

Implementation of Solar Street Lighting for Empowering Rural Communities

Ahmad Zaidi Abdullah^{1}, Nurhafiza Azizan¹, Zulhasrizal Bohari²*

¹Faculty of Electrical Engineering & Technology, 02600 Arau Universiti Malaysia Perlis, Malaysia

²Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka 76100 Ayer Keroh, Malaysia

Abstract. The integration of renewable energy solutions in humanitarian projects addresses the challenges faced by underserved communities. This paper explores the design and implementation of solar street lighting systems for humanitarian efforts, aiming to enhance safety, extend productive hours, and improve quality of life. We analyze lighting needs in various contexts, such as refugee camps and rural villages, focusing on appropriate solar technologies, optimal placement, and environmental resilience. The implementation strategy includes community engagement, local maintenance training, and partnerships for sustainability. Case studies from Sub-Saharan Africa and Southeast Asia highlight practical challenges and innovative solutions, showing significant improvements in safety, economic activities, and social well-being. Recommendations for policymakers, engineers, and humanitarian workers emphasize best practices for deploying solar street lighting, underscoring renewable energy's potential to boost sustainable development and humanitarian impact.

1 Introduction

In recent years, the need for sustainable energy solutions in humanitarian projects has become increasingly apparent. With over 1.1 billion people worldwide lacking access to reliable electricity, communities in underserved regions face significant challenges related to safety, productivity, and overall quality of life [1-2]. Solar street lighting presents a viable solution to these issues, offering a renewable, cost-effective, and sustainable alternative to traditional lighting methods.

Solar street lighting systems harness solar energy to provide illumination, thereby reducing reliance on non-renewable energy sources and mitigating the environmental impact associated with conventional lighting. These systems are particularly beneficial in humanitarian contexts such as refugee camps, rural villages, and disaster-affected areas, where infrastructure is often limited or damaged. By improving visibility, solar street lighting enhances security, enables extended hours of economic and social activities, and contributes to a sense of community well-being [3-4].

The design and implementation of solar street lighting for humanitarian efforts require a multi-faceted approach. This involves assessing the specific lighting needs of the community, selecting appropriate solar technologies, optimizing the placement and configuration of lights, and ensuring the resilience of the systems against environmental

* Corresponding author: zaidiabdullah@unimap.edu.my

factors. Additionally, successful implementation hinges on engaging the community, training local personnel for ongoing maintenance, and establishing partnerships with local and international organizations to ensure long-term sustainability [5-6].

This paper aims to provide a detailed analysis of the design and implementation processes of solar street lighting systems in humanitarian settings. The case studies from Arau, Perlis, Malaysia illustrating the practical challenges encountered and the innovative solutions employed. Through this exploration, we seek to offer actionable insights and recommendations for policymakers, engineers, and humanitarian workers, emphasizing the potential of renewable energy technologies to foster sustainable development and enhance the impact of humanitarian initiatives [7].

Solar street lighting has seen significant global adoption due to its sustainability and cost-effectiveness, particularly in areas with abundant sunlight and unstable electricity supplies. Studies show that solar street lights are beneficial in off-grid regions, enhancing safety and reliability. Examples from rural India and African countries like Kenya and Nigeria highlight successful implementations, demonstrating improvements in nighttime visibility, safety, and local economies [8-9].

The benefits of solar street lighting in humanitarian contexts are manifold. Environmentally, they reduce carbon emissions by using renewable energy. Financially, they offer long-term cost savings by eliminating electricity costs and requiring less maintenance compared to traditional streetlights. Socially, improved lighting can reduce crime rates and accidents while fostering economic activities by extending business hours and enabling safe social gatherings. Moreover, they provide energy independence, crucial in regions with unreliable national grids, ensuring continuous lighting during emergencies [10].

Despite these benefits, several challenges hinder the implementation of solar street lighting in humanitarian settings. High initial costs, technical issues, and maintenance requirements are significant barriers. Additionally, logistical challenges in transporting and installing these systems in remote or conflict-affected areas complicate efforts. Community acceptance and involvement are also critical for the success and sustainability of these projects. Addressing these challenges through community engagement, proper training, and securing funding is essential for maximizing the potential of solar street lighting in humanitarian efforts.

2 Methodology

The installation of solar street lighting was in Kg Sena, Perlis, was designed to ensure the project's success and sustainability, with a strong emphasis on community involvement and capacity building. The specification lighting as shown in Figure 1. The process was divided into four main phases: planning and assessment, community engagement, installation, and knowledge sharing.



Fig. 1. Specification of 1000w solar streetlight complete with pole

2.1 Planning and Assessment

A detailed site survey was conducted to identify optimal locations for the solar streetlights, focusing on high-traffic areas, community centers, and previously underlit spots that posed safety risks. This assessment was crucial to ensure effective lighting coverage and maximize community benefits. Then technical evaluations were carried out to determine solar insolation levels, identify potential shading obstacles, and assess the structural integrity of installation sites. This ensured that the solar panels would receive maximum sunlight, thereby optimizing their performance. A meticulous plan for resource allocation was developed, involving the procurement of high-quality solar panels, batteries, LED lights, and mounting hardware. The budget was managed to balance cost-effectiveness with the need for durable and efficient components.

2.2. Community Engagement

Multiple consultations with the local community were held to explain the project’s objectives, benefits, and the ways residents could contribute. These consultations were essential for fostering community ownership and cooperation. Key stakeholders, including local leaders, community organizations, and residents, were actively involved in the planning phase. Their input was invaluable in identifying priority areas and addressing specific community concerns. Community volunteers were trained in the basics of the installation process and safety protocols. This training not only facilitated the installation but also equipped the community with the skills necessary for minor maintenance tasks in the future.

2.3. Installation

The installation process began with site preparation, which included digging holes for the poles and ensuring stable foundations. Proper alignment was crucial to maximize solar panel efficiency. Solar panels were mounted on poles at optimal angles to capture the most sunlight. Each unit was securely fixed to withstand local weather conditions. The solar panels, batteries, and LED lights were carefully wired together, using waterproof connectors and protective conduits to safeguard the system from environmental damage. Each unit underwent thorough testing to ensure proper functionality. This included checking the battery charge, automatic on/off function, and overall illumination effectiveness.

2.4. Knowledge Sharing

Following the installation, educational workshops were conducted to explain the basics of solar photovoltaic technology to the community. These workshops covered system operation, the importance of regular maintenance, and safety precautions. Detailed training sessions taught community members how to perform routine maintenance tasks, such as cleaning solar panels, checking battery health, and troubleshooting common issues. Instructional manuals and contact information for technical support were provided to the community. Additionally, a schedule for periodic maintenance checks was established to ensure the system's longevity. A feedback mechanism was implemented to gather community insights on the solar street lights' performance. Follow-up visits were planned to monitor the systems and provide additional support as needed.

3 Results and Discussion

The installation process of 10 units of solar street lighting in Kg Sena, Perlis, was a collaborative effort involving both technical experts and community members. It started with a site assessment to determine optimal locations for the lights, prioritizing high-traffic and previously underlit areas. Community meetings were held to inform and engage residents, ensuring their input and support. The installation team, which included trained local volunteers, began by setting up poles and mounting the solar panels and LED fixtures as shown in Figure 2. Wiring and connections were carefully managed to ensure safety and efficiency. Local volunteers received hands-on training for basic maintenance and troubleshooting, fostering a sense of ownership and sustainability. The project concluded with a community event to celebrate the new lighting, emphasizing the importance of ongoing maintenance and community involvement.



Fig. 2. Humanitarian activity by installing solar street light complete with pole

During night, around 7:30 pm, the solar streetlight was automatically switch on as programmed. Figure 3 show the differentiate between before and after installation of the streetlight. Before the installation of 10 units of solar street lighting in Kg Sena, Perlis, the village faced numerous challenges due to inadequate lighting, such as increased safety risks, restricted evening activities, and limited social and economic opportunities after dark.

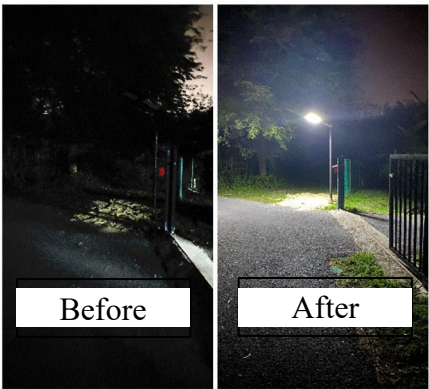


Fig. 3. Comparison between before and after installation solar streetlight at rural.

The community relied on dim, unreliable sources of light, which hindered mobility and contributed to a sense of insecurity. After the installation, the area experienced a significant transformation. The new solar streetlights provided consistent and bright illumination, enhancing safety and allowing residents to move freely and confidently at night. This improvement also extended business hours, facilitated community gatherings, and contributed to a stronger sense of community well-being and development.

Figure 4 shows after completing the installation of 10 solar streetlights in Kg Sena, Perlis, a knowledge-sharing session with the community to ensure long-term sustainability and empowerment was organized. This session covered the basics of solar photovoltaic technology, explaining how solar panels convert sunlight into electricity and the importance of regular maintenance for optimal performance. Routine tasks such as cleaning the panels, checking battery health, and troubleshooting common issues was demonstrated. Additionally, informational materials and contact details for technical support also provided. By educating the community on the functionality and upkeep of their new solar streetlights, the foster self-reliance and ensure the benefits of the project are aimed to sustained for years to come.



Fig. 2. After installation, sharing knowledge on topic solar photovoltaic is a must.

4 Conclusions

The literature highlights the significant potential of solar street lighting in improving safety, security, and economic activities in humanitarian contexts. While there are clear benefits, addressing the challenges related to costs, technical issues, maintenance, logistics, and community involvement is crucial for the successful implementation of these projects. Further research and collaboration among governments, NGOs, and the private sector are needed to develop sustainable and scalable solutions for solar street lighting in humanitarian efforts.

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