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Analysis of Solar Power System Planning For Street Lighting SUPP LY at Campus I Universitas Pembangunan Panca Budi Medan

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ABSTRACT
Solar energy is a renewable energy source (EBT) that will not run out. One of the uses of solar energy is as a source of energy for solar-powered public street lighting (PJUTS). Public street lightingCampus Area of Panca Budi Development Universityaims to help improve road safety at night. In this study, planning will be carried out for solar-powered Public Street Lighting (PJUTS) located inCampus Area of Pancasila Development Universitywith a road width of 5 m and a road length of 320 m. Planning for solar-powered public street lighting (PJUTS) requires 14 lighting points with a load of 24 Watt LED lights. With a pole height of 7 m and a distance between poles of 25 m, the lighting intensity is 6.72 lux for manual calculations. Meanwhile, according to applicable standards, the lighting intensity value is 3-7 lux. The solar module used has a capacity of 75 Wp. PJUTS operates 12 hours a day and is able to continue operating for 3 days without a solar energy source. The total cost that must be incurred for this solar-powered public street lighting is IDR 1,224,500,000

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INTRODUCTION

The increasing activity at night causes the need for lighting sources to increase, especially in the campus area. One part that requires lighting is the Universitas Pembangunan Panca Budi Medan Environment. Roads in the campus environment are the main infrastructure that must be considered for their condition and use. Street lighting is a campus facility so that teaching and learning activities and the campus community are not hampered by passing through the campus environment. Street lights are usually installed on the road or in the middle of the sidewalk.

Currently, street lighting in the Panca Budi Development University Campus Area still uses electricity from PLN so that the electricity bill for street lights in the campus area can swell. From the problems above, in this study a Solar Power Plant (PLTS) will be planned as a Power Source for Street Lighting at Campus I of Panca Budi Development University Medan, where this solar-powered street light is a cheap and efficient alternative to be used as a source of electricity for lighting because it uses free and unlimited energy sources from nature.

Solar panels function to receive sunlight which is then converted into electricity through the photovoltaic process. Then stored in batteries so that it does not require supply from PLN. In this study will be conducted to determine the cost of installation and efficiency of solar-powered public street lighting and to determine the need for solar panels and the number of light points to be installed on the Campus Area Road from the Entrance Gate to the road to Building M Universitas Pembangunan Panca Budi Medan.

Literature Review

Solar Powered Street Lighting (LPJUTS)

Solar Street Lighting is one of the cheap and economical alternatives to be used as a source of electric lighting because it uses a free and unlimited energy source from nature, namely solar energy. Using solar modules/panels with a service life of up to 25 years whose function is to receive sunlight (ray) which is then converted into electricity through the photovoltaic process. Then stored in a battery so that it does not require a supply from PLN, automatically turns on in the afternoon and turns off in the morning with easy and efficient maintenance for years. Overall, this system is designed to provide public lighting using renewable energy sources, free of maintenance costs and with a long economic life.

Figure1. Solar Street Lighting

Solar Module (*Photovoltaic*)

Solar panels are components that function to convert sunlight energy into electrical energy. This panel is composed of several solar cells connected in series or parallel. A solar panel generally consists of 32-40 solar cells depending on the size of the panel, the combination of the panels.

Solar cells are composed of two layers of semiconductors with different charges. The top layer of the solar cell is negatively charged while the bottom layer is positively charged. Silicon is the most common semiconductor material used for solar cells. By utilizing the influence of sunlight from semiconductor materials, solar cells can directly convert sunlight energy into direct current (DC) electricity. Solar panels are used to absorb solar energy and then convert it into electrical energy (DC). The capacity of solar panels requires several factors that must be considered, namely total energy requirements, light insolation and adjustment factors. This adjustment factor is intended to take into account the losses that can be seen in the following equation:

$$Kapasitas \rightleftarrows Panel = \frac{E_T}{Insolasi} x1,1$$

Where:
ET = Total Energy (Wh)
To find out the number of modules required, use the following equation:

$$\sum mod\,u\,l = \frac{E_T}{E_{Modul}}$$

Where:
∑ module= number of modules
ET = total energy (Wh)
Emodul = energy produced by the module

Battery

The battery is one of the components that functions to produce DC electrical energy in the solar system. The electrical energy in the battery is produced by solar panels that convert sunlight into electrical energy. To calculate the battery capacity that matches the solar panel and its output load can be calculated using the following equation:

$$I_{Ah} = \frac{E_T}{V_S}$$

Where:
Oh = required current capacity (Ah)
ET = total energy (Wh)
VS = source voltage (V)

The provision that limits the maximum depth of discharge applied to the battery. The depth of discharge (DOD) of the battery is usually expressed as a percentage. For example, a battery has a DOD of 80%, meaning that only 80% of the available energy can be used and the remaining 20% is in reserve. The battery capacity considering the depth of discharge (DOD) factor can be determined using the following equation:

$$I_{Ah}Total = \frac{I_{Ah}}{DOD}$$

Where:
Oh, that's all = total battery capacity (Ah)
Oh = required current capacity
DOD = depth of discharge (%)

Once you know the total battery capacity needed and the battery capacity per unit to be used, you can determine the number of batteries needed using the following equation:

$$\sum Baterai = \frac{I_{Ah}Total}{KapasitasBateraiPerUnit}$$

Where:
∑ battery = number of batteries (units)
Oh, that's all = total battery capacity (Ah)

*Solar charge controller*regulate overcharging (overcharging - because the battery is 'full') and overvoltage from the solar module. Overvoltage and overcharging will reduce battery life. This charge controller applies Pulse width Modulation (PWM) technology to regulate the battery charging function and the discharge of current from the battery to the load. To calculate the BCR capacity requirements, the characteristics and specifications of the solar panels must first be known and what must be considered is the Isc value (short circuit current), this value is multiplied by the number of solar panels, then the result is the minimum value of the charge controller required. The current BCR capacity can be determined by the following equation:

$$I_{Max} = \frac{P_{Total}}{V_s}$$

Where:

Imax = maximum current, BCR capacity (A)
Total = total system power (W)
Vs = system voltage (V)

Lighting Basics

Lighting basics are the initial benchmark used in designing or planning a lighting system. There are several terms and formulas in designing a lighting system to determine a lighting system that meets efficient budget standards. The following are terms and formulas commonly found in lighting basics.

a. Luminous Flux

Luminous flux is the amount of light emitted by a light source. The symbol for luminous flux is F/Φ and its unit is lumen (lm). To calculate luminous intensity, you can use the following equation:

$$\Phi = \omega . I$$

Where :

Φ = luminous flux (lm)
ω = room angle in steradians (sr)
I = light intensity (cd)

From the light flux equation above, the following light intensity equation is obtained:

$$I = \frac{\Phi}{\omega}$$

Where:

I = light intensity (cd)
Φ = luminous flux (lumens)
ω = room angle in steradians (sr)
ω = 4π

b. Lighting Intensity (Illumination)

Lighting intensity or illumination or illumination strength is the light flux that falls on an area or surface. The unit of lighting intensity is lumen/m2 (Lux) or 1 lux = 1 lumen/m2. If an area of A m2 is illuminated with Φ lumens. To calculate the lighting intensity or lighting strength or illumination, you can use the following equation:

$$E_{Rata-Rata} = \frac{\Phi . \eta . MF}{W . S}$$

Where :

Eaverage = average illumination in lux units (lx)
Φ = luminous flux (lumens)
η = utility factor

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MF = maintenance factor/Light Loss Factor
W = road width (m)
S = distance between poles (m)

To calculate the amount of illumination at a certain point/coordinate, use the following formula:

$$E = \frac{1}{E^2} CosCos\phi$$

Where r is the distance from the lighting point to point P (the lighting level measurement point).

c. Luminance (L)

Luminance is the amount of light intensity per unit area. It is a measure of the brightness of an object. Too much lighting will dazzle the eyes. It is formulated with the following equation:

$$L = \frac{I}{As}$$

Where:
L = luminance (cd/m2)
I = intensity (cd)
US = total surface area (m2)
With
US = A cosθ
So we get the following equation:

$$L = \frac{I}{ACosCos\theta}$$

d. Efficacy

Efficacy is the range of comparison numbers between luminous flux (lumens) and electrical power of a light source (watts), in lumens/watt units. Efficacy can also be referred to as specific luminous flux. Efficacy can be obtained from lighting product catalog data. Efficacy can also be determined by manual calculation using the following formula:

$$K = \frac{\theta}{P}$$

Where:
K = light efficacy (lm/watt)
Φ = luminous flux (lm)
P = electrical power (watts)

RESEARCH METHODOLOGY

In this study, a flow diagram is needed to facilitate the planning process for solar-powered public street lighting. The following is a picture of the flow diagram.

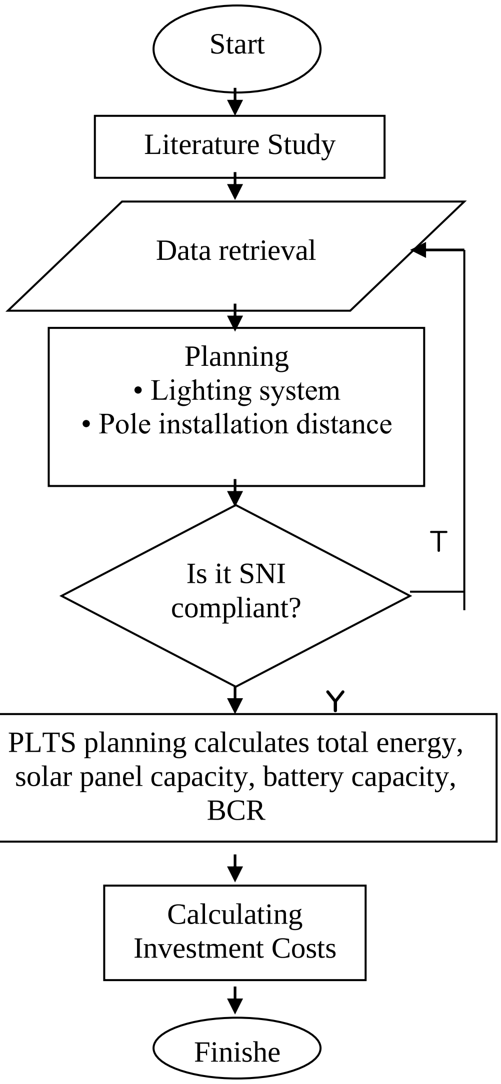

Figure 2. Research Flow Chart

RESULTS AND ANALYSIS

Ornament Handlebar Slope Calculation

From the results of determining the specifications for public street lighting poles that have been made previously, namely with a pole height of 7 m and an ornamental handlebar length of 1 m, the parameters for the pole specifications can be used to calculate the slope of the ornamental handlebar.

$$t = \sqrt{h^2 + c^2}$$
$$t = \sqrt{7^2 + 1.5^2}$$
$$t = 7{,}158$$

After getting the t value, to determine the slope of the ornament handlebars, use the equation

$$CosCos\theta = \frac{h}{t}$$
$$CosCos\theta = \frac{7}{7{,}158}$$
$$\theta = Cos^{-1}\frac{7}{7{,}158}$$
$$\theta = 12{,}06^{0}$$

Light Intensity Calculation

The magnitude of the light intensity in candela (cd) with a lumen of 3000 Lumen LED lamp is:

$$I = \frac{\varphi}{\omega}$$
$$I = \frac{3000}{4\pi}$$
$$I = 238{,}73 Cendela(cd)$$

So the light intensity obtained from each street light is 238.73 candela (cd)

Calculation of Lighting Intensity

To calculate the average lighting intensity using the Equation:

$$E_{Rata-Rata} = \frac{\Phi.\eta.MF}{W.S}$$

For valueη= 0.35 (SNI) and for the MF value = 0.7-0.9 (SNI) the middle value is taken for the MF value, namely 0.8, then we get

$$E_{Rata-Rata} = \frac{\Phi.\eta.MF}{W.S}$$
$$E_{Rata-Rata} = \frac{3000.0{,}35.0{,}8}{525}$$
$$E_{Rata-Rata} = 6{,}72 Lux$$

To find out the illumination at a point/coordinate (P), the equation used is:

$$E = \frac{1}{E^2} CosCos\phi$$

As a sample taken at the end of the road pavement with a value of h = 7 m and W2 = 4 m.

$$r = \sqrt{h^2 + {W_2}^2}$$
$$r = \sqrt{7^2 + 4^2}$$
$$r = 8{,}06$$

Once you know the value of r, plug it into the equation to become

$$E = \frac{I}{r^2} CosCos\phi$$
$$E = \frac{238{,}72}{8{,}06^2}$$
$$E = 3{,}59 Lux$$

So the illumination value at the end point/coordinate of the pavement is 3.59 lux.

Luminance Calculation

To calculate the luminance (L) of an LED lamp, the following equation is used:

$$L = \frac{I}{As}$$

With As = A cosθSo to get the amount of luminance (L) on the LED lamp, namely

$$L = \frac{I}{ACosCos\theta}$$

$$L = \frac{238{,}73}{12^0}$$

$$L = 1{,}95$$

So the amount of luminance obtained for each LED lamp installed is 1.95 (cd/m2)

Efficacy Calculation

Light efficacy in lumen/watt units in public street lighting design can be calculated using the equation

$$K = \frac{\theta}{P}$$

With the parameters obtained from the previous calculation, namely light flux Φ = 3000 Lumens and the LED lamp power used is 24 Watts, then

$$K = \frac{\theta}{P}$$

$$K = \frac{3000}{24}$$

$$K = 125 Lumen/Watt$$

So that the light efficacy obtained from the LED lights installed on each street lighting pole is 125 Lumen/watt.

Lighting Point Calculation

Determine the number of light points needed for solar-powered public street lighting inCampus Area of Panca Budi Development Universityfrom the Main Gate to Building M using the equation

$$T = \frac{L}{S} + 1$$

Campus Area of Panca Budi Development Universityfrom the Main Gate to Building M with a road length of 320 m and a calculated distance between poles of 25 m, then

$$T = \frac{L}{S} + 1$$

$$T = \frac{320}{25} + 1$$

$$T = 13{,}8 Titik$$

So the number of light points needed onCampus Area of Panca Budi Development Universityfrom the main gate to Building M, there are 14 light points.

Planning Analysis and SNI

To ensure that the design of public street lighting in this study is in accordance with applicable standards, it is necessary to analyze the planning results using national standards that have been established in Indonesia. The following are the planning results and Indonesian National Standards (SNI).

Table 1. Comparison of design results and SNI

Parameter	Calculation	SNI
E average	6.72 lux	3-7 lux

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Parameter	Calculation	SNI
E min	3.59 lux	3 lux
L average	1.95 cd/m2	1.00 cd/m2
Equality	0.469	0.14
L max	1.98 cd/m2	-
L min	0.96 cd/m2	-
VD	0.484	0.40
VI	0.50	0.50

Determining Solar Power Specifications

Energy Requirements Calculation

In this study, the amount of power used is 24 W. The load in question is a light load that is usually used for 12 hours a day, but as an anticipation according to the transportation department regulations that back up solar energy is for 3 days, meaning for 36 hours of use. then the energy requirement is

$$E_T = P_L x t$$
$$E_T = 24x36 \rightleftarrows Jam$$
$$E_T = 864 Watt$$

Solar Module Capacity Calculation

The determination of the solar panel power capacity is taken based on the lowest solar insolation price. Based on solar insolation data, the lowest solar insolation price is 4.31 kWh/m2/day. So the solar panel capacity is

$$KapasitasPanel = \frac{E_T}{Isolasi} x1,1$$
$$KapasitasPanel = \frac{864}{4,31} x1,1$$
$$KapasitasTotalPanel = 220,5wp$$

The solar module to be used is a 75 Wp solar module. Assuming 3 hours of sunlight, the energy produced by the solar panel is.

$$Emodul = Pmodul\ x\ faktor\ pengali$$
$$Emodul = 75Wp\ x3\ h$$
$$Emodul = 225Wh$$

With a module capacity of 75 Wp and a lighting time of 3 hours, 225 Wh of energy is produced. The number of solar panels needed on one lighting pole is

$$\sum Modul = \frac{E_T}{E_{Modul}}$$
$$\sum Modul = \frac{220,5}{225}$$
$$\sum Modul = 0,98 \approx 1Unit$$

Battery Calculation

The number of batteries and the battery capacity used must be able to accommodate the total energy needed. The unit of battery capacity is Ah, while the unit of energy is Wh, so determining the battery capacity must be divided by the system voltage.

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$$I_{Ah} = \frac{E_T}{V_S}$$
$$I_{Ah} = \frac{864}{12}$$
$$I_{Ah} = 72Ah$$

Taking into account the DOD (depth of discharge) factor, the required battery capacity is

$$I_{Ah}Total = \frac{I_{Ah}}{DOD}$$
$$I_{Ah}Total = \frac{72}{80\%}$$
$$I_{Ah}Total = 90Ah$$

If using a 100Ah, 12V battery, the number of batteries needed for one public street lighting pole is

$$\sum Baterai = \frac{I_{Ah}Total}{KapasitasBateraiPerUnit}$$
$$\sum Baterai = \frac{90}{100}$$
$$\sum Baterai = 0{,}9 \approx 1Unit$$

Table 2. Calculation of investment costs per point

Material Type	Lots	Unit price	Total
Pole +Ornamental handlebar	1	2,400,000	2,400,000
Solar panels	1	1,125,000	1,125,000
Battery	1	1,250,000	1,250,000
LED +lamp house + sensor	1	225,000	225,000
BCR	1	347,000	347,000
MCB	1	170,000	170,000
Cable	4 m	4,500	18,000
Panel box	1	750,000	750,000
Installation costs	1 point	1,465,000	1,465,000
Investment Cost per point			7,775,000

To find out the total cost of investing in public street lighting, multiply the number of points by the cost per point. So the total cost that must be spent for solar-powered public street lighting is IDR 1,224,500,000.$Biaya\ total$= Rp. 1,224,500,000

CONCLUSION

The Conclusion of this paper are: The number of solar panels used on each street lighting pole is 1 unit with a capacity of 75wp. The number of batteries used on each street lighting pole is 1 unit with a capacity of 100 Ah. Meanwhile, the BCR on each street lighting pole must have a current capacity of at least 2 A. The solar-powered street lighting system in this study was able to operate for 3 days or 36 hours, with the details of 12 hours per day the lights would operate. The total cost that must be spent for solar-powered public street lighting is IDR 7,775,000 per point.

REFERENCES

Asrul Andi, Zuraidah Tharo, Dicky Lesmana, 2024 "Analysis of Solar Panel Design as a Power Source For CCTV at PT. Link NET, TBK" Scientia Journal Volume 13, Number 04, 2024, DOI 10.58471/ scientia.v13i04 ESSN 2723-7486 (Online)

Andreansyah, Muhammad Erpandi Dalimunthe, Dicky Lesmana, 2024 "Analysis of Aquaponics Solar Panel Innovation in Building C of Pembangunan Panca Budi University"Journal of Electrical EngineeringVol. 6, no. 1, January 2024, pp. 60-63 p-ISSN:2686-3650 | e-ISSN: 2686-3642, DOI:10.52005/fidelity.v6i1.201

Aryza. S et al (2023). Enhanced of Electric Power Consumption Monitoring System in Household Based on Sensorless. *Jurnal Scientia*, *12*(04), 2107-2113.

Hamdani, Zuraidah Tharo, and Siti Anisah. "Comparison of solar power plant performance between mountainous and coastal areas." National Engineering Seminar (Semnastek) Uisu. Vol. 2. No. 1. 2019.

M Aidil Akbar, Amani Darma Tarigan, Dicky Lesmana, 2024 "Analysis of Hybrid Power Generation System Planning (PLTS and Diesel) on Tanker Ships" Power Elektronik: Jurnal Orang Elektro, Vol.13, No.1, 2024 p-ISSN: 2301-6949, e-ISSN: 2715-5064

Muhammad Dzulkifli, Verra Aullia, Abdurrahim, 2023 "Planning of Public Street Lighting Installation (PJU) on Jalan Tani Subur, Loa Janan Ilir District, Samarinda" PoliGrid Vol. 04 No. 02, December 2023 ISSN 2723–4428 eISSN 2723-4436

Rahmaniar, Agus Junaidi, Jul Andri Syahputra Sinaga, 2023 "SHADING SIMULATION ANALYSIS OF 5,348 WP ON-GRID SOLAR POWER PLANT" Proceedings The 1st Annual Dharmawangsa International Conference, P.Issn : 2808-859X E.Issn : 2809-0853

Jeckson, Dasweptia, Nasirul Farkhain, 2023 "Design of PLTS for Street Lighting Resources in Iringmulyo Metro Village" UML Electrical Engineering Scientific Journal (JITRO-UML) Vol. 06, No. 01, Pp. 7 - 13, 2023 e-ISSN 2746-1750

Widodo Restu Putra, Ir. Ali Mokthar, MT., IPM., ASEAN Eng, 2023 "Study of Public Street Lighting (PJU) Planning and Determination of Light Points on Kanjeng Jimat Street, Trenggalek Regency" Engineering Seminar 2023 ISSN (Print) 2798-0405 eISSN (Online) 2797-1775

Zuraidah Tharo, Supiyandi, Haris Gunawan, 2024 "The Integration of Solar and Wind Energy to Enhance Optimization and Efficiency of Renewable Energy" Evolutionary Studies in imaginative Culture ESIC2024 Posted: 16/10/2024

Zuraidah Taro, Hamdani, 2020 "Cost Analysis of Household-Scale Rooftop Solar Power Plants (PLTS)" JESCE,3(2) February2020 ISSN2549-628X(Print)ISSN2549-6298(Online)10.31289/jesce.v3i2.3266.g2494