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ACHIEVING SUSTAINABLE ENERGY SOLUTION FOR MOSQUES IN PERAK THROUGH MICRO-SCALE SOLAR TECHNOLOGIES: A COMMUNITY-BASED APPROACH (CBA)

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Abstract: *This research presents a community development project that utilize a community-based approach (CBA) to emphasize energy-saving initiatives with the aid of micro-scale solar technology systems at two mosques in Perak. The primary goal of these projects is to increase community development among local residents while promoting green energy practices, fostering a sense of commitment toward energy sustainability. The study focuses on two mosque communities in Perak, employing a mixed-method approach that actively involves local participants throughout the project. This initiative aligns with Sustainable Development Goal (SDG) No. 7, which emphasizes in providing affordable and sustainable energy to communities. The project incorporated action-based research on-site, with volunteers and stakeholders—including mosque management, UiTM Perak branch, and local residents—collaborating under a university-social responsibility (USR) program. The positive outcomes of this project include mosque' community empowerment, demonstrated through tangible benefits such as enhanced community development, improved lighting conditions, and reduced electricity bills during nighttime. These benefits stem from the self-sufficient electricity generated by the small-scale solar solutions installed at the mosques. By utilizing solar technology systems ranging from 10 to 300 watts, the mosques have decreased their reliance on traditional energy sources, contributing to energy security and achieving a 5% to 9% reduction in monthly electricity bills. This project has not only showcased the advantages of solar energy but has also raised broader energy awareness within the mosque communities in Perak. In the near future, the widespread*

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adoption of solar energy technologies is expected to contribute to more sustainable mosques in Malaysia and further enhance community development through sustainable practices.

Keywords: *Community Development, Community-Based Approach, Mosque, Micro-Solar Technology, Sustainable Energy*

Introduction

At the moment, the number of mosques in Malaysia has seen a substantial increase over the past 10 years, reaching a total of 6,817 as of 2021 (JAKIM, 2021). This growth has contributed to the Malaysia's escalating energy demand (Mat Zain, Ahmad, and Tun Jamil, 2023), as mosques are frequented five times daily by worshippers who utilize various electrical devices such as lighting, air conditioning, fans, and public automation systems (Azmi et al., 2021). It is noted that in Malaysian mosques, lighting systems are the second-largest contributors to energy consumption, following air-conditioning systems (El Fouih, et. al., 2020). This high energy use is due to the extensive lighting required, which not only illuminates the external facades but also remains operational around the clock. According to Noordin Saleem (2020), the continuous operation of lighting, coupled with instances where visitors neglect to turn off lights upon leaving the mosque, significantly contributes to increased electricity bills. While exterior lighting is crucial for safety, particularly at night, it inevitably leads to higher energy costs. Moreover, as mosques are open 24 hours a day, energy consumption is further exacerbated by careless practices such as leaving lights on unnecessarily (Rahman, Ahmad & Sheikh Ahmad, 2021; Utaberta et al., 2015). To address the rising energy demand and its related challenges, it is prudent to establish energy sustainability in mosques by adopting green energy technologies. Solar technologies, for example, can be effectively utilized for lighting and electricity charging purposes, thereby contributing to a more sustainable energy consumption model (Mat Zain, Ahmad, and Tun Jamil, 2023; Rahman, Ahmad, and Sheikh Ahmad, 2021).

The adoption of green energy technologies holds immense potential for addressing energy sustainability challenges. Given Malaysia's high annual solar radiation, averaging 4.96 kWh/m² per day (SEDA, 2021), solar lighting technologies not only reduce monthly electricity costs but also improve safety by providing brighter illumination. This enhanced lighting can help prevent crimes such as theft, which is a significant concern in poorly lit areas of mosques (Mat Zain, Ahmad, and Tun Jamil, 2023). Currently, there is a noticeable lack of interest and awareness in incorporating solar lighting technologies into mosque management practices. It is crucial to embrace green technologies like solar lighting systems to promote energy efficiency and safety in mosques across Malaysia, thereby mitigating the risks of increased energy consumption, safety and security issues, and incidents resulting from insufficient lighting (Rahman, Ahmad, and Sheikh Ahmad, 2021; Jamil and Ahmad, 2017).

Literature Review

The primary challenge in adopting solar energy technologies in mosques across Malaysia is the associated cost. However, this barrier can be alleviated through community development initiatives, known as community-based approach (CBA) programs (UNDP, 2015). CBA programs engage local communities in the development, performance, and operational of solar energy projects, thereby lowering costs through volunteer efforts, community contributions, and collective resources (Ahmad and Jamian, 2021).

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The United Nation encourages community members to participate and empowered local energy projects (UNHCR, 2008) through this CBA program, which, in turn, leads to greater support towards sustainability for solar energy initiatives in any communities' projects. In the case of mosque in Malaysia, the goal is to establish sustainable and equitable solutions that not only deliver clean energy but also bolster community resilience, promote economic growth, and enhance social cohesion (Ahmad, Hussein, Anas, and Jamian, 2020). This method encourages community engagement and develops resiliency for mosque communities. As depicted in Figure 1, this initiative is in line with the community-based approach theory introduced by the United Nations in 2008 (UNHCR, 2008), which focuses on four (4) main components:

(i) Energy Sustainability Improvement - Involving energy generation options such as solar, mini-hydro, and wind power to tackle electricity supply challenges in many developing countries since 2000 (UNHCR, 2008).
(ii) Livelihood Improvement - By working together on sustainable energy development, community members foster trust and collaboration, reinforcing social connections and unity (Ahmad and Jamian, 2021).
(iii) Safety Improvement - The shared experience of overcoming obstacles and achieving collective goals through the solar project instills sense of security, thereby reducing safety vulnerabilities and enhancing community spirit and resiliency against future challenges (UNDP, 2015).
(iv) Economic Development – By monthly bill saving in a long-run for the mosque (Ahmad and Jamian, 2021).

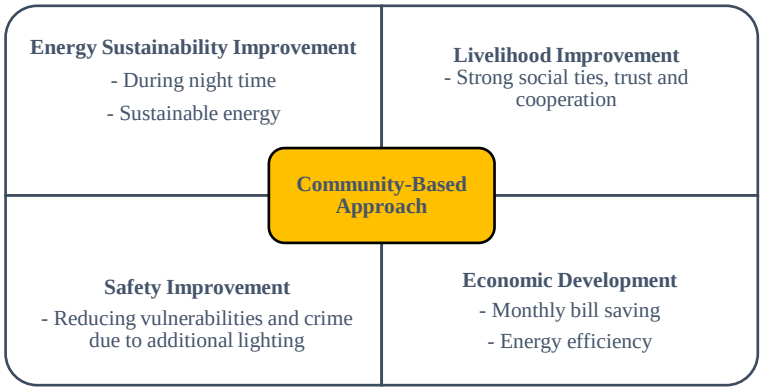

Figure 1: The Components of Community-Based Approach (CBA) for Local Energy Program

Source: **Constructed by Authors**

The Fundamental Benefits of Installing Solar Technologies for Mosque

Ahmad, et. al. (2024) has recognized the fundamental benefits of applying the solar technologies to the mosque:

(i) Community Development – Provide trust and cooperation among the locals in securing energy alternative for the mosque.
(ii) Environmental Sustainability - Mitigating climate change via the natural energy resources
(iii) Cost Savings – Provide long-term cost savings on monthly electricity expenses due to the durability of solar systems.
(iv) Energy Independence - Mosques have the capability to self-generating their own electricity, ensuring energy security and reliability in case of power disruption or blackouts.

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(v) Educational Opportunities - Mosques can educate the local about sustainable energy and the good prospects of solar energy.

Solar energy technologies offer numerous benefits to mosques by providing a sustainable energy resource that aligns with the environmental and social responsibility principles (IRENA, 2019). As recommended by the United Nation in its Sustainable Development Goal (SDG 7) (SDG, 2017), the goal is to develop sustainable and equitable energy solutions that not only supply clean energy, but also enhance community resilience, drive economic development, and promote social cohesion (Ahmad, Hussein, Anas, and Jamian, 2020). By integrating solar energy systems, mosques can lead by example and advocate for sustainability within their communities especially for any public buildings, for example schools and hospitals.

The Potential

Although the initial investment may be considerable high, solar energy systems have a long lifespan and require minimal maintenance (Rahman, Ahmad, and Sheikh Ahmad, 2021). Therefore, installing solar panels on mosque rooftops can result in significant long-term cost savings. By embracing solar energy systems, mosques can greatly reduce their electricity costs by 10% to 15% depending on the system capacity (Mat Zain, Ahmad, and Tun Jamil, 2023).

It can also serve as an educational resource for the mosque communities in Malaysia. Mosques can educate their members and the broader public about the benefits of solar energy and the importance of sustainable practices through workshops and seminars. This outreach can inspire other mosques in Malaysia to adopt similar technologies. By generating their own electricity through solar energy, Malaysian mosques can reduce their dependence on external power sources, preventing from any power disruption and significantly lower their monthly electricity bills. This energy independence enhances security and resilience, especially during power outages or disruptions in the grid (Ahmad, Abdullah Salleh, and Jamil, 2019), enabling mosques to continue providing essential services to their communities even in challenging situations.

Micro-Solar Technologies

Micro-solar technologies refer to small-scale solar power systems that are designed to provide energy for specific, localized needs. These technologies are particularly useful in remote areas, for small buildings, or for individual devices. The common types of micro-solar technologies are:

(i) Solar Home Systems (SHS): These are small solar power systems typically used to power homes in off-grid areas. They usually consist of solar panels, a battery for energy storage, a charge controller, and sometimes an inverter to convert DC to AC power. SHS can power basic household appliances such as lights, fans, radios, and even small refrigerators (Ahmad, Abdullah Salleh, and Jamil, 2019).

(ii) Solar-Powered Charging Stations: Small solar systems that provide charging points for mobile phones, laptops, and other portable electronic devices. These are often used in rural communities, schools, and public places where grid electricity is unavailable or unreliable (Ahmad and Jamian, 2021).

(iii) Solar Street Lights (Mounted or Pole): These are standalone systems that use solar panels to power LED street lights. They are commonly used in areas where extending the grid for street lighting would be costly. Solar street lights are energy-efficient and can be equipped with motion sensors or timers to optimize energy usage (Mat Zain, Ahmad, and Tun Jamil, 2023).

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The Methodology

The methodology involves selecting case studies and conducting field research for 3 months, which includes site visits and observations at each of the selected locations. An action research approach is employed, with researchers performing direct observations and collecting on-site empirical data to assess the operational effectiveness of the solar systems. This hands-on research is carried out directly at the case study sites. Volunteers and community stakeholders, including local mosque communities and nearby residents, contribute physical assistance as part of a Community-Based Approach (CBA) program. Figure 2 illustrates the methodology process.

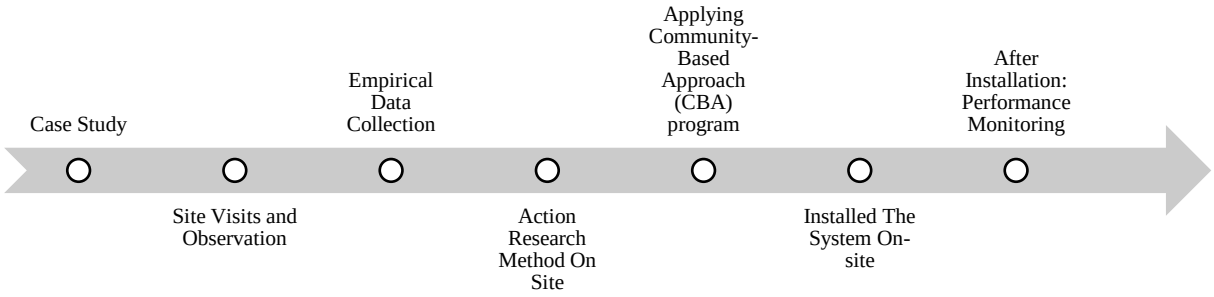

Figure 2: The Methodology Process

The Case Studies

Two prominent mosques in the Perak Tengah district have been chosen as case studies for this research project; the Mosque of Bandar Universiti (MBU) and the Mosque of As-Siddiq (MAS). Both are located in the rapidly developing area of Bandar Seri Iskandar, Perak, where they cater to the spiritual needs of a diverse and growing population. These mosques are integral to their communities, providing not only religious services but also social and educational support. Figure 3 illustrates the location of the selected case studies in Perak Tengah district (the red zone) in the central of Perak state.

Figure 3: The Case Studies (From Left; MBU and MAS)

The CBA programs, involved the mosque congregation members from both case studies, representatives from the Perak Tengah District Council (MDPT), 14 academic staffs from UiTM Seri Iskandar campus, Perak, three external guests from the industry, three postgraduate students, and 20 undergraduate students.

The program received strong support from various stakeholders, like the industry partners, locals and local authority ensuring its success. From this Community-Based Approach (CBA) initiative, participants were exposed to the importance of solar energy for mosques and able to deliver long-term benefits to the community by raising awareness and encouraging the adoption

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of green energy technologies. Figure 4 illustrates the CBA programs, highlighting the involvement of numerous stakeholders and volunteers at the case study sites.

Figure 4: The CBA Programs for Solar Technologies Involving Many Stakeholders and Volunteers

The Data Collection

Two types of solar lights have been installed at the mosques: mounted-type lights and pole-street lights. Additionally, a solar charging hub with battery storage and a solar inverter has been installed at Case Study 1, the Mosque of Bandar Universiti (MBU). The installation of these technologies was guided by on-site empirical analysis and the specific needs identified by the mosque congregation members.

During the installing of the solar power systems for various outdoor areas in Mosque (like walkways, ablution areas, and external courtyards), several factors can affect the power requirements, including location, height, and shading. The requirement of each area has been listed as follows:

1. Walkway Location: Remote or less frequented areas require more lighting for safety and security. Fixtures mounted higher (e.g., on poles) can illuminate a wider area but require more powerful lights to ensure even coverage.
2. Gazebo and parking areas: Roof-mounted fixtures to give more focused lighting.
3. Shading: Areas with high shading from trees or buildings need additional lighting to compensate for reduced natural light. Shaded areas may also benefit from higher-wattage fixtures to ensure visibility.
4. Ablution Area: More isolated areas need less intense lighting but still adequate to ensure safety and cleanliness. Using ceiling-mounted fixtures or wall-mounted lights at appropriate heights to ensure sufficient illumination without creating shadows.
5. External Courtyard Location: Central courtyards have higher wattage lights to ensure good illumination and ambiance. Higher wattage to maintain brightness at the edges of the space.
6. General Considerations: In term of energy efficiency using lamp like LED bulbs, which provide good illumination with lower wattage and give good uniformity of lighting where lighting is even to avoid dark spots and enhance safety.

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The empirical data supporting these installations is presented in Table 1.

Table 1: The Empirical Data for Solar Technologies for Both Case Studies

Types of Solar Technologies	Case Studies Information			
	The System Used	Function	Case Study 1: MBU	Case Study 2: MAS
Solar Mounted-Lights		Various power system (watt) due to location, height and shading factors, for walkway, ablution area and external courtyard.	9 units of 10-watts (min), 25-watts, 40-watts, and 300-watts (max)	9 Units of 10-watts (min), 25 watts, and 60 watts (max)
Solar Poled-Lights		For street lighting purposes (Parking areas, street, field) due to height and location to disperse the lighting.	5 units of 200-watts	3 Units of 100 watts and 120 watts)
Solar Charging Point	 	A USB charging hub has been installed in the gazebo area, allowing visitors to charge their mobile phones or tablets using solar power. This setup is equipped with battery storage and a solar inverter, ensuring that devices can be charged even when direct sunlight is not available.	2 units of 300-watts (for 2 gazebo)	NA

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Finding and Discussion – (i) Positive Economic Impacts

The implementation of Solar Community-Based Approach (CBA) projects has demonstrated considerable advantages for mosques, notably in improving energy efficiency and realizing monthly financial savings. By embracing these solar initiatives, the mosque communities in both case studies have significantly reduced their reliance on conventional energy sources. This move has led to substantial energy savings and a reduction in electricity bills by approximately 5% to 9% within one month of the system's installation. This improvement is reflected in the lower monthly electricity costs for the mosque, as shown in Table 2.

Table 2: Positive Economic Impacts (Monthly Bill Saving)

	CASE STUDY 1 (MBU)		**CASE STUDY 2 (MAS)**	
Electricity Tariff (From TNB)	**Electricity Bill/MYR (Before the Installation)**	**Electricity Bill/MYR (After 1 month of the Installation)**	**Electricity Bill/MYR (Before the Installation)**	**Electricity Bill/MYR (After 1 month of the Installation)**
Average Bill# (MYR/Per month)	4300.10	3900.25	3800.29	3591.70
First 200kWh* TNB Standard (RM 0.44 x 200 kWh = RM88.00)	The usage of the first 200kWh (RM 0.44 x 200 kWh = RM 88.00)			
Next 201kWh* (RM 0.51 x per kWh) (The later usage of remaining power/watt)	RM 0.51 x 8259 kWh* = RM 4212.10	RM 0.51 x 7475 kWh* = RM 3812.25	RM 0.51 x 7279 kWh* = RM 3712.29	RM 0.51 x 6870 kWh* = RM 3503.70
Total Bill Saving (MYR) **Total Bill Saving (%)**	Before Saving	After Saving: 4300.10 – 3900.25 = **399.85 (9.3%)**	Before Saving	After Saving: 3800.29 - 3591.70 = **208.59 (5.5 %)**

* Standard tariff rate from TNB (2014)
\# Retrieved from the Case Study (MBU and MAS)

In addition to promoting environmental sustainability, this approach provides notable economic benefits. The reduced energy consumption leads to monthly utility bill savings of 5% to 9%. These savings can be allocated towards essential needs or invested in additional energy-efficient improvements, ultimately strengthening the mosque's financial stability.

Finding and Discussion – (ii) Positive Effects from the Community Development Perspective

The Solar CBA projects also enhanced community development by raising awareness and fostering green education among the mosque congregation members and users. 100 questionnaires have been distributed to mosque communities of both case studies (MBU and MAS). The results have shown positive feedback from the respondents following the

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installation of solar technologies. The questionnaires assessed five key community development skills.:

(i) Green Knowledge and Awareness
(ii) Self-Development Skill
(iii) Energy Awareness
(iv) Social and Life Skill
(v) Technological Skill.

The results, displayed in Figure 5, illustrate a significant impact on the community development skills within the mosque communities. These outcomes underscore the broader benefits of the projects, extending beyond energy efficiency to empower the mosque community with valuable knowledge and skills.

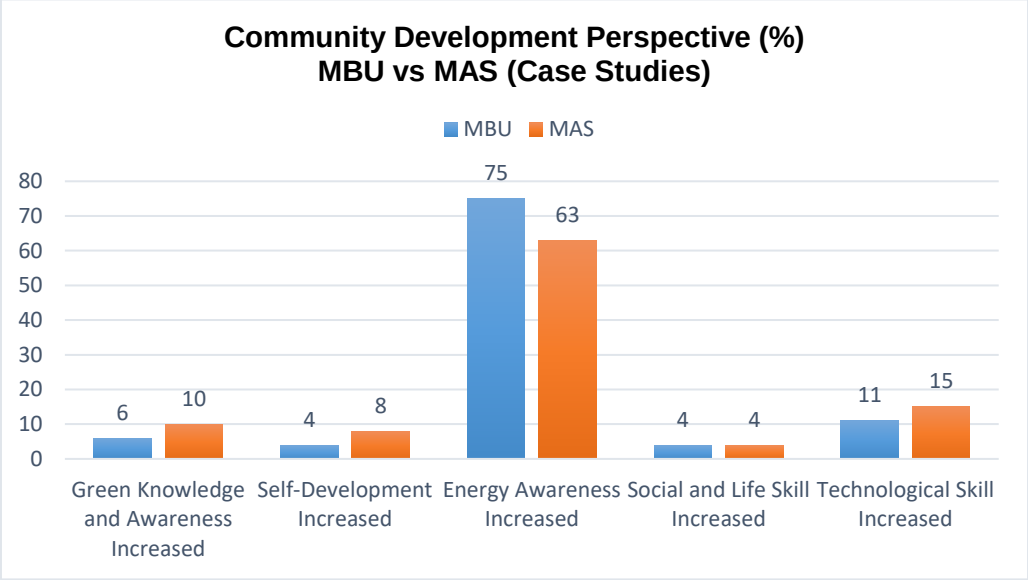

Figure 5: Positive Effects from the Community Development Perspective

The results reveal that integrating solar technologies into the community not only provides practical experience in renewable energy and energy efficiency but also significantly boosts various community development skills. Specifically, these initiatives have led to the highest increase in Energy Awareness, with a rise of 63% to 75% as community members become more knowledgeable about energy consumption and savings. Hands-on experience with solar technologies has also supported improvements in Technological Skills, increasing by 11% to 15%, thereby equipping the community with the necessary expertise for implementing and maintaining sustainable energy solutions. Additionally, Green Knowledge and Awareness have grown by 6% to 10%, educating people about the benefits of solar energy through savings and efficiency. Self-Development Skills have been enhanced by 4% to 8%, as individuals gain confidence and competence in adopting sustainable practices, while Social and Life Skills have seen a 4% increase due to the social interactions and collaborations fostered through these programs.

Conclusion

As public gain a deeper knowledge on the benefits of solar energy and its positive impact, they are increasingly motivated to empower green initiatives and micro-solar energy solutions within their communities. This heightened awareness, fueled by the Community-Based Approach

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(CBA) program, results in substantial energy savings as mosques are empowered to make sustainable choices that can help to reduce their electricity bills. The CBA program is instrumental in promoting community development within mosque communities by bringing individuals together in a common commitment and collective resources. Through its collaborative nature, the CBA program not only advances the community towards a greener future but also strengthens social bonds and collective action, paving the way for more sustainable mosques for Malaysia.

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