data in Table-1 which is assumed to be ISC 5 PV panels = 11.62A × 5 = 58.1 A and the total panel area (ATotal Panel) = 1290 × 760 mm × 5 = 4.9 m2. To recapitulate the calculation results of P max, Pin and the efficiency of the PLTS system can be seen in Table 4.

Table 4 – Efficiency Analysis

Portrait			**Landscape**		
Pmax (Watt)	*Pin (Watt)*	*η* Solar Panel Efficiency	*Pmax (Watt)*	*Pin (Watt)*	*η (%)* Solar Panel Efficiency
1213,13	3284,34	36,94	1210,22	3289,24	36,79
1198,60	3127,48	38,32	1198,60	3137,28	38,21
1198,60	3147,08	38,09	1198,60	3147,08	38,09
1152,70	3058,85	37,68	1152,70	2308,84	49,93
1148,06	3029,44	37,90	1148,06	2303,94	49,83
1118,43	3088,26	36,22	1118,43	2009,82	55,65
1206,74	3225,52	37,41	1206,74	3225,52	37,41
1216,03	3382,38	35,95	1216,03	3333,36	36,48
1206,16	3274,54	36,83	1206,16	3274,54	36,83
1203,25	2882,38	41,75	1203,25	2882,38	41,75
1210,80	3289,24	36,81	1210,80	3289,24	36,81
1136,44	2431,39	46,74	1136,44	2279,43	49,86
1112,62	1975,51	56,32	1112,62	1941,19	57,32
1178,58	**3015,11**	**39,77**	**1178,36**	**2801,68**	**43,46**

Based on Table 4, it can be analyzed that the average PLTS system efficiency value is more effective is the installation of PV array modules with a landscape pattern with a value of 43.46% when compared to the installation of PV array modules with a portrait pattern of 39.77%.



(a) (b)

Fig. 4. Grafik Analysis; a) Voltage Analysis b) Efficiency Analysis

As a comparison of the recommendations for installing solar PV array modules for roof-mounted with portrait and landscape patterns from several researchers are shown in Table 5.

Table 5- Rekomendasi pemasangan modul array PV systems.

Posisi dudukan PLTS	Orientasi pemasangan Modul PV
Ground Mounted [7]	Landscape
Roof Mounted [4] [7]	Portrait
This research (Rooftop)	Landscape and Portrait

5. CONCLUSION

From the results of the research that has been done, it can be concluded that the average voltage value on the solar panel array module with landscape pattern installation is slightly more effective than the portrait pattern, this is due to weather conditions during data collection. Installation of solar panel array modules with a portrait pattern is superior in a narrow space such as on the roof of a house with high light intensity while the landscape pattern requires a large area with high sunlight intensity. In general, there is no difference in the value of the installation of PV array modules with portrait and landscape patterns. The contribution of this paper provides an overview in the selection of the optimal solar panel position for use and space requirements. The implementation of the research results is expected to increase the efficiency of the PLTS system and accelerate the adoption of renewable energy in various sectors.

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References

[1] ebtke.esdm.go.id, “Kinerja Subsektor EBTKE 2023 dan Program 2024: Diversifikasi Produk BBN dan Peningkatan Kapasitas Pembangkit EBT,” https://ebtke.esdm.go.id/,2024.[Online].Available::/ebtke.esdm.go.id/post/2024/01/18/3700/kinerja.subsektor.ebtke.2023.dan.program.2024.diversifikasi.produk.bbn.dan.peningkatan.kapasitas.pembangkit.ebt

[2] esdm.go.id, “Pemerintah Perkuat Komitmen Transisi Energi Melalui Peraturan Presiden Pengembangan EBT,” esdm.go.id. Accessed: May 15, 2024. [Online]. Available: https://www.esdm.go.id/en/media-center/news-archives/pemerintah-perkuat-komitmen-transisi-energi-melalui-peraturan-presiden-pengembangan-ebt

[3] Ministry of Energy and Mineral Resources of Indonesia, “Technology Data for the Indonesian Power Sector,” no. February, pp. 1–215, 2021, [Online]. Available: https://ens.dk/sites/ens.dk/files/Globalcooperation/technology_data_for_the_indonesian_power_sector_-_final.pdf

[4] M. Silva, R. Castro, and M. Batalha, “Technical and economic optimal solutions for utility-scale solar photovoltaic parks,” Electron., vol. 9, no. 3, 2020, doi: 10.3390/electronics9030400.

[5] M. Tamoor, A. R. Bhatti, M. Farhan, A. Rasool, and A. Sherefa, “Optimizing tilt angle of PV modules for different locations using isotropic and anisotropic models to maximize power output,” Sci. Rep., vol. 14, no. 1, p. 30197, 2024, doi: 10.1038/s41598-024-81826-9.

[6] K. A. Sado, L. H. Hassan, and S. Sado, “Photovoltaic panels tilt angle optimization,” E3S Web Conf., vol. 239, 2021, doi: 10.1051/e3sconf/202123900019.

[7] H. Oufettoul, N. Lamdihine, S. Motahhir, N. Lamrini, I. A. Abdelmoula, and G. Aniba, “Comparative Performance Analysis of PV Module Positions in a Solar PV Array Under Partial Shading Conditions,” IEEE Access, vol. 11, no. February 2023, pp. 12176–12194, 2023, doi: 10.1109/ACCESS.2023.3237250.

[8] N. F. Wahidin, E. Yadie, and M. A. Putra, “Analisis Perbandingan Solar Charging Controller (SCC) Jenis PWM Dan MPPT Pada Automatic Handwasher with Workstation Bertenaga Surya Politeknik Negeri Samarinda,” PoliGrid, vol. 3, no. 1, p. 12, 2022, doi: 10.46964/poligrid.v3i1.1490