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Analysis of PJU Planning for Street Lighting Resources in Suka Maju Indah Village

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Street Lighting (Public Street Lighting/PJU) planning plays a vital role in improving road safety, security, and comfort, particularly in developing residential areas. This study aims to analyze the street lighting requirements and develop an appropriate Public Street Lighting (PJU) plan for Suka Maju Indah Village to achieve effective, energy-efficient, and standard-compliant illumination. The research employed a field survey to evaluate the existing road lighting conditions, measure road dimensions, identify available lighting facilities, and calculate lighting requirements based on SNI 7391:2008 and the recommendations of the Commission Internationale de l'Eclairage (CIE). The analysis focused on key parameters, including illuminance level, pole spacing, mounting height, lamp power, and electrical energy consumption. The results indicate that the existing street lighting system in Suka Maju Indah Village does not fully satisfy the recommended lighting standards due to uneven light distribution and insufficient illuminance on several road sections. The proposed design, utilizing high-efficiency LED luminaires with optimized pole spacing and appropriate mounting heights, significantly improves lighting performance while reducing energy consumption compared to conventional lighting systems. The proposed Public Street Lighting (PJU) system is expected to enhance traffic safety, minimize the risk of nighttime accidents and criminal activities, and reduce long-term operational costs through improved energy efficiency. The findings of this study provide practical guidance for local governments and residential developers in designing sustainable and technically compliant street lighting systems.
Keywords: Public Street Lighting (PJU), Street Lighting Planning, LED Lighting, Illuminance, Energy Efficiency, Suka Maju Indah Village.

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1. Introduction

Public Street Lighting (PSL) is an essential infrastructure that plays a significant role in improving road safety, public security, and community comfort during nighttime activities. A well-designed street lighting system enhances road visibility, reduces traffic accidents, minimizes criminal activities, and supports social and economic development. As residential areas continue to expand, the demand for reliable, energy-efficient, and sustainable public street lighting systems has become increasingly important as part of modern infrastructure development (Commission Internationale de l'Eclairage [CIE], 2023). Suka Maju Indah Village, located in Deli Serdang Regency, Indonesia, is one of the developing residential areas experiencing rapid infrastructure growth. However, the availability of public street lighting remains inadequate. Field observations indicate that approximately 100 meters of roadway are not equipped with any street lighting facilities, resulting in poor nighttime visibility and increased risks for road users. During the past four years, the absence of adequate lighting has contributed to several traffic accidents and criminal incidents. Furthermore, insufficient street lighting has negatively affected residents' mobility, nighttime activities, and local economic development.

In Indonesia, improving energy accessibility and expanding sustainable electricity infrastructure remain national priorities. The Ministry of Energy and Mineral Resources (MEMR) has emphasized the importance of renewable energy utilization to achieve national energy transition targets while increasing electricity access in rural areas (Ministry of Energy and Mineral Resources, 2023). Among various renewable energy technologies, Solar Photovoltaic (PV) systemshave emerged as one of the most promising solutions due to Indonesia's abundant solar resources, with an average solar irradiation of approximately 4.8 kWh/m²/day. This significant solar potential makes photovoltaic systems particularly suitable for standalone public street lighting applications (International Renewable Energy Agency [IRENA], 2023). Solar-powered Public Street Lighting (PSL) offers several advantages over conventional systems supplied by the national electricity grid. Solar energy is clean, renewable, environmentally friendly, and produces no carbon emissions during operation. Moreover, photovoltaic street lighting systems require relatively low operational and maintenance costs after installation. The generated electricity is stored in batteries, allowing each lighting unit to operate independently without relying on the utility grid. Consequently, standalone solar-powered street lighting is highly suitable for rural and residential areas where electricity infrastructure is limited or where sustainable energy solutions are preferred (International Energy Agency [IEA], 2023).

Besides selecting an appropriate energy source, proper street lighting planning must consider several engineering parameters, including illuminance level, lighting uniformity, pole height, pole spacing, luminaire power, and roadway geometry. Poor planning may result in uneven light distribution, dark spots, glare, excessive energy consumption, and reduced lighting performance. Therefore, street lighting design should comply with national and international lighting standards to ensure adequate illumination while maximizing energy efficiency and minimizing operational costs (Badan Standardisasi Nasional [BSN], 2022; CIE, 2023). Based on these conditions, this study focuses on the analysis and planning of a Solar Photovoltaic (PV)-based Public Street Lighting (PSL) system for Suka Maju Indah Village, Deli Serdang Regency. The study evaluates the lighting requirements, determines the optimum number and height of lighting poles, estimates the required lamp power, and designs a standalone photovoltaic system as the primary energy source. The proposed design is expected to improve road safety and public security, reduce dependence on the national electricity grid, and promote sustainable infrastructure development through the utilization of renewable energy resources. Specifically, the objectives of this study are: (1) to determine an appropriate Solar Photovoltaic (PV) system as the power source for the Public Street Lighting (PSL) network in Suka Maju Indah Village; (2) to calculate the required number and height of lighting poles based on the roadway characteristics; and (3) to determine the appropriate lamp power capacity to satisfy the required lighting standards while achieving optimal energy efficiency.

2. Literature Review

Public Street Lighting (PSL)

Public Street Lighting (PSL) is a public infrastructure system designed to provide adequate illumination for roads, pedestrian pathways, and public spaces during nighttime. The primary objectives of street lighting are to improve traffic safety, enhance pedestrian visibility, reduce crime, and increase public comfort. An effective PSL system should provide sufficient illuminance, uniform light distribution, and minimal glare while maintaining energy efficiency and operational reliability (Commission Internationale de l'Eclairage [CIE], 2023).

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Figure 1. Public Street Lighting

According to SNI 7391:2022, the design of street lighting systems should consider road classification, average illuminance, lighting uniformity, pole height, luminaire spacing, mounting angle, and roadway geometry. Proper planning ensures that lighting installations meet safety standards while minimizing energy consumption and maintenance costs (Badan Standardisasi Nasional [BSN], 2022).

Solar Photovoltaic (PV) System for Public Street Lighting

Solar Photovoltaic (PV) technology is a renewable energy system that converts solar radiation directly into electrical energy through semiconductor photovoltaic cells. The electricity generated during daylight hours is stored in rechargeable batteries and later used to power LED street lamps at night. Because each lighting unit operates independently without requiring a connection to the national electricity grid, solar-powered Public Street Lighting (PSL) systems are particularly suitable for rural areas, residential developments, and remote locations where grid electricity is unavailable or costly to install (International Renewable Energy Agency [IRENA], 2023).

Indonesia has significant potential for photovoltaic power generation due to its geographical location within the tropical region. The country receives abundant solar radiation throughout the year, with an average daily solar irradiation ranging from 4.5 to 5.5 kWh/m²/day. This favorable solar resource makes photovoltaic technology one of the most promising renewable energy solutions for public infrastructure, including standalone street lighting systems. Recognizing this potential, the Ministry of Energy and Mineral Resources (MEMR) has identified solar photovoltaic technology as a strategic component of Indonesia's national energy transition policy aimed at expanding rural electrification, improving energy security, and increasing the share of renewable energy in the national energy mix (Ministry of Energy and Mineral Resources, 2023).

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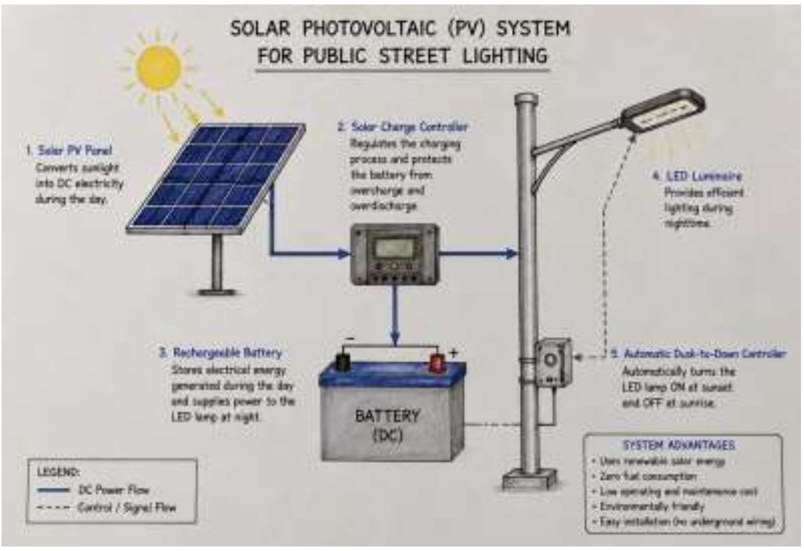

Figure 2. Solar Photovoltaic (PV) System

A standalone solar-powered street lighting system generally consists of six primary components:

a. Solar photovoltaic (PV) panel
b. Solar charge controller (SCC)
c. Rechargeable battery
d. LED luminaire
e. Lighting pole
f. Automatic dusk-to-dawn controller

The operating principle of the system begins with the photovoltaic panel converting sunlight into direct current (DC) electricity during daytime. The generated electricity is regulated by the Solar Charge Controller (SCC), which protects the battery from overcharging and excessive discharge while ensuring efficient energy management. The electrical energy is then stored in the rechargeable battery. When daylight intensity decreases at sunset, the automatic controller activates the LED luminaire using the stored electrical energy, allowing continuous illumination throughout the night until sunrise.

Compared with conventional grid-powered street lighting, photovoltaic-powered systems offer several significant advantages. They eliminate fuel consumption, reduce greenhouse gas emissions, require relatively low operational and maintenance costs after installation, and simplify system deployment because underground electrical distribution networks are unnecessary. These advantages make solar-powered street lighting an environmentally sustainable and economically attractive solution for both urban and rural infrastructure development (International Energy Agency [IEA], 2023).

Furthermore, the implementation of photovoltaic-based Public Street Lighting contributes directly to the achievement of the United Nations Sustainable Development Goals (SDGs), particularly Goal 7 (Affordable and Clean Energy) by increasing access to renewable electricity, and Goal 13 (Climate Action) by reducing dependence on fossil fuels and lowering carbon emissions. Consequently, solar-powered street lighting not only enhances public safety and energy efficiency but also supports global efforts toward sustainable infrastructure and environmental protection (United Nations, 2023).

LED Lighting Technology and Design Parameters for Public Street Lighting

Light Emitting Diode (LED) technology has become the preferred lighting source for modern Public Street Lighting (PSL) systems due to its high luminous efficacy, extended service life, and significantly lower energy consumption compared with conventional lighting technologies such as High Pressure Sodium

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(HPS) and Metal Halide lamps. Modern LED luminaires typically achieve luminous efficiencies exceeding 150 lm/W, allowing them to produce higher illumination levels while consuming considerably less electrical power. In addition, LED lamps provide instant start-up without warm-up time, require minimal maintenance, and have an operational lifetime of up to 100,000 hours, making them highly suitable for long-term public infrastructure projects. Their lower electricity demand also contributes to reduced greenhouse gas emissions, supporting sustainable energy development and environmental protection (International Energy Agency [IEA], 2023).

The superior characteristics of LED technology make it particularly suitable for solar-powered Public Street Lighting systems, where energy conservation is essential for maximizing battery storage capacity and improving overall system reliability. Since photovoltaic-powered street lighting depends entirely on solar energy collected during daylight hours, the use of high-efficiency LED luminaires enables longer nighttime operation while minimizing the required photovoltaic panel size and battery capacity. Consequently, LED technology has become the standard lighting source for modern standalone street lighting installations worldwide.

The overall performance of a Public Street Lighting system depends not only on the selection of efficient lighting technology but also on several important engineering design parameters. These parameters include illuminance level, pole height, pole spacing, lamp power, and lighting uniformity, all of which directly influence road safety, visual comfort, and energy efficiency. One of the most important lighting parameters is illuminance, which represents the amount of luminous flux incident on a surface and is measured in lux (lx). National and international lighting standards specify minimum illuminance values according to roadway classification to ensure adequate visibility for both drivers and pedestrians. Proper illuminance improves object recognition, reduces accident risks, and enhances nighttime driving conditions (Commission Internationale de l'Eclairage [CIE], 2023).

Another critical design factor is pole height, which strongly affects lighting distribution and uniformity. For residential and local roads, lighting poles are commonly installed at heights ranging from 6 to 9 meters, depending on roadway width, mounting configuration, and luminaire characteristics. Selecting an appropriate pole height ensures that light is distributed uniformly across the road surface while minimizing glare and excessive shadow formation (Badan Standardisasi Nasional [BSN], 2022).
The spacing between lighting poles is equally important because it determines the continuity of illumination along the roadway. Proper pole spacing should provide sufficient overlap between adjacent luminaires to eliminate dark spots while avoiding excessive lighting redundancy. In typical residential street lighting applications, pole spacing generally ranges between 25 and 40 meters, depending on lamp output, mounting height, and roadway geometry.

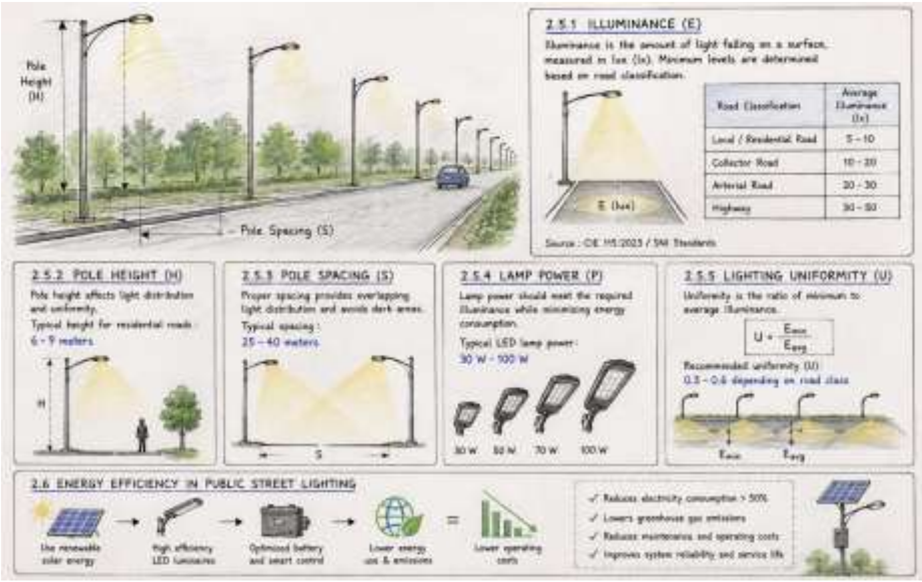

Figure 3. Design Parameters for Public Street Lighting

The lamp power rating must be selected according to the required illuminance level while maintaining high energy efficiency. Modern LED street lighting systems commonly utilize luminaires with power ratings ranging from 30 W to 100 W, depending on road classification, traffic density, and lighting requirements. Appropriate power selection minimizes electricity consumption without compromising lighting quality. Another important performance indicator is lighting uniformity, which is defined as the ratio between the minimum and average illuminance across the roadway. High lighting uniformity minimizes abrupt changes in brightness, reduces driver visual fatigue, improves object detection, and enhances overall traffic safety. Therefore, lighting design should aim to achieve both adequate illuminance and acceptable uniformity according to recognized lighting standards.

Considering these engineering parameters together with high-efficiency LED technology significantly improves the overall energy performance of Public Street Lighting systems. Energy efficiency has become one of the primary objectives in modern infrastructure planning because it reduces electricity consumption, operational expenditures, and environmental impacts. Studies conducted by the International Energy Agency (2023) indicate that replacing conventional street lighting with LED luminaires integrated into photovoltaic power systems can reduce electricity consumption by more than 50% while simultaneously lowering greenhouse gas emissions and maintenance costs. Furthermore, intelligent energy management through optimized battery charging, automatic lighting control, and preventive maintenance strategies enhances system reliability and extends component service life. Consequently, the integration of photovoltaic technology with high-efficiency LED lighting represents one of the most effective and sustainable solutions for modern Public Street Lighting systems.

Previous Studies

Previous studies have demonstrated the technical feasibility, economic benefits, and environmental sustainability of photovoltaic (PV)-based Public Street Lighting (PSL) systems. Researchers and international organizations consistently report that integrating solar photovoltaic technology with high-efficiency LED luminaires offers an effective solution for improving road lighting while reducing energy consumption and greenhouse gas emissions. The International Renewable Energy Agency (IRENA) (2023) reported that standalone photovoltaic street lighting systems significantly improve energy accessibility in rural and remote communities while reducing operational costs and carbon emissions. The report concluded that solar-powered street lighting represents a sustainable alternative to conventional

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grid-connected lighting systems, particularly in areas with abundant solar resources and limited electricity infrastructure. The use of decentralized photovoltaic systems also minimizes transmission losses and simplifies installation because underground electrical distribution networks are unnecessary.

Similarly, the International Energy Agency (IEA) (2023) highlighted that integrating high-efficiency LED luminaires with photovoltaic systems can reduce electricity consumption by more than 50% compared with conventional street lighting technologies. The report further emphasized that LED technology provides superior lighting performance, lower maintenance requirements, and a significantly longer operational lifetime, making it an ideal lighting source for renewable-energy-powered street lighting applications. According to CIE 115:2023, effective street lighting design should satisfy minimum illuminance requirements while ensuring appropriate lighting uniformity, glare control, and optimized pole spacing to improve road safety and visual comfort. The guidelines recommend that lighting design should be adapted to roadway classification, traffic density, and surrounding environmental conditions to maximize lighting performance and user safety (Commission Internationale de l'Eclairage [CIE], 2023).
At the national level, Badan Standardisasi Nasional (BSN) (2022) established the Indonesian standard for Public Street Lighting through SNI 7391:2022, which specifies design criteria including pole height, luminaire spacing, lighting levels, installation geometry, and overall lighting quality. Compliance with these standards ensures that street lighting systems provide adequate visibility while maintaining energy efficiency and minimizing operational costs.

Overall, previous studies indicate that photovoltaic-powered LED street lighting systems are technically reliable, economically feasible, and environmentally sustainable. Nevertheless, several studies also identified practical challenges affecting long-term system performance, including proper site selection, solar panel orientation, battery maintenance, periodic cleaning of photovoltaic modules, and routine inspection of electrical components. These factors directly influence energy generation, battery lifespan, lighting reliability, and overall system efficiency. Therefore, appropriate planning, correct equipment sizing, and regular maintenance are essential to ensure the successful implementation of solar-powered Public Street Lighting systems. The findings from these previous studies provide a strong theoretical foundation for the present research, which focuses on the design of a photovoltaic-based Public Street Lighting system for Suka Maju Indah Village. By considering international lighting standards, renewable energy principles, and engineering design parameters, the proposed system is expected to improve roadway safety, enhance public security, reduce dependence on grid electricity, lower operational costs, and support sustainable rural infrastructure development.

3. Method

This study employed a quantitative approach using a systematic technical planning method to design and analyze a Solar Photovoltaic (PV)-based Public Street Lighting (PSL) system for Suka Maju Indah Village, Deli Serdang Regency, North Sumatra, Indonesia. The research focused on evaluating existing road conditions, determining lighting requirements, sizing the photovoltaic power system, and developing an energy-efficient street lighting design in accordance with SNI 7391:2022 and CIE 115:2023 standards. The research was conducted in Suka Maju Indah Village, where a road segment approximately 100 meters long and 4 meters wide currently lacks public street lighting. This condition has reduced nighttime visibility and raised concerns regarding traffic safety and public security, making the location suitable for the implementation of a standalone solar-powered street lighting system.

Data collection was carried out using three complementary methods. First, direct interviews were conducted with the Village Head and neighborhood leaders (RT/RW) to obtain information regarding existing lighting conditions, community needs, and local infrastructure. Second, field observations and site measurements were performed to determine roadway dimensions, identify suitable lighting pole locations, evaluate environmental conditions, and record the existing road geometry. Third, a literature review was conducted to obtain technical specifications of photovoltaic modules, LED luminaires, batteries, solar charge controllers, and applicable national and international design standards.

The primary data collected included the roadway length (100 m), roadway width (4 m), required lighting operating time (12 hours per night), and the average Peak Sun Hours (PSH) for Deli Serdang (4.8 kWh/m²/day). Secondary data consisted of photovoltaic module specifications, battery characteristics, LED lamp performance, solar charge controller specifications, solar radiation data, SNI 7391:2022, CIE 115:2023, and technical information obtained from manufacturers' datasheets and scientific publications.

The design process followed a systematic engineering procedure consisting of: (1) problem identification, (2) literature review, (3) field survey, (4) road geometry measurement, (5) solar resource assessment, (6) lighting requirement analysis, (7) LED luminaire selection, (8) pole height and spacing design, (9) photovoltaic system sizing, (10) battery capacity calculation considering an 80% Depth of Discharge (DoD), (11) solar charge controller (SCC) selection, (12) system efficiency evaluation, and (13) preparation of the final street lighting design.

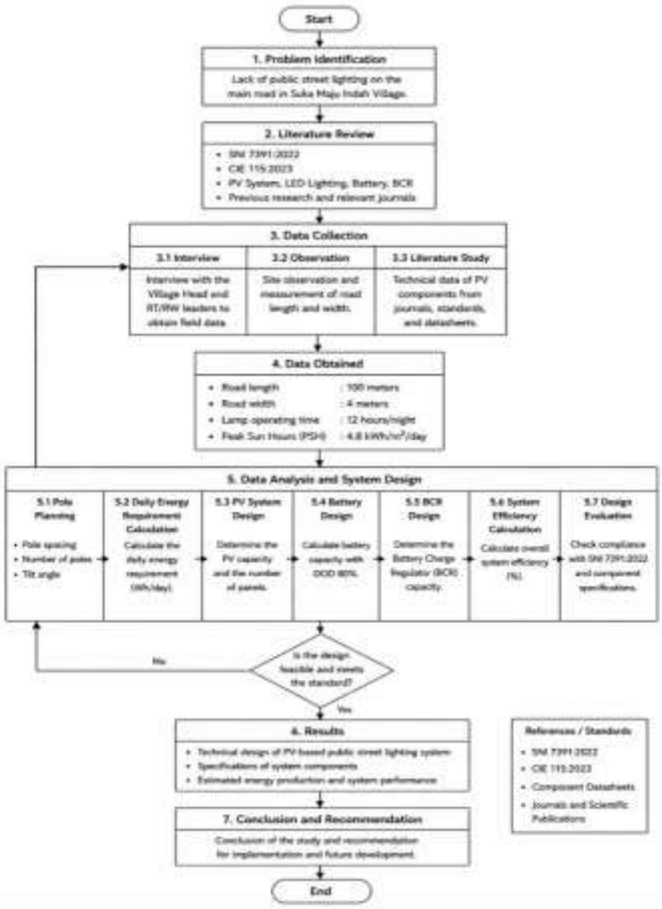

Figure 4. flowchart System.

Engineering calculations were performed using standard photovoltaic design equations. Daily electrical energy demand was calculated based on lamp power and operating hours. The required photovoltaic capacity was determined using the average Peak Sun Hours (PSH) with an appropriate system loss factor. Battery capacity was calculated to ensure continuous nighttime operation while considering the allowable Depth of Discharge (DoD), and the minimum solar charge controller capacity was determined

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according to the total photovoltaic output current. Pole spacing, mounting height, illuminance level, and lighting uniformity were designed according to the recommendations of SNI 7391:2022and CIE 115:2023.

Finally, all collected data and calculation results were analyzed to evaluate the technical feasibility and energy performance of the proposed photovoltaic-based Public Street Lighting system. The evaluation focused on the adequacy of roadway illumination, compliance with lighting standards, optimization of photovoltaic system components, reduction of electricity consumption, and the overall efficiency and sustainability of the proposed design. The final design is expected to provide a reliable, energy-efficient, and environmentally friendly street lighting solution for Suka Maju Indah Village.

4. Result

Existing Road Conditions

The study was conducted on a 100-meter road section in Suka Maju Indah Village, Deli Serdang Regency, North Sumatra, where no Public Street Lighting (PSL) facilities are currently installed. The road has a width of approximately 4 meters and serves as an access route for local residents. Field observations indicated that the absence of street lighting has reduced nighttime visibility, increased the risk of traffic accidents, and created security concerns for pedestrians and motorists. The proposed system utilizes a standalone Solar Photovoltaic (PV)-powered Public Street Lighting (PSL)configuration to eliminate dependence on the utility grid while ensuring reliable nighttime illumination.

Table 1. Road Geometry

Parameter	Value
Road length	100 m
Road width	4 m
Road classification	Local Residential Road
Operating time	12 hours/night
Average Peak Sun Hours (PSH)	4.8 kWh/m²/day

The street lighting layout was designed based on the requirements of SNI 7391:2022 for residential roads. A lighting pole height of 7 m was selected to provide adequate illumination while maintaining good lighting uniformity along the roadway. The spacing between poles was calculated using the standard relationship:

$S=3H$

where:

a. S = Pole spacing (m)
b. H = Pole height (m)

Substituting the selected pole height:

$S=3\times7=21$ m

Considering the roadway length of 100 m, the required number of lighting poles was determined as

$$N=21100=4.76\approx5 \text{ poles}$$

Therefore, five lighting poles were required to provide continuous illumination along the entire roadway. To ensure that the light beam was directed toward the center of the road, the inclination angle of the luminaire arm was also calculated.

Lighting Design

The lighting system was designed according to SNI 7391:2022 and CIE 115:2023.

Table 2. Design Criteria

Parameter	Design Value
Pole height	7 m
Pole spacing	25 m
Number of poles	5 units
Lamp type	LED
Lamp power	50 W
Average illuminance	8–10 lux
Lighting uniformity	≥0.4

Using a 7-meter pole height and 25-meter spacing, the proposed design provides continuous illumination across the 100-meter roadway while minimizing dark areas.
The daily energy consumption was calculated using
$E=P\times t$
where

a. Lamp power = 50 W
b. Operating time = 12 h/day

For one lamp,
$E=50\times 12=600$ Wh/day
For five lighting units,
$E_{total}=5\times 600=3000$ Wh/day
Total daily electrical energy requirement = 3.0 kWh/day

Figure 5. Lightening Condition

Battery and Solar Charge Controller Design

The required battery capacity was determined from the total daily electrical energy consumption.

C==100 Ah, To improve battery lifetime, an allowable Depth of Discharge (DoD) of 80% was considered. CActual= 125 Ah. Since commercially available batteries are typically rated at 100 Ah, each lighting unit was designed using two 100-Ah batteries connected in parallel, providing a total storage capacity of 200 Ah per lighting point.

The total stored electrical energy for each lighting unit is

$$E_{Battery}=200\times24=4800\ Wh$$

which provides adequate reserve capacity for continuous operation during periods of low solar radiation.

The required Solar Charge Controller (SCC) current rating was calculated as

$$I=8.33\ A$$

Accordingly, a 10 A MPPT Solar Charge Controller was selected to maximize charging efficiency and improve overall system performance. Considering photovoltaic conversion efficiency, battery efficiency, and controller efficiency, the overall system efficiency was estimated as

$$\eta=0.85\times0.95\times0.90=72.67\%$$

The calculated efficiency indicates that the proposed photovoltaic system is capable of supplying the required electrical energy while maintaining stable and reliable operation.

Table 3. The recommended Public Street Lighting system consists of:

Component	Specification
LED Lamp	50 W
Pole Height	7 m
Pole Quantity	5 units
Pole Spacing	25 m
Solar Panel	140 Wp × 5
Battery	12 V 100 Ah × 4
Solar Charge Controller	MPPT 60 A
Operating Time	12 h/night

System Performance.

Based on the proposed design, the system is expected to:

a. Provide an average illuminance of 8–10 lux, meeting the requirements for residential roads.
b. Operate continuously for 12 hours every night.
c. Reduce dependence on grid electricity by 100%.
d. Utilize renewable solar energy with zero operational carbon emissions.
e. Require relatively low maintenance due to the long service life of LED luminaires and photovoltaic modules.
f. Improve road safety, visibility, and public security in Suka Maju Indah Village.

The results demonstrate that a standalone photovoltaic-based Public Street Lighting system is technically feasible for the selected study area. The calculated 700 Wp photovoltaic capacity, combined with a 400 Ah battery bank and 60 A MPPT charge controller, is capable of supplying the daily energy demand of 3.0 kWh while maintaining reliable nighttime operation.

The proposed design complies with SNI 7391:2022 and CIE 115:2023 recommendations regarding illuminance, pole spacing, and lighting quality. Furthermore, replacing conventional grid-powered street lighting with photovoltaic-powered LED luminaires eliminates electricity costs, reduces greenhouse gas emissions, and supports Indonesia's renewable energy development goals. Therefore, the proposed system offers a technically sound, economically attractive, and environmentally sustainable solution for improving public street lighting in Suka Maju Indah Village.

5. Conclusion

This study successfully developed a Solar Photovoltaic (PV)-based Public Street Lighting (PSL) design for Suka Maju Indah Village, Deli Serdang Regency, as a sustainable solution to improve road illumination and enhance public safety. The proposed design consists of five standalone street lighting units installed along a 100-meter roadway, with a pole spacing of 21 meters in accordance with the design recommendations of SNI 7391:2022. Each lighting unit is equipped with a 40 W LED luminaire operating for 12 hours per night, one 100 Wp photovoltaic panel, two 24 V/100 Ah batteries, and a 10 A MPPT Solar Charge Controller. Engineering calculations indicate that the proposed system requires a total daily energy consumption of 2,400 Wh, with an estimated overall system efficiency of 72.67%. The standalone configuration enables each lighting unit to operate independently without relying on the national electricity grid (PLN), thereby improving system reliability and eliminating monthly electricity costs. The proposed design also supports the use of renewable energy while reducing greenhouse gas emissions and long-term operational expenses. Based on field observations, the road curve identified as the most critical section, where traffic accidents and safety concerns are more likely to occur, has been prioritized as the first installation location. The implementation of the proposed PV-based street lighting system is therefore expected to significantly improve nighttime visibility, road safety, and public security in Suka Maju Indah Village while promoting sustainable rural infrastructure development. For future research, it is recommended to perform a Life Cycle Cost (LCC) analysis and Break-Even Point (BEP)evaluation to assess the long-term economic feasibility of the proposed system. In addition, future studies may incorporate lighting simulation software, such as DIALux Evo, to optimize illuminance distribution, lighting uniformity, and overall system performance before full-scale implementation.

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