KERIGAN
Jurnal Pengabdian Masyarakat
Volume 4, Nomor 2, October 2026, Halaman 89-103
DOI: https://doi.org/10.21274/kjpm.2026.4.2.89-103

Community Empowerment through Solar-Powered Street Lighting to Support the Renewable Energy Transition in Nglutung Village, Sendang District, Tulungagung Regency

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Volume
4
Issue
2
Page
89-103
Year
2026

Article History

Submission: 17-09-2026
Review: 01-10-2026
Accepted: 21-10-2026

Keyword

Solar Panel; Renewable Energy; Street Lighting; Energy Independence.

How to cite

Rokhim, Lusiana Dewi Anggraini, IKK Asyfiana, Mila Umil Habibah, Muhamad Eka Zuli Kurniawan, Hakim Tobroni HR, Naimatul Khoiroh. (2026). Article Title. Jurnal Pengabdian Masyarakat, Volume 4 (2),89-103 https://doi.org/10.21274/kjpm.2026.4.2.89-103

Abstract

Purpose: This study aims to improve street lighting through the implementation of solar-powered renewable energy technology in Nglutung Village, Sendang District, Tulungagung Regency, while introducing the use of solar energy and strengthening community capacity to support the maintenance and sustainable use of the system.
Method: The community service activity implemented a solar-panel-based energy system using 600-watt solar panels. The electricity generated by the panels was stored in batteries and used to operate the street lighting and other electrical equipment.
Practical Applications: The implementation of solar energy improves street lighting quality, especially in areas with limited access to conventional electricity. It also reduces dependence on generators and supports the use of environmentally friendly and sustainable energy sources.
Conclusion: Solar-panel-based renewable energy is a practical and sustainable alternative for village street lighting applications. The system supports energy independence, improves lighting quality, and contributes to the transition to renewable energy in rural communities.

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Introduction

Energy is an essential resource that supports various aspects of community life (Avila Souza, 2024). Developments in social and economic activities have led to a continuous increase in the demand for electrical energy worldwide (Hu & Mu, 2022). Electricity is used not only to meet household needs but also plays an important role in supporting public facilities, economic activities, education, transportation and environmental security (Sapthu, 2023). Adequate energy availability contributes to creating a safe, comfortable, and productive community environment. Therefore, providing energy that can effectively meet community needs should be part of development efforts, including those in rural areas (Handayani et al., 2024).

As the demand for energy continues to increase, the use of sustainable energy sources is becoming increasingly important (Almabrouk & Ali Abulifa, 2023). To date, most energy needs still depend on conventional energy sources, the use of which can cause various problems, particularly regarding resource availability and environmental impacts (Parvez & Chaubey, 2023). This condition encourages efforts to develop alternative energy sources that are more environmentally friendly and can be utilised sustainably in the future. Solar energy is a promising energy source with great potential for development (Khan et al., 2022). The sun is a potential energy source for human needs, as its energy can be obtained from either the heat reaching the Earth's surface or sunlight falling on the Earth's surface (Liu et al., 2021). As a tropical country, Indonesia has considerable solar irradiation potential that can be utilised as an energy source using solar panel technology.

Renewable energy is a solution to the energy problems occurring worldwide because it is continuously available and can reduce dependence on conventional energy sources (Farghali et al., 2023). The utilisation of solar energy through solar panels is one form of renewable energy application that is increasingly relevant to the community (Meredith, 2024). This technology works by converting solar energy into electrical energy, which can then be used directly or stored in batteries for later use. Solar energy utilisation has the advantage of relying on a naturally available energy source and does not require fuel, as fossil-fuel-powered generators do (Osman et al., 2023). Therefore,

this technology can serve as an alternative to meet certain electricity needs, particularly in public facilities such as roads or locations requiring independent lighting systems.

Street lighting is a relatively simple energy need that plays an important role in community life. Street lighting is part of the road-supporting infrastructure that can be placed or installed on either side of a road or in the middle to illuminate the road and its surrounding environment (Prasetyo et al., 2025). Street lighting provides illumination at night and supports community safety and comfort when people carry out activities or travel after dark. Adequate road lighting helps road users see the surrounding conditions more clearly, reduces the risk of accidents, and provides a sense of security for the community (Uttley et al., 2025). Conversely, poorly lit roads can create difficulties for residents, particularly in areas with nighttime mobility or locations that are relatively far from residential centres.

Several previous community service programs have demonstrated the application of solar-powered street lighting as an alternative solution for improving lighting conditions in rural and community areas (Analieva et al., 2023). These programs generally emphasise the installation of solar-powered lighting infrastructure and the introduction of renewable energy technology into local communities. The application of solar-powered street lighting has the potential to provide lighting in areas where conventional electricity infrastructure is limited or where additional lighting facilities are needed. However, the sustainability of community-based renewable energy programs is not determined solely by the availability and installation of technology (Hudișteanu et al., 2025). Community understanding, involvement, and capacity to use and maintain the installed system are also important aspects of supporting the continued utilisation of technology.

In this context, community empowerment is relevant to the implementation of renewable energy technologies. Community involvement can help residents understand the function of the technology, recognise the basic components of the system, and participate in its maintenance (Global & Kazanskaia, 2025). Previous community-based renewable energy initiatives have shown that the introduction of technology accompanied by community involvement can support the adoption and sustainability of renewable energy at the local level (Uzorka et al., 2024). Nevertheless, some initiatives have primarily focused on the technical installation of solar-powered

street lights, while community capacity building related to the use and maintenance of the system may receive less attention. This provides an opportunity for community service programs to integrate the provision of lighting infrastructure with community education and capacity building.

Street lighting was one of the conditions identified in Nglutung Village, Sendang District, Tulungagung Regency. Based on observations of the village environment, several road points still have inadequate lighting. Consequently, some road sections are poorly lit at night. This problem was particularly noticeable at certain points located relatively far from existing light sources or without adequate street lighting facilities. Although the problem did not occur throughout the entire village, the existence of several poorly lit points remained an issue requiring attention because it was directly related to community comfort and safety of the residents.

Insufficient lighting at several road points can affect community participation. At night, people using these roads require adequate illumination to see the road conditions and surrounding environment (Uzorka et al., 2024). Dark roads can also increase concerns when travelling at night. Thus, providing lighting at points that remain poorly illuminated is not only related to physical infrastructure but is also part of an effort to create a safer and more comfortable environment for the community to use.

To address this problem, a solution is needed that can provide lighting while considering the efficiency and sustainability of the energy source used. One alternative is the use of solar-powered streetlights. Solar-powered lights utilise solar energy as their primary energy source through solar panels. A solar cell, or solar panel, is an electronic device designed to convert solar energy directly into electrical energy via the photovoltaic effect. They are made of semiconductor materials, usually silicon, which can absorb light energy. When photons from sunlight strike a solar cell, electrons are released from the material, creating an electric current (Shaker et al., 2024). Thus, the energy obtained from sunlight is converted into electrical energy and stored in batteries. The stored energy can then be used to power lights at night. This system allows lights to operate without directly depending on conventional electricity networks, making it suitable for specific points requiring additional lighting.

Therefore, the implementation of solar-powered street lights in Nglutung Village is designed not only to address the identified lighting problem but also to introduce the practical application of renewable energy to the local community. The program

combines the provision of solar-powered street lighting infrastructure with community involvement in understanding the basic operation and maintenance of the system. Through this approach, residents are expected to gain practical knowledge and the capacity to support the continued use and maintenance of the installed technology.

The present program differs in its emphasis on integrating the installation of solar-powered street lighting with community empowerment in Nglutung Village. Rather than focusing solely on the provision of lighting infrastructure, the program seeks to involve the community in the introduction, utilisation, and basic maintenance of renewable energy systems. This approach is expected to provide immediate benefits in the form of improved nighttime street lighting and longer-term benefits through increased community understanding and capacity to utilise renewable energy technology. Therefore, the program aims to contribute to the development of sustainable community-based renewable energy utilisation in rural areas of the country.

Method

This community service activity employed a qualitative descriptive method with a participatory approach (Vaughn, 2024). The qualitative descriptive method was used to describe the existing street lighting conditions, the process of installing solar-powered street lights, community involvement, and the observed benefits following the implementation. A participatory approach was applied by involving village officials and community members in the identification of lighting needs, selection of installation locations, implementation, and evaluation of the project. This approach was selected because the activity was not solely focused on the technical installation of solar-powered lights but also considered local conditions and community needs. According to (Greckhamer & Cilesiz, 2022), qualitative research examines objects in their natural conditions, with the researcher serving as the main instrument and emphasising meaning rather than generalisation of results.

The activity was conducted from 15 July to 21 August as part of the Community Engagement Program (Kuliah Kerja Nyata/KKN) in Nglutung Village, Sendang District, Tulungagung Regency, Indonesia. The implementation consisted of six stages: assessment, planning, implementation, community orientation, monitoring, and evaluation.

1. **Assessment**

   The assessment stage involved field observations and site surveys to identify street lighting conditions and locations requiring additional illumination. The assessment was conducted with village officials by observing road conditions, nighttime lighting needs, community activities, safety considerations, and the availability of sunlight for solar panels. Discussions with local community members were conducted to identify locations that required additional street lighting. Based on these observations and discussions, several locations were identified as potential installation points for the proposed system.

2. **Planning**

   The planning stage involved determining the priority locations, installation requirements and implementation schedule. Based on field observations and discussions with the local community, ten points were selected as priority locations for the installation of solar-powered street lights. The selection considered inadequate nighttime lighting, community activity, safety needs, sufficient sunlight exposure for solar panels, and local community requirements. Two installation points were allocated in each of the five hamlets: Tlogo, Wotgalih, Badong, Cerme and Pakel. The required equipment, including solar panels, lamps, batteries, poles, and other supporting components, were prepared during this stage.

3. **Implementation**

   The implementation stage consisted of preparing and installing solar-powered street lights at designated locations. Before installation, the completeness and condition of the solar panels, lamps, batteries, and other supporting equipment were checked. Installation was gradually carried out in each hamlet with the involvement of Nglutung Village officials. Their involvement helped ensure that the installation points corresponded with the identified community needs and the local environmental conditions. After installation, the position of the solar panels, component connections, and lamp functions were checked to ensure that the system operated properly.

4. **Community Orientation**

   Following installation, information was provided to community members and village officials regarding the function and use of the solar-powered street

lighting system. The activity introduced the basic functions of solar panels, batteries, and lighting systems and emphasised the importance of maintaining the installed facilities. Community involvement at this stage was intended to support the understanding of the technology and encourage local participation in maintaining the system.

5. Monitoring

Monitoring was conducted after installation to observe the performance of the solar-powered street lights. The monitoring focused on whether the lights operated at night, illumination conditions around the installation points, and general condition of the installed components. Communication with community members and village officials was conducted to identify any initial problems or responses related to the operation of the lights.

6. Evaluation

The evaluation stage involved assessing the observed results of the installation and collecting responses from community members and the village officials. The evaluation focused on changes in nighttime lighting conditions, perceived usefulness of the lights for community activities, and the community's understanding of the function and maintenance of the solar-powered lighting system. Documentation was collected throughout the activity, including the preparation, installation, and completion stages. The observation results, community responses, and documentation were subsequently analysed descriptively to provide an overview of the implementation and utilisation of solar-powered street lights as an alternative lighting solution in the Nglutung Village.

Result and Discussion

The implementation of the community service program in Nglutung Village resulted in the installation of 10 solar-powered street lights, with two units installed in each of the five hamlets: Tlogo, Wotgalih, Badong, Cerme, and Pakel. The installation points were identified through field surveys conducted with village officials, focusing on road sections with inadequate nighttime lighting, particularly locations that were relatively far from residential areas and required additional illumination. The selection of installation points considered local lighting needs, community activities, safety considerations, and the availability of sunlight for solar panel operation.

Picture 1. Trial of solar panel lights

The installation process was conducted gradually at the designated locations. Before installation, the solar panels, lamps, batteries, poles, and supporting components were checked to ensure their completeness and good condition. After installation, the positions of the solar panels, component connections, and lighting functions were checked. All 10 solar-powered street lights were observed to function properly, absorbing solar energy during the day and providing light at night. Previously poorly illuminated road sections subsequently received additional lighting, supporting community mobility and nighttime activities.

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Picture 2. Installation solar-powered lights

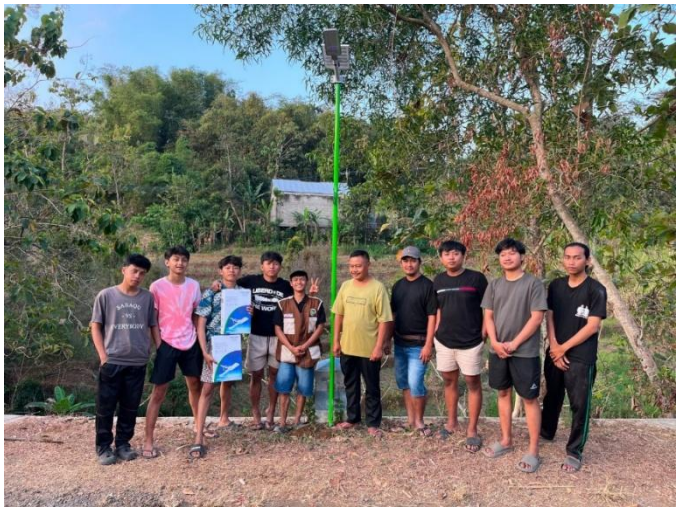
The improvement in nighttime lighting can be attributed to the selection of installation points based on actual field conditions and community requirements. Locations with inadequate lighting and relatively limited access to existing light sources were prioritised, allowing the intervention to directly address identified lighting gaps. This finding demonstrates that the effectiveness of solar-powered street lighting in rural areas depends not only on the technical performance of the equipment but also on the suitability of the installation location.

These findings are consistent with previous studies and community-based renewable energy programs that identify solar energy as an alternative to meet electricity needs in areas where conventional electricity infrastructure may not adequately support specific public facilitie (Asuni et al., 2023). In Nglutung Village, the installed system operates independently from the village electricity network because solar panels convert sunlight into electrical energy and store the generated energy in batteries for nighttime use. This mechanism is based on the photovoltaic effect, in which solar cells convert solar radiation into electrical energy (Lesala & Mukumba, 2025). The successful operation of the installed units demonstrates the practical potential of solar energy for localised public lighting.

The observed improvement in lighting has implications for community mobility, comfort, and perceived safety. Community members and village officials reported that the improved lighting made road conditions easier to see and provided greater comfort when travelling at night, particularly in locations that had previously lacked adequate lighting. This finding is consistent with that of (Yusuf et al., 2025), who explained that street lighting serves not only to provide illumination but also to support road-user safety and comfort. However, the community responses in this program represent perceived benefits and should not be interpreted as direct evidence of a measurable reduction in traffic accidents or crimes.

Several factors supported the program's implementation. The involvement of village officials facilitated the identification of priority locations and ensured that the selected points corresponded to local conditions. Community input also provided information on nighttime activities and areas requiring additional lighting. In addition, sufficient sunlight exposure at the selected locations supported solar panel operation.

These factors indicate that combining technical considerations with local knowledge is important for implementing renewable energy infrastructure in rural areas.



Picture 3. Installation of solar panel lights on posts at designated road locations

The program also provided an opportunity to introduce renewable energy technologies to the community. Through direct observation of the solar-powered lighting system, residents and village officials can gain practical awareness of how solar energy can be utilised for everyday public facilities. Community involvement is particularly relevant to the sustainability of such infrastructure because the continued operation of the system depends not only on the initial installation but also on its appropriate use, monitoring, and maintenance.

In addition to the installation of solar-powered street lights, the program included assistance in documenting and publishing community activities using digital media. This activity provided residents and village officials with opportunities to participate in the digital documentation and dissemination of village activities and events. Therefore, the digital literacy component functioned as a supporting element of the community empowerment process. However, because the activity primarily focused on documentation and publication rather than a structured digital literacy training program, its contribution should be interpreted as an accompanying outcome rather than the intervention's primary result.

Despite these positive results, several limitations should be considered. The program installed only 10 units, meaning that the improved lighting coverage was limited to the selected locations and did not encompass all roads in Nglutung Village.

In addition, the evaluation relied primarily on field observations and community responses and did not include quantitative measurements of illumination intensity, solar energy generation, battery performance or long-term maintenance costs. Therefore, the findings provide an initial description of the program's implementation and perceived benefits, rather than a comprehensive quantitative assessment of its long-term effectiveness.

Regular maintenance of solar panels, batteries, and other components is necessary to maintain system performance. Continued community involvement is important for identifying technical problems at an early stage and supporting the sustainability of installed facilities. Future community service programs could strengthen the intervention by providing structured maintenance training, conducting periodic technical monitoring, and using quantitative indicators, such as illumination intensity, battery performance, and energy generation.

From a rural community development perspective, the program demonstrates how small-scale renewable energy infrastructure can be integrated into community participation to address specific local needs. The intervention provided an immediate lighting facility while simultaneously introducing the practical application of renewable energy technology to the residents. The combination of infrastructure provision, community involvement, and continued maintenance has the potential to support the more sustainable utilisation of renewable energy at the village level.

Conclusion

Based on the findings presented above, the community service program resulted in the installation of 10 solar-powered street lights, with two units installed in each of the five hamlets in the Nglutung Village. Field observations indicated that all installed units functioned properly and provided additional lighting at road sections that previously had inadequate illumination. Community responses also indicated that improved lighting supported nighttime mobility and provided greater comfort when using illuminated road sections. The program also introduced the community to the practical use of solar energy for public lighting and provided opportunities for residents and village officials to participate in documenting and disseminating village activities through digital platforms. For students, the activity provided practical experience in

implementing a community-based renewable energy program and collaborating in the field.

To ensure the sustainability of the program, regular monitoring and maintenance of solar panels, batteries, lamps, and other supporting components are recommended. Continued involvement of village officials and the community is also needed to identify technical problems and maintain the functionality of the installed facilities in the long term.

Acknowledgments

We thank God Almighty for His blessings and guidance, which enabled us to complete the Community Service Program (KKN) and this journal. We would like to express our sincere gratitude to:

1. **Ns. Hakim Tobroni HR, S.Kep., M.Tr.Kep.**, as the field supervisor of the KKN program in Nglutung Village, for his guidance, support, motivation, and valuable feedback throughout the program.
2. **All KKN team members**, whose cooperation, dedication, ideas, and enthusiasm contributed to the successful implementation of the program.
3. **Mr. Katam, S.AP.,** as the Head of Nglutung Village, and the village administration, for their permission, support, and cooperation in facilitating our community service activities.
4. **The residents of Nglutung Village**, for their warm welcome, active participation, and support throughout the program.
5. **All institutions, agencies, and companies** that provided assistance and resources to support the implementation of the program.
6. **All other individuals** who contributed their time, support, and prayers to the successful completion of the program and this journal.

We sincerely appreciate every contribution and support that made this community service program possible.

Finally, we realise that this KKN activity is not only about the programs that have been implemented but also about the encounters, collaboration, and experiences that have left a lasting impression on both the community and us. May all forms of support and kindness that have been given be rewarded in the best possible way, and may the activities that have been carried out provide benefits and become a valuable experience for all.

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Volume ##, Nomor ##, Bulan Tahun, Halaman 101-101155
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