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A COMPARATIVE ANALYSIS ON THE SOLAR PV LIGHTING APPLICATION AS A SAFETY MECHANISM FOR PLAYGROUND AREAS IN PUNCAK ISKANDAR RESIDENTIAL AREAS IN PERAK

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ABSTRACT

This article examines the effectiveness of solar photovoltaic (PV) lighting as a safety mechanism in playground areas within the Puncak Iskandar residential areas in Perak. The research focuses on the insufficient awareness among the Malaysian public regarding the advantages and potential of utilizing solar energy as a safety measure in playgrounds and demonstrates that solar PV lighting offers substantial safety improvement, effectively reducing the likelihood of accidents and hazards in playground areas. Additionally, solar PV lighting emerges as an environmentally friendly solution, relying on renewable energy sources and contributing to the reduction of carbon emissions. The research employs a quantitative method, utilizing a lux meter to determine illuminance levels in the Puncak Iskandar playground during both daytime and nighttime to gather data, facilitating the identification and implementation of research insights. The study recommends using solar PV lights with higher wattages to ensure optimal lighting conditions and create a secure environment for children to engage in recreational activities. The findings highlight the reliability and sustainability of solar PV lighting as a viable option for playground areas, promoting safety and environmental responsibility.

Keywords: *Illuminance, Solar-outdoor Lighting, playground,Safety*

INTRODUCTION

This research aims to assess the safety level of residential playgrounds by investigating the role of Solar PV lighting as a tool for enhancing safety measures. In recent times, there has been a growing emphasis on renewable energy sources, driven by economic, technological, social, and environmental factors worldwide, particularly in developing and emerging countries (Salim & Abu Dabous, 2022). The significance of energy, especially in the modern technological era, cannot be understated, and historically, fossil fuels have been the primary source of energy. Despite the increasing use of renewable energy, fossil fuels still dominate the global energy supply, accounting for 87 percent of the demand in 2012, with renewable energy contributing only 2 percent (Bp energy outlook, 2012) . However, the negative environmental impact and unsustainable nature of fossil fuels have led to calls from the Intergovernmental Panel on Climate Change (IPCC) to prioritize the use of renewable energy sources like solar energy to generate electricity (Usa & Bruckner, 2011)

Among the various renewable energy options, Solar Energy has emerged as the preferred alternative due to its abundance, cleanliness, and cost-effectiveness (Silva & Andrade, 2021). Two main types of solar energy are photovoltaic (PV) solar power energy, which converts light energy directly into electricity through the photovoltaic effect (Mohammad Bagher, 2015), and solar thermal, which generates mechanical energy using the heat of solar energy (Tayyebatossadat P.Aghaei, 2014). Among these, photovoltaic (PV) solar power energy technology stands out as the most sustainable and environmentally beneficial method of electricity production. Its viability as a significant sustainable power source has been proven over the past decade through the widespread deployment of solar PV systems with capacities ranging from kilowatts (kW) to hundreds of megawatts (MW) (Ahmad et al., 2017). As the world continues to transition towards a more sustainable energy landscape, the prominence of solar PV technology is expected to increase, playing a crucial role in shaping the future of global energy production and consumption.

LITERATURE REVIEW

Solar energy has gained increasing popularity as a viable source of renewable and green electricity, attributed to its adaptability, ease of installation, declining production costs, and continuous improvements in performance (Pearce et al., 2007). Consequently, various applications have emerged, utilizing solar-powered lighting in diverse settings, including residential areas, schools, road stops, tunnels, marine lanterns, and park lights. Among its numerous advantages, solar lighting technology proves particularly beneficial in providing illumination during nighttime, an essential aspect for larger cities and industrial areas. Moreover, for locations lacking access to conventional electricity sources, solar lights represent an ideal and sustainable illumination option.(Tayyebatossadat P.Aghaei, 2014).

Since that, as solar-powered lighting gains momentum, its viability for enhancing safety conditions in playgrounds becomes a subject of interest and investigation. The Puncak Iskandar residential areas, situated in Perak, serve as a pertinent case study, given the

growing demand for sustainable solutions and the potential benefits that solar PV lighting may offer in playground safety and environmental sustainability.

Solar energy

Solar energy, a renewable energy that defined as combination of light and heat from the sun, has extraordinary potential to meet global energy needs. The sun, a 4-billion-year-old fusion reactor, produces enough energy in a minute to power the world for a year. Solar collectors capture this energy, making it a viable source for generating electricity equivalent to 650 barrels of oil annually (Mohammad Bagher, 2015). The demand for clean energy has led to substantial growth in solar applications, including small-scale uses like batteries in developed countries. Countries like Japan, Germany, and other European nations are actively advancing solar energy development to attract investors (Liu, 2018). Due to rising energy consumption, solar power's significance is emphasized worldwide (Solangi et al., 2015). Given the limitations and expense of fossil fuels, the solar market is steadily increasing on a global scale, making it a superior option in terms of availability, cost effectiveness, accessibility, capacity, and efficiency compared to other renewable energy sources (Kannan & Vakeesan, 2016).

- Type of solar energy

  There are two main types of solar energy: photovoltaic (PV) solar power energy and solar thermal energy. However, for a practical and effective solution Photovoltaic (PV) energy is chosen and recommended. Photovoltaic (PV) solar energy converts solar radiation into electricity using the photovoltaic effect discovered by Becquerel in 1839. Solar cells in photovoltaic modules (solar panels) transform light energy into electricity. The PV industry is rapidly growing, and efforts to increase cell efficiency focus on material use, energy consumption in production, device design, and production methods (Sampaio & González, 2017).

  Solar thermal energy systems use the sun's heat for various applications, such as solar space heating, solar water heating, solar ponds, and more. Replacing electric water heaters with thermal solar systems can lead to significant energy savings and environmental benefits (Tayyebatossadat P.Aghaei, 2014). Solar thermal technology relies on collectors, including flat plate, evacuated tube, and concentrated collectors, to gather solar radiation heat and operate at different temperature ranges (Asif & Muneer, 2007).

- Connection of safety and lighting

  Safety is a crucial aspect influencing the quality and appeal of public spaces (Machielse, 2015). People's perception of safety strongly shapes their willingness to utilize or avoid such spaces (Mehta, 2014). Research indicates that well-lit areas are associated with reduced crime and violence, leading people to feel safer in well-lit environments (Brands et al., 2015). Public lighting plays a vital role in ensuring the safety of individuals, property, and goods, with researchers

studying various methods and implications of lighting installations (Peña-García et al., 2015). The presence of adequate lighting positively impacts individuals' safety, as insufficient lighting increases the risk of becoming a victim of crime (Maruthaveeran, 2015). Violent crimes are more prevalent during weekends and nighttime hours, particularly between 10 pm and 6 am (IAS, 2020). Studies have shown that improved illumination positively influences people's perceptions of safety (Haans & de Kort, 2012). However, additional research is needed to determine the specific illumination requirements and their impact on safety perceptions (Dastgheib, 2018).

Figure 1: Playground with bad luminous of light (source: TeohTeoh,2021)

Figure 2: Playground with good luminous of light (source: Mecree, 2021)

METHODOLOGY

The research methodology in this study involves mixed method approaches which cover four (4) research stages, which are (i) Research proposal, (ii) literature review, (iii) data collection and (iv) data analysis. Figure 1 presents the overall process of this research.

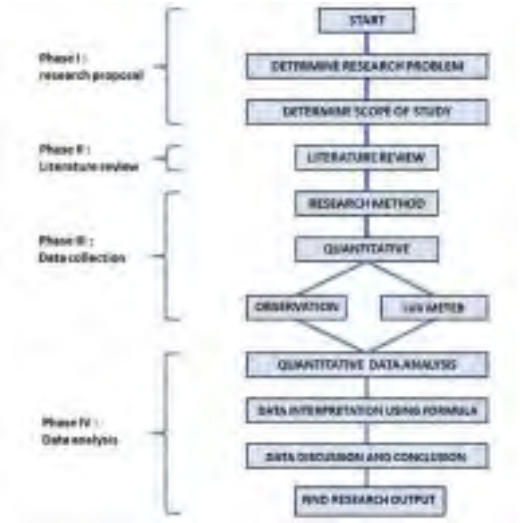


Figure 3: Research Design Phases

The research is divided into four phases. In Phase I, the research problem, objectives, and scope are determined through thorough analysis, leading to the selection of the research title, focusing on current issues, or arising problems. Phase II involves conducting a comprehensive literature review to meet the study objectives, focusing on the issues of solar PV lighting as a safety mechanism at residential playgrounds in Puncak Iskandar, Perak. Various secondary sources such as journals, articles, books, and online platforms like Google Scholar and Emerald Insight are utilized for this purpose. Phase III employs a quantitative method to determine the illuminance of light at the playground in Puncak Iskandar using a lux meter during both daylight and nighttime. Additionally, a qualitative approach is used to gather data and identify the implementation of the research. Lastly, in Phase IV, data analysis is performed to draw conclusions on What is the solar PV lighting criteria in providing safety mechanism at playground of residential areas. What is the potential application of solar PV lighting in providing safety at the playground in residential areas of Puncak Iskandar? and What is prospective safety level of playground in Puncak Iskandar with the aid of Solar PV lighting application as one of the safety mechanisms tools. The research methodology guides the use of data in the study and reporting of results, ultimately leading to research findings, conclusions, and recommendations.

CASE STUDY

The case study selected a playground of residential areas in Puncak Seri Iskandar Perak (see figure2). The playground is consisting of 5 playgrounds in the same areas which located almost 1.9km from University Seri Iskandar that need only appropriately takes 4 minutes. The Five (5) playgrounds have been selected at Puncak Iskandar for this research and each playground has been coded with PG1, PG2, PG3, PG4 and PG5

Figure 4: Location of Case Study (source: Google Maps, 2023)

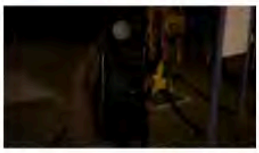
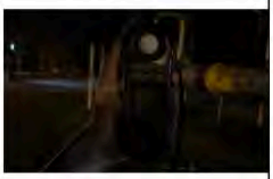
Table 1: Case Study Information

NAME	PLAYGROUND OF RESIDENTIAL AREAS IN PUNCAK ISKANDAR, PERAK (5 playground)
ADDRESS	Persiaran Puncak Iskandar, Puncak Iskandar, 32610 Seri Iskandar, Perak

FINDINGS

For this stage, a Lux Meter has been used to measure the illuminance level in the case study during night-time and daylight. Table 2 shows the data collection of luminous for daytime at 12pm and nighttime at 12am. It shows a huge difference in illuminance and brightness level of each playground between before and after the installation of the solar-outdoor lighting system.

Table 2: Data collection for illuminance by lux meter

LOCATION /REMARK	BEFORE	AFTER (CURRENT OBSERVATION)	
		DURING DAY TIME 12PM	DURING NIGHTTIME 12AM
	illuminance reading (lux)		
PG1	0 lux 	19900 lux 	12 lux 
PG2	0 lux 	18700 lux 	16 lux 
PG3	0 lux 	17860 lux 	18 lux 
PG4	0 lux 	16020 lux 	14 lux 
PG5	0 lux 	13640 lux 	28 lux 

For this data analysis stage, 6 types of solar lighting power (watt) have been used, which are 10-watt, 25-watt. 30-watt, 45-watt, 60-watt, and 100-watt. The reason for selecting this type of power is to assess the accurate comparison between the lighting standard and the current lighting condition and to recommend the needed unit of this solar lighting system stated on table 3, table 4, table 5, table 6, table 7 and table 8.

Table 3: 10-watt data collection and analysis

LOCATION	AREA (m2)	DURING NIGHT TIME LUX	LIGHTING LEVEL STANDARD (UBBL, ASHRAE STANDARD)	LUX NEEDED	RECOMMENDATION UNIT OF LIGHTING SYSTEM	% OF LIGHTING IMPROVEMENT
PG1	638.03	12	50 lux	38 lux	27 unit	76%
PG2	994.88	16		34 lux	38 unit	68%
PG3	1531.91	18		32 lux	54 unit	64%
PG4	636.32	14		36 lux	25 unit	72%
PG5	1300.54	28		22 lux	32 unit	44%

Table 4: 25-watt data collection and analysis

LOCATION	AREA (m2)	DURING NIGHT TIME LUX	LIGHTING LEVEL STANDARD (UBBL, ASHRAE STANDARD)	LUX NEEDED	RECOMMENDATION UNIT OF LIGHTING SYSTEM	% OF LIGHTING IMPROVEMENT
PG1	638.03	12	50 lux	38 lux	11 unit	76%
PG2	994.88	16		34 lux	15 unit	68%
PG3	1531.91	18		32 lux	22 unit	64%
PG4	636.32	14		36 lux	10 unit	72%
PG5	1300.54	28		22 lux	13 unit	44%

Table 5: 30-watt data collection and analysis

LOCATION	AREA (m2)	DURING NIGHT TIME LUX	LIGHTING LEVEL STANDARD (UBBL, ASHRAE STANDARD)	LUX NEEDED	RECOMMENDATION UNIT OF LIGHTING SYSTEM	% OF LIGHTING IMPROVEMENT
PG1	638.03	12	50 lux	38 lux	9 unit	76%
PG2	994.88	16		34 lux	13 unit	68%
PG3	1531.91	18		32 lux	18 unit	64%
PG4	636.32	14		36 lux	8 unit	72%
PG5	1300.54	28		22 lux	11 unit	44%

Table 6: 45-watt data collection and analysis

LOCATION	AREA (m2)	DURING NIGHT TIME LUX	LIGHTING LEVEL STANDARD (UBBL, ASHRAE STANDARD)	LUX NEEDED	RECOMMENDATION UNIT OF LIGHTING SYSTEM	% OF LIGHTING IMPROVEMENT
PG1	638.03	12	50 lux	38 lux	6 unit	76%
PG2	994.88	16		34 lux	8 unit	68%
PG3	1531.91	18		32 lux	12 unit	64%
PG4	636.32	14		36 lux	6 unit	72%
PG5	1300.54	28		22 lux	7 unit	44%

Table 7: 60-watt data collection and analysis

LOCATION	AREA (m2)	DURING NIGHT TIME LUX	LIGHTING LEVEL STANDARD (UBBL, ASHRAE STANDARD)	LUX NEEDED	RECOMMENDATION UNIT OF LIGHTING SYSTEM	% OF LIGHTING IMPROVEMENT
PG1	638.03	12	50 lux	38 lux	4 unit	76%
PG2	994.88	16		34 lux	6 unit	68%
PG3	1531.91	18		32 lux	9 unit	64%
PG4	636.32	14		36 lux	4 unit	72%
PG5	1300.54	28		22 lux	5 unit	44%

Table 8: 100-watt data collection and analysis

LOCATION	AREA (m2)	DURING NIGHT TIME LUX	LIGHTING LEVEL STANDARD (UBBL, ASHRAE STANDARD)	LUX NEEDED	RECOMMENDATION UNIT OF LIGHTING SYSTEM	% OF LIGHTING IMPROVEMENT
PG1	638.03	12	50 lux	38 lux	3 unit	76%
PG2	994.88	16		34 lux	4 unit	68%
PG3	1531.91	18		32 lux	5 unit	64%
PG4	636.32	14		36 lux	3 unit	72%
PG5	1300.54	28		22 lux	3 unit	44%

DISCUSSION

The analysis of data collected reveals that all types of solar lighting systems can meet the recommended 50 lux standard successfully. However, three specific solar outdoor lighting systems present challenges due to their high panel requirements. For example, the 10-watt system requires 25 to 54 units, the 25-watt system needs 10 to 22 units, and the 30-watt system necessitates 8 to 18 units, making large-scale

installations economically unviable under standard building codes and regulations. This limitation is attributed to space restrictions and increased costs. To address this issue, alternative solar lighting systems are recommended to reduce reliance on numerous panels while meeting the criteria set by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the Uniform Building By-Laws (UBBL). The proposed solutions include using 45-watt solar outdoor lighting with 6 to 12 units, opting for 60-watt lighting requiring 4 to 9 units, or considering 100-watt lighting with only 3 to 5 units, significantly reducing panel needs and ensuring compliance with standards.

CONCLUSION

In conclusion, the comparative analysis conducted on the application of solar PV lighting as a safety mechanism for playground areas in Puncak Iskandar residential areas in Perak reveals several significant findings. especially in terms of safety and environmental impact. With the help of solar PV lighting can create a safety environment and comfort to the user by providing the correct amount of illuminance to comply with the standard and regulation based on UBBL and ASHRAE. Many aspects need to be determined and overlooked in installation of solar PV lighting to make sure the benefit can be maximized.

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