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ILLUMINATING LIVES: ENHANCING COMMUNITY SATISFACTION THROUGH SOLAR ENERGY IN INDIGENOUS SCHOOLS OF PAHANG

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Abstract

In remote Orang Asli communities, especially in Pahang, where the majority of these communities live, solar lighting is a practical way to address electricity shortages. Energy reliability is increased by incorporating solar lights into schools, which serve as important educational hubs and central gathering spaces for them. The purpose of this study is to evaluate the effectiveness of solar lighting applications for a remote school with 40 school users, who represent a diverse group of staff, who will participate voluntarily. In a case study conducted in Jerantut, the effects of solar lights are assessed using field installations, observations, and questionnaire surveys. The study assesses community involvement, sustainability, and energy efficiency. The findings show night illumination has significantly improved, going from 15 lux to 100 lux, and almost 90% of the respondents are satisfied. These results address important energy concerns in rural areas, foster a resilient learning environment, and add to the larger conversation on sustainable energy availability.

Keywords: Indigenous Community, School, Solar Lighting, Sustainable Energy

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INTRODUCTION

The Orang Asli were the first indigenous tribes to have settled in Malaysia, which they populated around 5,000 years ago amid the peninsula's thick rainforest (Mat Dong et al., 2022). As time passes, Orang Asli, who live inland or in the outback, are viewed as a marginalised group because they are unable to receive any facilities or incentives from the government, like schools (Nazmi et al., 2021). Besides that, the indigenous people have pivoted their lives to be closely related to nature; for instance, the forest serves as the basis for their primary income sources and economic activities (Ismail et al., 2024).

Living in remote areas has caused the Orang Asli limited access to government incentives for basic utilities such as electricity supply. According to Jamil et al. (2018), power interruptions that lead to blackouts during a natural disaster may interrupt the telecommunication networking of the people. Being part of a minority (0.7%) of Malaysia's overall population, which is estimated to be over 33 million, the power disruption issues that take place among the Orang Asli community do not get enough attention from the authorities (Mat Dong et al., 2022). The issues of electrification among these communities have led to many associated issues. Contrary to reports claiming Malaysia is 100 percent electrified, out of 142 Orang Asli villages, 17% of Orang Asli communities remain left behind and in the dark (Malaysia Kini, 2023). The rural communities' lack of basic infrastructure and facilities, such as schools, is a sign that they are usually overlooked by the authorities (Hayder & Kareem, 2015; Jamal & Naghmeh-Abbaspour, 2020).

The objective of the study is to evaluate the effectiveness of solar lighting applications for a remote school; one of the best solutions comes from utilising solar energy technologies for the institution. Malaysia has a great potential for solar uptake, as it is estimated that monthly solar irradiation for Malaysia is at 400-600 MJ/m² (Abdullah et al., 2019). One of the solar energy applications widely used is solar photovoltaic (PV) (Soonmin & Taghavi, 2022), through which sunlight is converted into electricity. Moreover, this type of solar lighting system is suitable for the Orang Asli communities, especially at schools, since solar lighting can bring low-cost and environmentally friendly lighting (Khan et al., 2019).

This study focused on the state of Pahang, where 37.9% of Orang Asli communities are situated (Hussain et al., 2017). The Jahut tribe is part of the Senoi tribe, and the population of Jahut in Jerantut and Temerloh is currently above 5000 and expanding (Idrus et al., 2023). Tok Batin, the community leader, mentioned that the Sungai Kiol settlement in Jerantut, Pahang, is home to approximately 200 Orang Asli Jahut families (Burhan et al., 2023), where they are more community-focused, and there is a school nearby, SK Sungai Kiol. The school for the indigenous communities in Kampung Kiol was chosen as the main

case study for this paper to assess the effectiveness of solar lighting applications for remote schools. Moreover, the school users comprise a diverse group of school staff who play a crucial role in enhancing the learning environment for the students participating in the surveys. Their perspective can help increase the engagement level of solar energy implementations among the students and the communities as well.

It thereby addresses critical knowledge gaps within the literature on sustainable planning and energy access through its specific focus on the context of Indigenous schools in Malaysia, hence practically proving the usefulness of solar energy in a resource-scarce educational setting. Desirably, this concept can guide the government in creating ‘solar communities,’ where locally generated solar energy is distributed and managed by the community (N. A. Ahmad et al., 2024).

LITERATURE REVIEW

Orang Asli is a term in the Malay language that translates to ‘original people’ or ‘*Orang Asal*’. According to Ahmad et al. (2015), Orang Asli account for 149,723 of the total population of 30 million people in Malaysia. In September 2021, the population of Orang Asli communities in Malaysia was estimated to be around 178,197 individuals. The distribution of Orang Asli indicated that Pahang and Perak have the highest and second-highest numbers in Peninsular Malaysia, respectively, as stated (see Table 6):

Table 6: Total Distribution of Orang Asli

STATES	DISTRIBUTION OF ORANG ASLI
Pahang	67,506
Perak	53,299
Selangor	17,587
Kelantan	13,457
Johor	13,139
Negeri Sembilan	10,531
Melaka	1,515
Terengganu	893
Kedah	270
TOTAL DISTRIBUTION OF ORANG ASLI: 178,197	

Source: (Hussain et al., 2017)

Issues of Electrification Disruption for Orang Asli Communities

Poor lighting in the evenings and at night simply makes them afraid to be outside because they are exposed to threats by wild animals that usually roam the area during that time (Mahmud et al., 2022). As mentioned by Mazlan et al. (2021), students would normally share illumination at school for group study sessions

after sunset, but this was less prevalent in their study environment because of the dangers of letting little children out after dark. Because of their restricted connectivity to the national electrical grid, these remote, rural settlements can benefit greatly from off-grid solar lighting systems, which are more reasonably priced, perform dependably year-round, and are quick and simple to install (Inc, 2017). The lack of electricity supply has far-reaching implications that significantly affect various aspects of the school-related activities among the Orang Asli, contributing to issues such as poverty (J. Abdullah et al., 2015), deprived education (Fitri et al., 2020), and restricted use of digital tools (Yasin, 2018).

i) Poverty

The lack of electricity forces Orang Asli communities to rely on kerosene, diesel generators, or firewood, which are inefficient energy sources: they face the greatest poverty rates, disproportionately bad health conditions, and a lack of basic infrastructure and services (Jamal & Naghmeh-Abbaspour, 2020).

ii) Deprived Education

Education is the main agenda in the Orang Asli's development program for Malaysia, and stable electricity that can give proper artificial lighting, which is most needed, especially for young children, to get themselves ready for school in the early morning, since it is still dark during that time (Azizul Sulaiman et al., 2020). Besides that, the lack of electricity also affects students' ability to study at home, where they cannot study effectively after dark, perhaps due to its location in a rural area: this predicament would negatively impact their studies (Abdullah et al., 2015).

iii) Restricted Use of Digital Tools

Modern educational resources, like computers and the Internet, are needed in rural areas to provide access to a vast amount of information. According to Sulaiman & Junaenah (2021), in places without electricity, teachers are unable to obtain online training, which restricts their ability to improve their teaching abilities, and Orang Asli students are deprived of these opportunities, resulting in a major educational disadvantage (Figueirêdo Neto & Rossi, 2019). The teachers find it difficult to apply creative teaching techniques that meet the cultural and academic needs of Orang Asli pupils when they lack access to digital learning platforms (Mazlan et al., 2021).

Studies assessing solar illumination's direct effects on lighting quality, safety, and satisfaction with use in indigenous schools are still lacking, despite research highlighting its advantages. Understanding community knowledge and involvement in the deployment of solar energy has also received scant attention.

To close this gap, a thorough analysis of community views and lighting performance improvements is necessary, offering important information for creating sustainable energy models for Orang Asli schools in Pahang.

Empowering Orang Asli Communities Through Solar Energy Technology Transfer Program

Orang Asli face multiple challenges, including low literacy rates and poor school attendance due to difficult transportation and road conditions (Bala & Tan, 2021). By providing reliable lighting and reducing dependence on conventional energy, solar energy can play a key role in addressing these issues. Therefore, technology transfer programs focused on solar energy are essential to empower Orang Asli communities, especially for students to further enhance educational opportunities and foster sustainable development.

The Suitable Types of Solar Lighting Technologies for Orang Asli

The minimal number of infrastructures due to the remote locations of the settlement makes access to centralized electrification limited to the village. This causes the communities to depend on traditional methods for producing electricity. Not having access to electricity has impacted the community's daily life, side incomes, and school attendance due to insufficient illumination (Munajat et al., 2021). Today, various types of solar lighting technologies are particularly suitable for the needs of Orang Asli communities (see Figure 5):

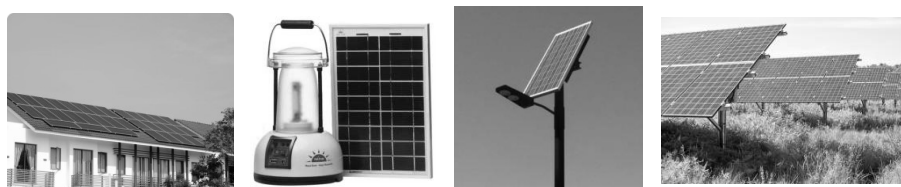


Figure 5: Solar Lighting Technologies

Source: Verdant Solar (2024), Moglix (2024), IndiaMART (2024), Energy Gov (2024)

(i) Solar Home Systems (SHS)

Solar Home Systems (SHS) are designed to provide electricity for household use in rural settings and do not rely on a connection to the national electricity grid, which is often unavailable in remote areas. SHS can provide a reliable and cost-effective alternative to diesel generators as the primary energy source for electricity (Khan et al., 2019).

(ii) Solar Lanterns and Portable Lights

Portable solar lanterns are small, rechargeable lights that are useful for students who need adequate lighting to study at night and for families to navigate their

homes safely after dark. According to Kudo et al. (2019), replacing kerosene lamps with solar products could potentially improve students' health, such as their respiratory systems, which may, in turn, positively affect academic performance.

(iii) Solar Street Lights

Solar streetlights are installed along pathways to improve the visibility and safety of the community, especially students who walk to school. With the aid of enhanced street lighting, dangers can be reduced, people are more encouraged to do outdoor activities and social interactions after dark: these contribute to a stronger sense of community. Lights are produced by absorbing solar energy during the daytime to convert it into electricity (Singh et al., 2019).

(iv) Solar Photovoltaic (PV) Systems

Solar Photovoltaic (PV) systems convert sunlight directly into electricity. Solar PV systems have a lifespan of around 10 years, making them a reliable source of energy for rural communities (Khan et al., 2019). These systems can power various applications, from lighting to small household appliances, enhancing overall living standards, offering flexible, dependable, and clean energy that is free of pollutants, which is more reliable (Hamid et al., 2018; Jamil et al., 2019).

METHODOLOGY

Research methods are the various procedures used by a researcher during a research study, and this research employs the exploratory approach in that area (Goundar, 2012; Hunter et al., 2019). This research used a mixed-method approach, consisting of a field survey and observation as qualitative methods and questionnaires for the quantitative method for data collection (see Figure 6), as the main objective is to evaluate the effectiveness of solar lighting applications for a school in a remote area.

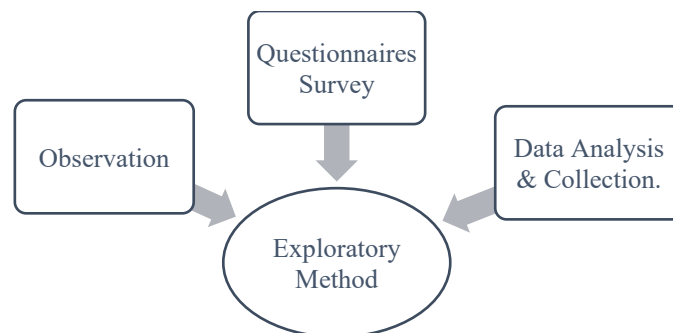


Figure 6: The Methodology Flowchart
Source: The authors (2023)

DATA COLLECTIONS

FIELD SURVEY AND OBSERVATION

The primary data was collected via a field survey, including direct observation and questionnaires. The observation was done during the field survey, where the researcher prepared a checklist that consisted of (i) the communities surrounding, (ii) solar efficiency, (iii) technology assessment, and (iv) safety impact, to address the issue of inadequate electricity supply, particularly in rural schools. During the observation, the location of Orang Asli settlements for communities surrounding the element was identified in deep forests with lush vegetation, as there were many surrounding trees: their heights and thick leaves can affect the performance of PV panels (Borhanazad et al., 2013). For solar efficiency, the sunlight exposure at the solar panel location was sufficient, and the solar panels were installed on the roof to avoid any shade from trees (Khan et al., 2019).

Next, for the technology assessment, PV systems present interesting technological possibilities, whereas the existing options used by indigenous people offer poor illumination for their children to go to school and pose health risks as they have been using kerosene oil lamps (J. Abdullah et al., 2015). Even with the lack of safety, 37% of 869 Orang Asli settlements remain rural and forested (Munajat et al., 2021). To observe the possibilities of adopting solar lighting technology for indigenous tribes, a daytime field survey was conducted in the school's area (Ahmad et al., 2015). The lack of electricity also affects students' ability to walk home or study at home, since darkness makes it challenging for them to study or do their homework. The checklists are sorted out according to the group of elements as a guide during the data collection based on the recommendation by Idrus et al. (2023), as shown in Table 7.

Table 7: Observation Checklist for the Field Survey

Element	Data
Communities Surrounding	The sunlight availability is based on the school's geographical location, the site orientation, and types of roofs used by the for solar installations.
Solar Efficiency	The sunlight exposure at the located solar panel that is installed on the roof, with no interference of potential shading from any structures or trees.
Technology assessment	The durability of the solar technologies installed at the school, and the community's willingness to learn the skill of repairing the technologies.
Safety impact	More social activities are done at nighttime, the communities' level of awareness and identify the areas that are required to improve for safety reasons in the school's area.

Source: (Idrus et al., 2023)

The observation was carried out during peak hours, approximately from 11:00 AM until 3:00 PM in the school's area. The temperature on the day of installation was 32°C, and the sky condition was clear. There are about 17 units of solar panels installed in selected areas of the school (see Table 8). The layout plan for solar installation is shown in Figure 8. Sekolah Kebangsaan Sg Kiol, which serves as both a school and a community gathering center, is built at an isolated location. The school is located far from the main road, and electricity is not always accessible. Due to the location of the school, inadequate lighting raises safety issues for both the community and the school. This might make criminal activity more likely to happen, particularly at night. The current condition of the school before the installation of solar lighting (see Figure 7).



Figure 7: The current condition at SK Sg Kiol in Jerantut, Pahang.

Source: The author (2023)

Table 8: The total of solar installations at SK Sg Kiol in Jerantut, Pahang.

Items	Units	Installation location
25 watts solar	1 x 3 locations: 3 units	Mini hostel, block A, badminton court
25 watts solar	2 units	Parking area
40 watts solar	1 x 2 locations: 2 units	Post guard, computer lab
60 watts solar	4 units	Canteen
60 watts solar	3 x 2 location: 6 units	Preschool playground, classroom area
Total	17 units	

Source: The author (2023)

The 17 units of solar panels, consisting of five (5) units of 25 watts, two (2) units of 40 watts, and 10 units of 60 watts, were installed at the school. The canteen area installed four (4) units of 60 watts; meanwhile, in the preschool playground and classroom area, three (3) units of 60-watt solar panels. At the mini hostel, badminton court, block A, post guard, and computer lab, only one (1) unit was installed, each from 25 watts and 40 watts, respectively. For the parking area, two (2) units of 25 watts were installed for proper lighting. The

installations empower Orang Asli communities, especially for the students who now enhance their educational opportunities and foster sustainable development through solar implementation at their school.

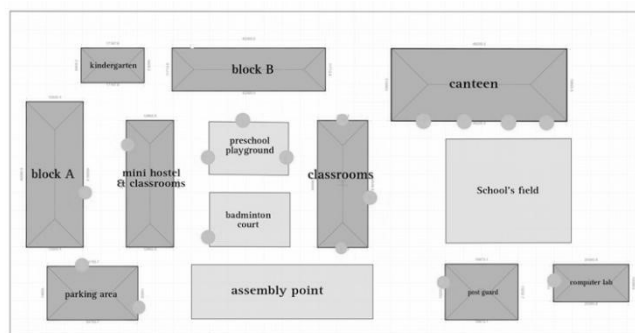


Figure 8: The layout plan of solar installation at SK Sg Kiol, Jerantut
 (Source: the author, 2023).

Remarks: The dots indicate the location where solar panels were installed

Questionnaires

The survey consisted of two sections, Section A and Section B, with 34 structured questions altogether. The questionnaire was developed ahead of time before the field survey to guarantee validity and the effectiveness of data collection. The primary purpose of the questionnaires was to gauge the Orang Asli's level of engagement in solar lighting technology by improving the lighting conditions in the school areas.

In the questionnaire, three (3) sections were designed. Section A is Respondent Information, where all the basic information about the respondents is required, and Section B consists of the question about "The Level of Awareness and the Involvement of the Rural Communities in Malaysia with Solar Energy," which consists of two (2) parts. The respondent's knowledge or engagement level among the communities will be identified in five (5) levels of agreement, where strongly disagree (SD), disagree (D), neutral (N), agree (A), and strongly agree (SA), to obtain pertinent information and greater relevance to achieve the objective.

For this study, purposive sampling and a small sample of 40 respondents reduced the generalizability of the findings, which were further constrained by (i) natural behavioral differences, (ii) language barriers, (iii) geographical challenges, and (iv) the lack of a lux meter for precise measurement. Thus, results must be interpreted with caution, and studies in the future should use larger samples and improved tools to strengthen validity. In addition, for this study, light intensity measurement will be limited, and the focus is only on solar radiation as the usage of a Lux meter may result in incomplete data and might not

be a true representation of the community's total lighting conditions since the time of day, the weather in the settlements, and site orientation can have an impact on Lux meter readings.

This study followed proper ethical procedures, including informed consent, voluntary participation, and adherence to research guidelines among Indigenous communities. All participants were a few indigenous community members, above 18 years, and any minor discomfort during focus groups or questionnaires was reduced by providing clear explanations and keeping the group sizes small enough to maintain comfort. The main objective is to improve the lighting system effectiveness, and community satisfaction should be considered to provide sufficient lighting for them, since it can affect the community's safety in the school's area.

FINDINGS

Observation

The lighting around the school makes it brighter and safer for the communities to have their social activities at night. In the morning, the dark conditions in the school area can be alleviated with the aid of solar lighting, enhancing the safety of the students and the teachers. Increased visibility lowers the risk of mishaps and security problems, making the learning environment safer and more comfortable. The condition of the case study in SK Sungai Kiol, Jerantut, before and after the installation is shown in Figure 9.

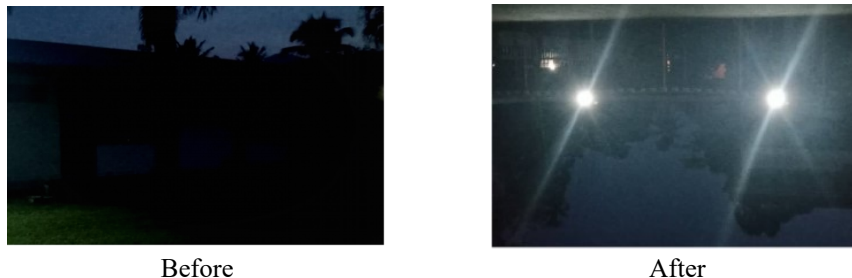


Figure 9: The conditions before and after solar installation at SK Sg Kiol, Jerantut, Pahang.

(Source: the author, 2023).

The installation of solar lighting technologies helps to reduce the crime rates that might happen at night. Furthermore, the social activities and the community meetings during the nighttime can be extended. The parameter will produce the results of average solar radiation in kilowatt-hour times per square meter (kWh/m^2) per day. The east coast of Malaysia, including Pahang, has an annual average daily sun irradiation ranging from $4.21 \text{ kWh/m}^2/\text{day}$ to $5.56 \text{ kWh/m}^2/\text{day}$ (Amirruddin et al., 2011). An effective conversion factor between

solar radiance (W/m²) and lux illuminance (lx) would allow light meters to be used to assess photovoltaic performance, which is measured in lux (Michael et al., 2020). During the night, the illumination increased from 15 to 100 lux, effectively illuminating the school.

Hence, the solar irradiance for SK Sungai Kiol located at Jerantut, Pahang is 5.04 kWh/m² per day, which is high radiation (see Table 9). This improved lighting quality ensures brighter, more uniform illumination, which in turn enhances visibility, safety, and the overall learning environment. Additionally, the high solar irradiance enables consistent and sustainable lighting performance, maximizing the efficiency of the installed solar system.

Table 9: Annual data for Solar Radiation in SK Sungai Kiol, Jerantut, Pahang

Month	Solar Radiation (kWh/m ² / day)
January	5.98
February	5.95
March	5.78
April	4.81
May	4.62
June	4.48
July	4.60
August	4.67
September	4.83
October	4.88
November	4.73
December	5.14
Annual Solar Radiation: 5.04	

(Source: the author, 2023)

Questionnaires

Through group discussions, the survey engaged 40 respondents, comprising a diverse group of school staff and teachers, providing valuable insights into their experiences and perspectives on solar lighting implementation. The questionnaires about awareness level - *knowledge, installation, participation, and maintenance* - where that knowledge has the highest percentage of strongly agree with 45%, followed by installation with 31%, participation with 28% and maintenance with 26% as the lowest. The building's users, who are also part of the communities, strongly agree that knowledge regarding solar energy technology can enhance community involvement, encourage responsible energy consumption from an early age, and foster a sense of ownership over technology. Data collected from the questionnaires concluded that communities were satisfied with the solar installation using solar photovoltaic (PV) at SK Sg Kiol, Jerantut, Pahang. The summation of the questionnaires was presented as shown in Table 10 and Figure 10.

Table 10: The awareness level of solar lighting technologies

Awareness Level	Percentage of Strongly Agree (SA) (%)
Knowledge	45
Installation	31
Participation	28
Maintenance	26

Source: the authors (2023)

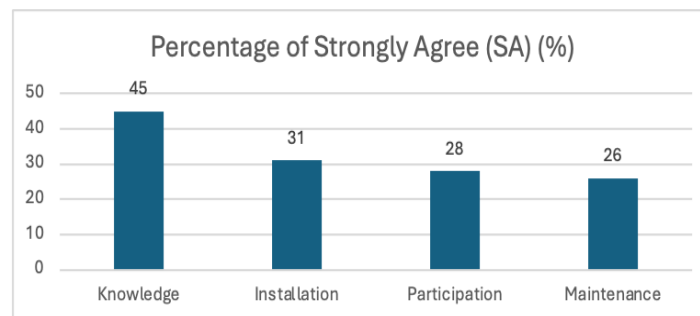


Figure 10: The percentage of awareness level of solar lighting technologies

Source: the author (2023)

DISCUSSION

It was found that the greater engagement in the community within SK Sungai Kiol, Jerantut, is because of knowledge beyond – installation, maintenance, and participation. Community satisfaction after the solar installation also reinforces their willingness to engage with renewable energy solutions that support the long-term sustainability of solar lighting in Indigenous schools.

Engagement Level Increased Among Orang Asli Communities

The implementation of solar lighting systems in schools within Orang Asli communities may have allowed the institutions to offer evening lessons and activities due to sufficient lighting at night. The teachers play a crucial role in helping gauge the level of awareness by conducting educational programs and practical training for the students, starting from a young age, to gauge the willingness to adopt the renewable energy solutions within the school. In addition, the heightened sense of safety can create greater community involvement in school activities, which enhances the relationship between families and the school. The higher the satisfaction, the higher the engagement with solar energy technologies.

Improved Lighting Quality and Increased Safety

Solar lighting improves visibility around the school area, providing better safety and facilitating evening lessons or other activities. With improved lighting, the atmosphere is safer for both students and teachers. In the bigger picture, this translates to an improved quality of life for the Orang Asli community, with safer spaces and better educational opportunities for the children. The consistent availability of light also encourages more structured after-school programmes, giving students additional time to learn and interact. Over time, improvements in these areas provide further support and a more enabling learning environment for Indigenous students.

CONCLUSION

The effort of installing solar lighting systems in Indigenous schools throughout Pahang marks a very important step toward sustainable energy solutions, ensuring safer and more conducive learning environments. Better lighting would mean better educational outcomes, better attendance, and a more comfortable study atmosphere for the students. Solar energy serves as a reliable source of electricity and increases awareness of renewable energy among the school community. Schools should therefore consider implementing systematic monitoring and evaluation procedures to ensure long-term impacts on well-being and performance resulting from the solar lighting. This paper identifies how solar systems can be used to improve learning spaces and community wellbeing within Indigenous schools, supporting more inclusive energy strategies. In addition, collaborating with government agencies, non-government organizations, or the private sector can help to fund the project and sustain solar technologies for long-term usage.

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