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An Undergraduate Research Study on Comparative Analysis between Light Dependent Resistor (LDR)-Based Light System and a Commercially Available Automatic Solar Powered Light System In The Area Of Barangay Payatas (A)

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Abstract

This paper provided a thorough comparative analysis between the light-dependent resistor (LDR)-based light system and the commercialized automatic solar- powered light system. It aimed to developed a better system of streetlights in the location of the study. The proposed work was carried out by creating a prototype of an automatic streetlight using a light-dependent resistor (LDR) and purchasing an automatic solar-powered light system from online retailers. An LDR sensor was used as a switch in the automated LDR-based street lighting system. The researcher's goal was to compare and analyze which streetlight system was more beneficial for the community of the location site. This project provided the most effective solution to the streetlight issues as well as the cost and durability of a better streetlight system. Additionally, the study analyzed both streetlights to determine which will be more beneficial in terms of total investment cost (by getting the total unit of Pesos), output efficiency (by getting the Lumens per watt), and durability (by using a table of literature review). This comparative analysis between the two streetlight systems was done at the study location. After the study, the final conclusion obtained was that the LDR-based light system was better in terms of output efficiency and durability. While the commercialized solar-powered light system was better based on the total investment cost that the researchers computed. The study concluded that the LDR-based streetlight system was chosen as the preferred alternative as an automatic streetlight system for the community of the location site because of its output efficiency savings and durability. The LDR- based streetlight system also proved to be an environmentally friendly, highly efficient, and durable type of streetlight system. Additionally, this study did not bothered residents since they were notified about the study being conducted. In addition to this, researchers also concluded that all of the hypotheses are valid.

Keywords

Streetlight Systems, Automatic, Solar-powered, Light-dependent Resistor, Output Efficiency

1. Introduction

Road accident cases are becoming a significant threat to society as they occur regularly and vary in danger. One reason is the inability to provide good street lighting. According to Abalos (2021), street lights are important to lessen and avoid fatal road accidents. Without the street lights, drivers and commuters are in danger. Part of road safety is making the road visible to all its users. In the Global Status Report on Road Safety 2018 published by the World Health Organization, According to Weiler (2018), there are existing bills on pedestrian safety, transportation safety, and emergency medical systems like in the country of the Philippines. Death rate from road crashes has continually increased over the years despite various efforts by the government and other road safety stakeholders. Data from the Philippine Statistics Authority indicates that there were 11,274 deaths from road crashes in 2016. Through its Philippine Road Safety Action Plan 2017–2022, the government now aims to reverse the trend and cut road traffic deaths by 20% by 2022. In unfortunate cases, road accidents lead to fatalities. If the numbers above were daunting,

even more alarming are the statistics obtained from all over the country. Aside from this, according to Meister Solar Power Solutions (2015), the energy crisis is one of the critical concerns in the Philippines. With an increase in energy demand because of typhoons that left a trail of destruction in its wake on the island nation of the Philippines.

This research contains information about the comparison analysis of both LDR-Based Streetlight and Automatic solar-powered Streetlight system. If there may be a possible way of reducing risks and accidents involving the roadways because of streetlights, this study may be the answer to that. Herewith is information about the said streetlight and how it will go on in relation to the said accidents. How it will function, how much it will cost, how it will be able to be a convenience for energy conservation, driving situations, etc. There is no guarantee for the actual prevention of risks and accidents on the road since only a miniature prototype is to be made, but it may become a reference for future research that will use the maximum scale.

Figure 1. Standard Automatic Streetlight

As a short introduction to the objectives, it is in this light that the researchers are tasked with innovating a prototype of an LDR-based streetlight that will be very effective in securing the safety of people, choosing a better type of streetlight system, and also maintaining the reduction of the carbon gasses that can affect the ozone layer. This research aims to develop and compare an LDR-based light system and Automatic solar-powered light system on its total investment cost, output efficiency, and durability to be able to provide a better decision for choosing a streetlight to a certain community that has quicker transmission rates compared to others, makes use of solar energy that saves electricity consumption, and is a better investment than other lights. Aside from this, the significant differences between the LDR-based light system and the automatic solar-powered light system prove how efficient the module is. The researchers strongly believe that the outcome of the study will help the area of the which the study has been conducted that is interested in improving the streetlight systems of the establishments and institutions that need an additional source of light for the protection of its citizens and for the progression of the community. The success of the study will provide information regarding the effects of the improvised automatic street light system on the community which will surely benefit a lot of people, especially those who are on public roads and streets during the night.

Figure 1 shows the Automatic Street Light system that will be replaced after the study. Following that, a prototype will be created and the components will need to be soldered together. It must be demonstrated through all of the tests which system uses a durable streetlight, a better light output, and is less expensive than an automatic sensor streetlight. Since in some cities here in the Philippines, they have some sort of LED Integrated Solar Street Light but not an Automatic Solar-Powered Light Dependent Resistor (LDR), which the researchers find helpful for the citizens and the community for their daily work. These streetlights glow too early in the evening or very late in the morning. The researchers need to figure out how to extend the life of these streetlights, especially the newer models. The researchers also need to find a solution to how the work is typically done immediately during rush hour traffic. Since maintenance is normally done towards the end of the light's life, the researchers need to find better materials and equipment so that it will maintain its functionality before it actually burns out. Its advantages over automatically sensor operated

streetlights revolve around sustainability, price, and quality. It is designed by using high grade materials and latest technology while being reliable and being easy to access.

Since streetlights are used to light up the streets, it makes the streets safer for people. Among other things, lighting up the streets makes it more beneficial for people who work or go home during the evening to have a light that will guide them on the roadways. This study aimed to investigate the comparison of the LDR-based Streetlight system and the Commercialized Solar-powered Streetlight system on its energy consumption and cost analysis.

The study will be conducted throughout the day. The researchers will discuss the comparison of both light systems by determining their total investment cost and output efficiency, and durability at the end of the study. These are important in coming up with the comparison between the LDR-based light system and Commercially Available Solar-powered light systems.

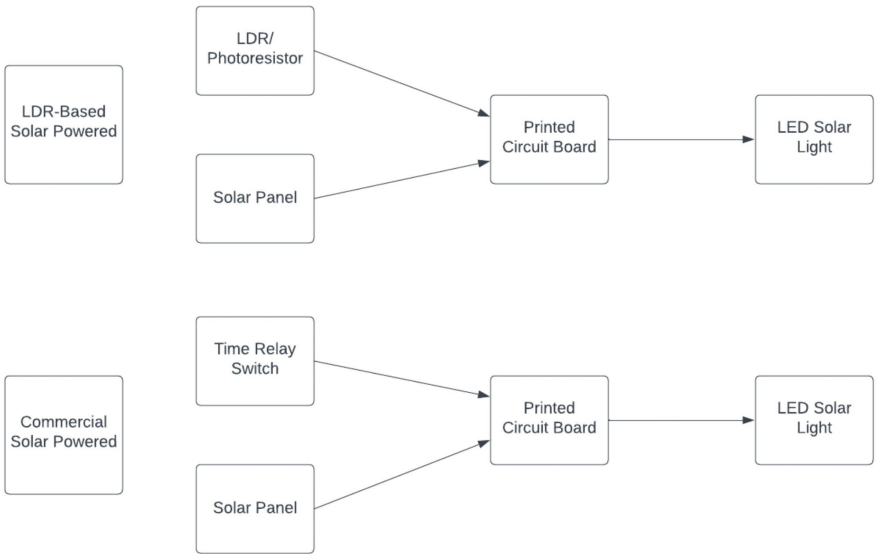

Figure 2. Theoretical Framework

This study aims to address how the residents will choose which streetlight system is better to use in the specified location of the study. This study also highlights the effects of the LDR-based street light system on the analysis objectives. Roadway lighting should be provided with reliable streetlights that can keep lights turned on and off automatically (Department of Energy, n.d.). In terms of energy consumption, this study aims to conduct a comparative

analysis on both LDR-based streetlight and Automatic solar-powered streetlight. This study also targets to conduct comparative analysis studies on LDR-based light system to the Commercialized automatic solar-powered light system. This research answers the questions on the impacts of both streetlight systems on its total investment cost, output efficiency, and durability. The results of the comparative analysis of this research should be able to provide data for the community of the study area to come up with a better decision making in choosing a streetlight system.

The general objective of this research is to determine the total investment cost, output efficiency of the streetlights, and durability of materials of both streetlight system. The researchers will install a prototype of the LDR-based streetlight in the location study to ensure residents safety. The researchers will show the comparison of the two streetlight systems at the end of the study. To design and assemble an LDR-based light system. To compare the researchers' LDR-based light system design with the commercially available light system by its dependent variables, which are total investment cost, output efficiency, and durability. To make conclusions and recommendations based on the comparison carried out.

1.1 Objectives

Hypothesis/es

- H1: The commercially available automatic solar powered light system will have a lower total investment cost than the LDR-based light system after the study.
- H2: The LDR-based light system will have a higher Lumens per watt in terms of the output efficiency than the commercialized automatic solar powered light system.
- H3: The LDR-based light system will be more durable in terms of the materials quality.

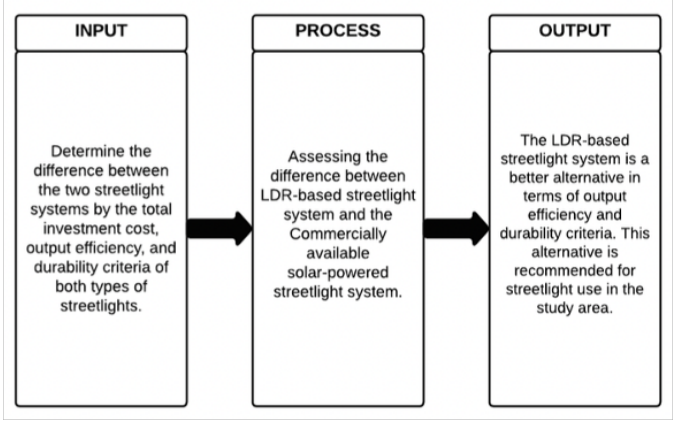

Figure3. Research Paradigm

The diagram above is composed of an input-process-output framework description. The input indicates that the researchers will determine the difference between the two streetlight systems by their three criteria: total investment cost, output efficiency, and durability. Next is the process, which indicates that the researchers will assess the study of comparing and analyzing the difference between two streetlight systems. Lastly, the output indicates the conclusion of the study, which is that the LDR-based streetlight system is a better alternative than the commercially available solar-powered streetlight system.

2. Literature Review

2.1.1. Current Streetlight Model in the Philippines

Recently, the Philippines changed streetlights from the previous orange fluorescent streetlights to LED streetlights. It is because LED streetlights use less energy and are better for the environment that they are a good choice for public roads. It also improves the vision of drivers when they drive at night. It reduces car accidents and crimes that always occur on the road during the night as well. One of the reasons why many accidents occur is the poor lighting of the streetlights. The Automatic Solar-Powered Streetlight from Sapang, Patay was created and published by Dr. Dexter S. Faustino (2017) because, not only is it solar powered and can generate electricity from the sun, but it is also cost-efficient and consumes less energy thanks to the help of LEDs. The project aims to illuminate the streets of Sapang Patay through the installation of solar powered street lights and provide its residents a sense of being safe throughout the night. A study and constant monitoring were conducted to check if the solar panel is charging. The result of the project has a positive response from the community of Sapang Patay. They now enjoy the streetlight and can now freely walk at night without any worries. This system of streetlight is a self- sustaining device. The device provides a reliable and enhanced alternative to a current street lighting system. Therefore, his research shows that it has already brought great accomplishment in helping the planet be safer as well. Furthermore, some people or researchers attempt to develop and innovate streetlights that may aid in the elimination of problems like street accidents and other street precautions that can occur on roads as new technologies emerge at an alarming rate in the modern age. For example, the Smart Solar Powered LED Street Lighting System that is being developed by Warlito M. Galita (2015). It has

already brought great accomplishment in his own perspective. He designed and developed this kind of streetlight in order to have a greener community for the country and also for the roads that have similar features to those of Dr. Dexter S. Faustino (2017). The only difference is that it can automatically turn on when night time comes and shut down the streetlight when the sun rises. It might be used in the near future and might provide improvements for public roads that might cause casualties as well. People from the local government try to think of the factors that might improve the LED streetlights. Furthermore, the impact that LED streetlights have recently had on public roads draws attention.

2.1.2. Zamboanga Village Uses Solar-Powered Streetlights

Streetlights have had a significant impact in the country by bringing lots of new upgrades to public roadways and allowing people to see more clearly when driving at night. Taluksangay, located 19 kilometers east of City Hall, was the first of the city's 98 barangays to employ renewable energy. This is because Taluksangay now uses solar power to light up the barangay's main highway. Abdurahman Nuño (2018), Taluksangay barangay chairperson, said they have allocated PHP 1 million to implement the project. According to Nuño (2018), he said they have initially installed 18 solar street lights in the barangay and they envision adding more by next year. He said they will also install similar lights at the barangay complex, which houses the health and daycare centers and the playground. Nuño, who has served for several years as a city councilor, said he learned about the solar-powered light project during his travels to Indonesia. He said the project will greatly help them in the peace and order campaign since the entire barangay will light at night with solar street lights.

2.1.3. Installs More Street Lights Along National Road

The recently widened stretch of national highway in Tacurong City will soon be engulfed with solar-powered lights as the city government continues to prioritize putting up streetlights. After two months of being held in abeyance due to the force majeure situation that is the COVID-19 pandemic, the city government has finally completed another solar-powered streetlight project. The P2 million worth of streetlights, lined up along the national highway from the rotunda going to the area in front of Dragon Complex, is composed of 19 street lights powered by solar panels, inbuilt batteries, LED lights, and smart sensors, all integrated into a single compact unit. According to Montilla (2020), he plans to allocate additional funds aside from the current budget that they have and also have a request to national agencies for financial augmentation on this priority project so that solar-powered lights will be provided in the central business district of the city before the end of his term of office. A modern solar street light has an embedded solar panel, inbuilt lithium-ion batteries, battery management system, night and motion sensors as well as automatic controls. The fully automatic device comes with LEDs, inbuilt and replaceable Lithium-ion battery and passive infrared (PIR) sensors. A typical solar street light is weather-proof and water-resistant, has low insect attraction rate and low glare and has a longer life. The embedded solar panel converts solar power into electrical energy which is stored in the inbuilt battery, and used for dusk-to-dawn lighting operations. The main innovation of modern solar street lights is the battery management system which is facilitated by the presence of night and motion sensors.

3. Methods

The components of the streetlight control system will be acquired by the researchers from the available electronic stores and online shopping stores: Lazada and Shopee. The LDR-based light system will be assembled by the researchers as a prototype for the study and the commercialized automatic solar- powered light system will be bought from online stores.

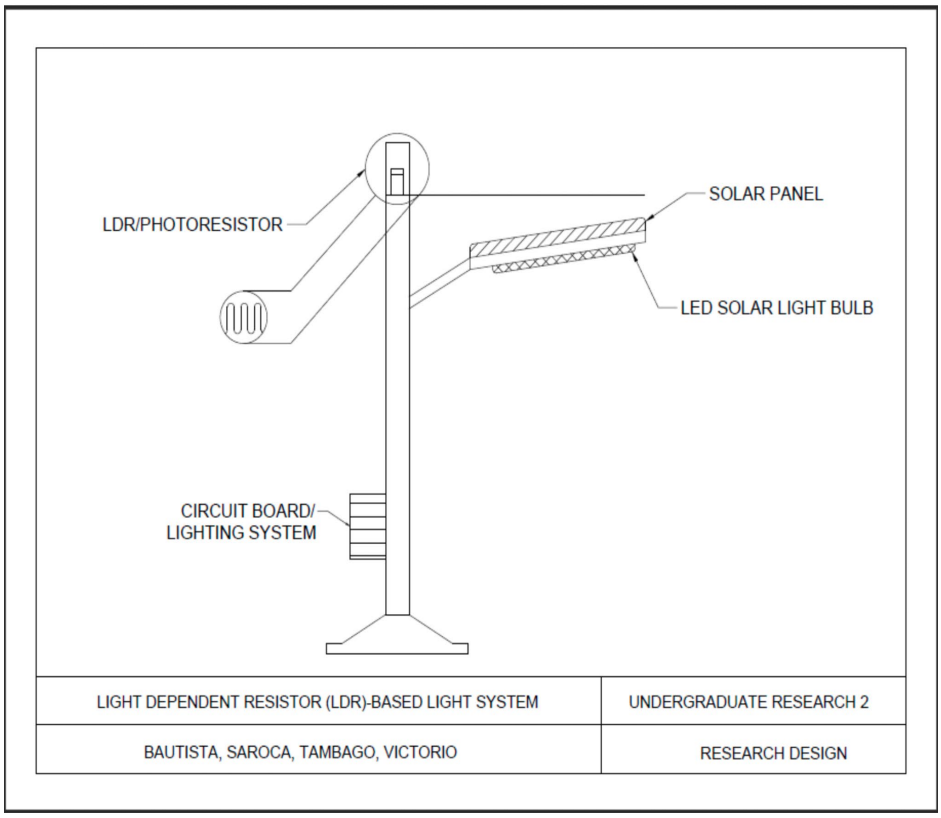

Figure 4: Research Design and Materials

4. Data Collection

There will be several instruments or devices that will be utilized in the data gathering. The Annual Cost Method will be used to measure the Total Investment Cost of both streetlight systems. The Output Efficiency will be measured by finding the Lumens per watt of both streetlight systems and the Durability of both light systems will be measured through literature review of the materials that the team used for the study of both light systems. These three criteria will be used as a data measure to be able to identify which of the two models is more suitable and effective in terms of the quality of lighting needed to light up roadways and side streets. The researchers would also be tasked with figuring out the total investment cost, output efficiency, and durability that the community in the barangay of Payatas (A) would likely invest in the streetlight model. The data to be gathered will be useful in order to analyze the comparison between both streetlight systems.

Table 2. Data Measures

Criteria	Unit of Measurement	Instrument used for Measurement
Total Investment Cost	Philippine Pesos	Annual Cost Method
Output Efficiency	Lumens per watt (lm/W)	Lumens, Watts
Durability	Table of Materials Specifications	Literature Review

5. Results and Discussion

Numerical Results

Table 3. Total Investment Cost

Annual Cost Method		
1. Items	LDR-based streetlight	Commercialized Solar-powered streetlight
2. First Cost	₱1,029.00	₱655.00
3. Depreciation ((First Cost-Salvage Value)/Useful Life)	₱514.50	₱655.00
4. Labor Cost	₱300.00	₱0.00
5. Maintenance Cost	₱600.00	₱600.00
6. Total Annual Cost	**₱1,414.50**	**₱1,255.00**

The researchers use the annual cost method of engineering economics. The first cost was calculated using the entire cost of the LDR-based light system component parts and the initial cost of the commercially available solar-powered light system purchased from Shopee. The depreciation for both streetlight systems was computed by dividing the difference between the first cost and the salvage value of 0 by the product lives of 2 years for the LDR-based system and 1 year for the Commercialized solar-powered system. The LDR-based street light requires PHP 300 to assemble, whereas both streetlights require PHP 600 to maintain. The annual cost for the commercialized solar-powered streetlight is PHP 1,255.00, whereas the LDR-based street light is PHP 1,414.50. The total annual cost is computed by adding the depreciation, labor cost, and maintenance cost. Thus, researchers conclude that the annual cost of the LDR-based streetlight system is more expensive than the commercialized solar-powered streetlight system.

Table 4. Output Efficiency

Streetlight System	Lumens	Watts	Lumens per watt
LDR-based Light System	8000	100	**80.00 lm/W**
Commercialized Automatic Solar-powered Light System	7000	100	**70.00 lm/W**

The LDR-based and commercialized automatic solar-powered light systems were both tested. The Lumens per watt is calculated by dividing the lumens by the actual watts of both streetlight systems. The computation shows that the LDR-based light system has a higher Lumens per watt which means that it has a better output efficiency at 80.00 lm/W, compared to the commercialized automatic light system, which is at 70.00 lm/W.

Table 5. Durability

LDR-based streetlight	Commercialized automatic solar-powered streetlight	Comparison
Solar Panel		
Monocrystalline	Polycrystalline	Monocrystalline solar panels are more durable compared to Polycrystalline panels since Monocrystalline has a higher heat tolerance and could perform better compared to polycrystalline at extreme temperature. Monocrystalline panels are reported to have a longer lifespan and has higher efficiency rates compared to polycrystalline.
LED Light		
Polycarbonate	Acrylic	Polycarbonate plastic delivers more resilience compared to acrylic plastic. Polycarbonate plastic has a higher melting point in contrast to acrylic plastics meaning it could withstand higher temperatures. Acrylic plastic is more prone to cracks and chips compared to Polycarbonate.
Printed Circuit Board		
Metal-based	Plastic-Based	The Printed Circuit Board of the LDR-based street light is made out of durable metal that has a glass-reinforced epoxy laminate sheet. The material is flame resistant and waterproof. The material offers a high tensile strength. The PCB for the commercialized streetlight has synthetic thermoplastic fluoropolymer which is also flame resistant and extremely flexible. However, it does not provide a high resistance level compared to the metal-based PCB of the LDR-based street light.

Overall, the materials used in the LDR-based prototype are more durable, high-performing, and long-lasting compared to the commercially available automatic powered street light. Starting from the solar panels used, the solar panel of the LDR-based street light (monocrystalline) is more durable, has a higher efficiency rate, a longer shelf life, and performs better under extreme heat compared to the solar panel used in the commercialized automatic powered streetlight (polycrystalline). The materials of the LED lights of both street lights were also compared, and the LDR-based street light has a material of polycarbonate, which is stronger and more durable compared to the acrylic plastic of the commercially available automatic powered street light. The Printed Circuit Board (PCB) of the LDR-based street light is metal-based, meaning that it is more durable and has a longer lifespan compared to the plastic-based PCB of the automatic solar-powered street light.

5.2 Graphical Results

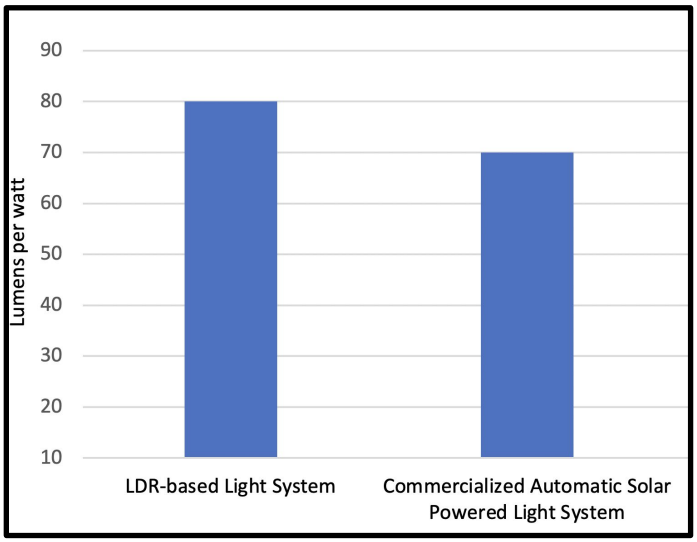

Figure 5: Graphical Analysis of Output Efficiency

6. Conclusion

Table 6. Conclusion Table

Hypothesis/es	LDR-based streetlight	Commercialized automatic solar-powered streetlight	Remarks
H1: The LDR-based light system has a lower total investment cost.	**Total Investment Cost**		
	PHP 1,414.50	PHP 1,255.00	Reject the Hypothesis
H2: The LDR-based light system has a higher output efficiency.	**Output Efficiency**		
	80.00 lm/W	70.00 lm/W	Accept the Hypothesis
H3: The LDR-based light system is more durable.	**Durability**		
	Based on table 8, it is shown that the materials of the LDR-based street light are more durable compared to the materials of the commercialized streetlight.		Accept the Hypothesis

The study between the two streetlight systems was carried out in the proponent's home in Barangay Payatas (A), Quezon City. The two streetlights are small in scale and thus also imply that it will be conducted inside the backyard of the proponent's house. This comparative analysis between the two streetlight systems was done at the study location. After the study, the final conclusion obtained was that the LDRbased streetlight system is better in terms of output efficiency and durability. while the commercialized solar-powered streetlight system is better on the total investment cost. Both streetlight systems have been observed throughout the day. According to the study's findings, the LDR-based streetlight system was chosen as the preferred alternative as an automatic streetlight system in the study area due to its output efficiency and durability; thus, it has been demonstrated to be a highly output-efficient and durable type of streetlight system. In addition to this, researchers also concluded that two of the hypotheses are valid.

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