Proposed Feasibility Study of Installed Solar Street Lights at Barangay Arenas, Arayat, Pampanga

BAZAR, ANJON R[1], MANALANG, IAN JASON T.[2], NAGTALON JHONRENZ P.[3], LORENZO DARWIN P.[4], BERNARTE ADRIAN S.[5], MANDAP, BRYAN M.[6], TANGCUANGCO, ALMA L.[7], SANTOS, EDGARDO M. [8]

[1, 2, 3, 4, 5, 6, 7, 8] *Don Honorio Ventura State University*

Abstract - The prevalence of robberies, thefts, and accidents has led to an increasing number of issues in the hamlet of Arenas in Arayat, Pampanga. The installation of solar lighting is one potential answer to these issues. Given the numerous advantages involved, installing solar-powered streetlights is the most advantageous course of action. For their study, the researchers will combine solar panels with an 8-ampere street light and a 100-watt LED. There will be sixty solar-powered lightings set at intervals of fifty meters along a three-kilometer road length. In barrio Arenas, Arayat, Pampanga, a solar street light is being proposed as a result of this research. By manually computing the proper sizes for the wires, breakers, and electrodes, solar streetlights for Arenas' streets can be installed. After calculating the total daily wattage of the streetlights, multiply that figure by 1.3 to account for system energy loss. Thus, the total daily watt-hours that the panels must produce were calculated. The researchers visited the location while taking note of important information including the criteria governing road length and width. In order to locate the poles, road curbs were also taken into account. For the calculated size of PV panels and batteries, the proponents also took into account equipment that was readily accessible on the market. To account for energy wasted in the system, multiply the total daily watt-hours of the street lights by 1.3. Thus, the total daily watt-hours that the panels must produce were calculated. W-hr required from the modules is equal to W-hr divided by 1.3. Divide the total Watt-hours per day needed from the PV modules by 3.43 to get the total Watt-peak rating needed for the PV panels needed to operate the street light. Divide the required Watt-peak rating for PV modules by the rated output Watt-peak of the PV modules that are currently on the market. Simply round up to the next greatest whole number if the solution had any fractional components. PV systems are advised to utilize deep cycle batteries. Specifically made to be rapidly recharged after being quickly discharged, or to cycle through charges and discharges repeatedly every day for years. The steps below were used to determine the battery size: To account for battery loss, divide the daily watt-hour usage by 0.85. 0.6 times the response from the preceding stage is the depth of discharge. Divided by the nominal battery voltage, the response from the previous step Add the number of autonomy days, or the number of days the system needs to run without PV panel electricity, to the result from the previous step. This allowed the deep cycle battery to reach the requisite ampere-hour capacity. The advocates sought advice from Alpha Solar Incorporated regarding the system's total cost. Data from polycrystalline solar panels, solar LED floodlights, brackets, poles, and labor/installation costs were surveyed. In order to install the solar PV road lights in their ultimate location, CAD tools like AutoCAD will be used.

Indexed Terms- Solar Streetlight, Solar PV System, safety, Polycrystalline Solar Panels, AutoCAD

I. INTRODUCTION

In today's modern world Renewable energy is more getting famous and one of the most appreciated renewable energies is solar panels. Solar panels (also known as "PV panels") are used to convert light from the sun, which is composed of particles of energy called "photons", into electricity that can be used to power electrical loads.

The sun is a dependable, non-polluting, and unlimited source of energy that, if properly investigated, may

offer an infinite energy supply to power the requirements of society. If proper exploration is not done, however, the sun's energy will continue to be wasted. Many modern society's energy requirements have traditionally been met by fossil fuels. However, because of the continuously increasing need for fuel, the risk of traditional energy supplies becoming depleted has become a very uncomfortably real possibility.

Solar lights are made up of four main components: the solar photovoltaic (PV) panel, battery, control electronics, and the light fixture. When the sun is available, a solar panel takes the light from the sun and produces electrical energy, and this energy can be used immediately or stored in a battery. The goal of most solar lights is to provide power at night with the help of a battery. The battery itself may not need to have a large capacity, due to the availability of solar energy, but it should be long-lasting to account for difficulties replacing batteries in many places across the globe.

To save energy stored in a battery, a Light Emitting Diode (LED) was introduced for illumination. LED area type of semiconductor diode and one of the most widely used lighting fixtures available today. Furthermore, the advent of the Light Emitting Diode (LED) for the light fixture has drastically reduced the capacity needs of both solar panels and batteries because LED uses significantly less energy than other types of lighting (Unite to light, 2019). In this circumstance, the solar panel and battery can be designed as small, transportable and less expensive. The solar light system can be controlled electronically using sensors or can be controlled manually. Solar lights made for outdoor lighting will often turn on automatically when it gets dark using a photo sensor. According to (Moss Modise, 2021) outdoor lighting plays a key role in the design of the public area and can have a profound impact on its structure whether it is used for roads, cycling paths, footpaths, residential areas or parking lots, and its quality has a direct impact on the community. Good lighting improves security, strengthens community ties, has a positive impact on the environment, enhances the attractiveness of towns and cities, and accelerates the economic and social development of off-grid populations. Relying on solar energy for public lighting projects, local authorities can effectively reduce energy consumption as well as carbon footprint. Adopting solar lighting solutions helps preserve biodiversity in areas that are the most sensitive to light pollution and can be designed based on the dynamic lighting profile of the area or existing ecosystem (Moss Modise, 2009).

Solar streetlights are maintenance-free due to photocells, and the batteries come with five to seven years of durability. While the rainwater will clean the solar panels. Moreover, the notable benefit of solar streetlights is using energy without paying monthly energy bills or not an issuance of the energy bill to the user (CHINT Group, 2022).

II. BACKGROUND OF THE STUDY

Solar street lights are elevated light sources that are often positioned on the lighting structure and are powered by solar panels. A fluorescent or LED light is powered during the night by a rechargeable battery that is charged by the solar panels. Every streetlight has the option of having its own photovoltaic panel, apart from other streetlights. Alternately, a number of panels can be set up as a single power source in a different place and used to power a number of lamps. The photovoltaic effect allows solar modules to produce electricity using the sun's light energy (photons). The bulk of modules employed crystalline silicon wafer-based cells or silicon or cadmium telluride thin-film cells. A module's top layer or rear layer may serve as the structural load-bearing part. Additionally, cells need to be shielded from moisture and mechanical harm. The majority of solar modules are rigid, however thin film cell-based ones that are semi-flexible are also available. The first time these early solar panels were utilized in space was in 1958.
Solar energy offers enormous promise for clean, renewable energy that, if properly investigated, might supply an endless supply of energy to meet all of humanity's requirements. For the majority of its energy needs, modern society has relied on conventional fuel sources. However, the possibility of traditional energy sources running out has become very disturbingly real as a result of the continuously increasing need for fuel. The development and suitable use of these technologies have been the focus of institutions' research and development efforts in response to the continuously expanding need for alternative energy sources. It is regrettable to see that

while living in a fast-paced society, certain places still lack access to fundamental public utilities like power and water. The beneficiary of the project at hand is one example where meeting these demands can only be met through unconventional ways.Due to a rise in the global average energy use per person, there is now a global energy shortage. As a result, the amount of oil and natural gas stored across the world has been steadily declining. Additionally, issues with pollution have been identified as a cause of stress on ground life. Since there is a global energy issue, renewable energy technologies have attracted a lot of attention. In recent years, PV systems have been used in a variety of applications, ranging from cameras, watches, and mobile devices to large-scale PV plants with cumulative power reaching just a few tenths of GWp and small-scale PV reaching just a few tenths of Watts. The independent street lighting system employing the most effective and economical Light Emitting Diode (LED) bulbs is one of these PV applications. A PV panel, top-notch battery, LED lamp, dc-dc converter, and controller make up this system.

All throughout the year, solar electricity is continuously and reliably produced by the sun. As the availability of our non-renewable resources will inevitably dwindle over time. Moving toward sustainable energy sources including wind, hydropower, biomass, and tidal is necessary. The fundamental advantage of solar energy is that, unlike wind or geothermal energy, it can be simply deployed by both residential and commercial customers. One of the most popular renewable energy sources is solar energy.

Possible replacements for the traditional streetlights have been proposed as a solution to the growing number of issues that have arisen as a result of their continued usage. Given the numerous advantages that solar-powered streetlights offer, replacing traditional streetlights with solar-powered ones would be the most advantageous course of action to take. In contrast to more conventional energy sources such as coal and oil, the source of this energy, which is referred to as solar energy, is a nonpolluting, low-maintenance, and renewable form of energy.

This research presents the outcomes of an investigation that was carried out by conducting interviews with individuals who were knowledgeable about the subject matter. Whichever of the two different sources of electricity for the lamps in Intramuros would be preferable – the traditional one or the solar-powered one – will result in a reduction in the number of incidents or crimes that take place in barangay arenas.

III. REVIEW RELATED LITERATURE

According to (ROSPA 2018) The Royal Society for the Prevention of Accidents, Street lighting provides a number of important benefits. It can be used to promote security in urban areas and to increase the quality of life by artificially extending the hours in which it is light so that activity can take place. Street lighting also improves safety for drivers, riders, and pedestrians. Driving outside of daylight hours is more dangerous. (ROSPA March 2020) Also, only a quarter of all travel by car drivers is between the hours of 7pm and 8am, yet this period accounts for 40% of fatal and serious injuries to the same group. Pedestrians and vulnerable road users suffer from decreased visibility in the dark too. For these reasons, ways of reducing the risk to all road users during the hours of darkness must be found. A study for the Department for Transport2 in 2003 found that road safety was perceived as a key benefit for street lighting improvement. In the study, 73% of respondents agreed that ‘better street lighting would improve the safety of children, and 63.8% agreed that ‘improved street lighting would lead to fewer accidents on the roads.

According to the Barangay Captain and police investigator, most of the prone accidents’ areas are the street with no Street lights. Most of the recorded accidents happen in Santa Ana-Magalang Road, like collisions of vehicles, hit and run and throwing corpses.

One of the main forms of energy is the sun's energy, which is also one of the cheapest and most ancient types of primary energy. Its historic applications have included drying textiles and agricultural products, and most underdeveloped nations still utilize it for similar purposes today (Solar thermal). A form of renewable energy that gets its source from the sun is solar power. Solar panels have the capacity to collect solar energy from the sun and convert it into the secondary energy

known as electricity. In 2011, just 0.5 percent of the world's total electricity consumption was met by solar energy, according to estimates from the Centre for Climate and Energy Solutions. (C2ES). To start, the sun produces around 7,000 times more energy than is required for human use. This suggests that there is a significant amount of energy in the sun that has not yet been captured. The advantages of solar energy remain among the most important even when compared to the advantages of other forms of renewable energy (Boxwell, 2014).

S. P. Sukhatme and J. K. Nayak (2008) claim that promoting widespread usage of solar-derived renewable energy sources is one method to promote positive and forward-thinking development in geographically different communities. Applications for solar energy might be direct or indirect. It may be directly used in a wide range of thermal operations, such as drying, distillation, heating air or water, and food preparation. The heated fluids can subsequently be used for a number of purposes, including the production of electricity and food preservation. The photovoltaic effect, which includes converting solar energy into electrical energy, is the second way that solar energy may be used directly. The wind blows, plants grow, precipitation falls, and temperature variations between the ocean's surface and its depths are all caused by the sun, if indirectly. These renewable energy sources all have the potential to provide useful energy, which may subsequently be used for a wide range of diverse commercial and noncommercial purposes.

Photovoltaic systems, according to Kalogirou (2014), are bundled into modules, and each module has a distinct voltage and current output when it is lit. Photovoltaic modules can be connected in series or parallel to produce higher voltages or currents. Solar photovoltaic (PV) systems have the ability to generate energy on their own or in combination with other kinds of power plants. Photovoltaic systems are used to power a variety of functions, including communications (on Earth and in space), remote power, remote monitoring, lighting, water pumping, and battery charging. Photovoltaic (PV) applications may be divided into two main categories: grid-connected systems and standalone systems. Standalone photovoltaic (PV) systems are used in places where connection to mains electrical networks is difficult or unavailable. Since a standalone system is not connected to the public power grid, the energy it produces is frequently stored in batteries. A typical freestanding system would consist of a solar photovoltaic (PV) module or modules, batteries, and a charge controller. The system may additionally include an inverter, whose function is to convert the direct current (DC) that the PV module produces into the alternating current (AC) that is needed by common household appliances.

The solar system is connected to the neighborhood's primary power grid in "grid-connected" applications. The photovoltaic (PV) system's capacity to generate power during the day can be used right away or sold to a company that provides energy. It is feasible to buy extra power from the network in the evening when the solar system is unable to provide the required quantity of electricity. The PV system does not require the installation of battery storage to operate correctly because the grids act as an energy storage system in effect.

Since photovoltaic panels power solar street lights, they generate sustainable and clean energy. Local governments may significantly cut their energy use and carbon impact by opting to use solar energy for public lighting installations. By doing this, companies adhere to national and international energy policies, reduce their influence on the environment, and actively participate in the energy transition. There is however more to it. Biodiversity is preserved in regions most vulnerable to light pollution by using solar lighting systems. Through the use of dynamic lighting profiles, solar street lighting systems alter the intensity of the light during the course of the night, making street lighting more considerate of living ecosystems, notably birds, whose migratory behavior is significantly impacted by light pollution (Sunna, D. 2020).

IV. STATEMENT OF THE PROBLEM

In the Barangay of San Arenas, there is a road that does not have street lights. It is dangerous to the residents and motorcyclists who pass during night.

The purpose of this study is to evaluate how well solar street lighting may reduce crime and other events. In

order to better evaluate this, the following particular objectives will be addressed:

- In order to lower crime in the region, it is important to assess the effectiveness and sustainability of the solar street light.
- Is a distance of fifty meters between each street light sufficient to adequately light the road?
- What size or capacity solar PV system is needed to power a 3-kilometer street light?
- Will the installment of solar streetlights be beneficial in reducing accidents, thefts, and crimes?
- Will the fifty solar-powered lightings be sufficient to illuminate a route that is thirty kilometers in length?

V. OBJECTIVES

A. Main/General Objectives

This project's goal is to install energy-efficient solar panel lamps in the Barangay Kalasungay in order to offer solar lighting for the protection of the community's people.

B. Specific Objectives

- To put up solar-powered lamps in the barangay of Arenas, in the municipality of Arayat, in the province of Pampanga
- To make people less vulnerable and protect drivers and passengers from becoming involved in accidents.
- To make people feel safer, which is a step toward reducing crime.
- In order to prevent the waste of energy, which may then be utilized to illuminate the subsequent evenings.
- To ensure that roadways are easily discernible in order to enhance both convenience and safety.
- To facilitate the movement of automobiles during the night in a manner that is safer, more pleasant, more convenient, and more efficient

VI. SCOPE AND LIMITATIONS

The main purpose of this research is to install solar-powered LED street lights on the road and it is one of the concerns of the people who live there to provide them with adequate solar street light panels in their area.

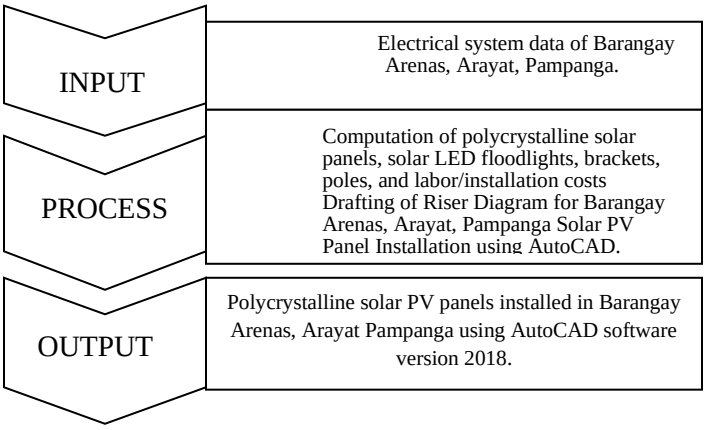
The scopes of this project are:

i. Install a solar street light panel
ii. To reduce the possibility of accidents

VII. SIGNIFICANCE OF THE STUDY

This project will have a significant impact on the lives of the people who live in each park of Barangay Arenas, Arayat, and Pampanga because it improves community sustainability, which in turn can improve security, reduce the number of crimes that occur, strengthen community ties, and make the Barangay more appealing. The adoption of solar lighting solutions has a long-lasting positive influence on the environment, in addition to providing a number of benefits, such as cost and performance, to the people of Barangay Arenas.

Conceptual Framework

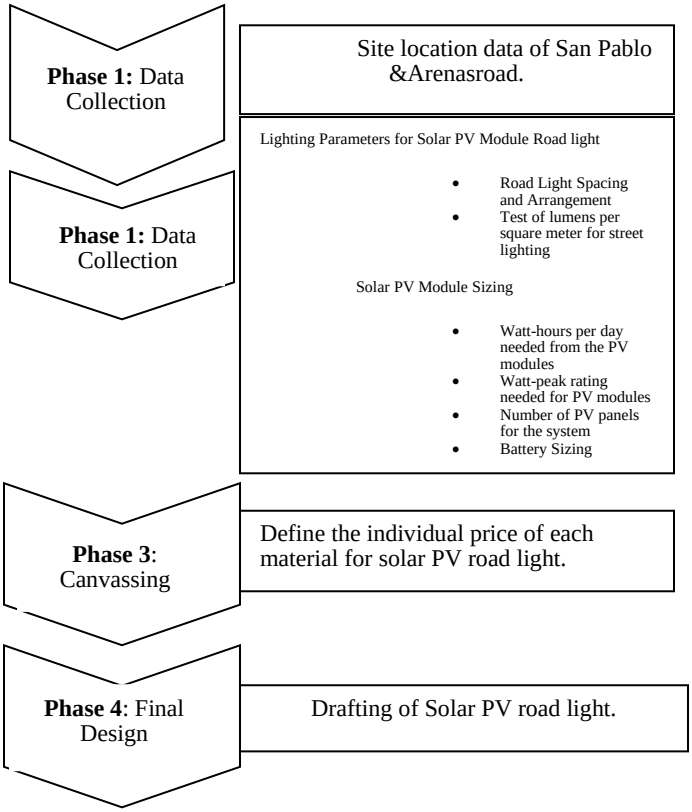


For the input, process, and output of the study. The input contains the existing data used to generate the results of this study which are the electrical system data of the Brangay Arenas, Arayat, Pampanga consisting of the AC Single-Line Diagram, and the Polycrystalline Solar PV System consisting of maximum system voltage and output-circuit current. Computation ofpolycrystalline solar panels, solar LED floodlights, brackets, poles, and labor/installation costs were surveyed. In order to install the solar PV road lights in their ultimate location, CAD tools like AutoCAD will be used.; and drafting of single-line diagram for Barangay Arenas Solar PV Panel Installation with Grounding System. Finally, the

output of the study comprises the Single Line Diagram of Solar PV Panels installed in Barangay Arenas.

VIII. METHODOLOGY

The proponents described the stages to undertake in developing the study as seen in this Figure:



Phase 1: Data Collection
The researchers conducted a site visitation forgetting the necessary data such asroad length parameters and road width. Road curbs were also took into consideration as to identify the position of the poles.The proponents also considered market-available equipment for the computed size of PV panels and battery.

Phase 2: Manual Computation
Lighting Parameters for Solar PV Module Road light
The proponents complied to the Roadway Lighting Guidelines of the Department of Energy (DOE), Roadway lighting guidelines was created to promote the use of energy-efficient lighting technologies for roadway installation while also providing technical and safety information regarding lighting system design and installation (DOE, 2017).

Specifically, section 6 which focuses on lighting parameters and table 6.5.1 for the minimum values for Roadway Lighting Parameters particular to roads for MotorizedTraffic and table 6.5.3 for the Placement Guide for Roadway Lighting.

Test of Lumens per square meter for street lighting
With the use of a lux meter, the proponents were able to measure the appropriate lumens per square meter or lux in the area and aligned the desired lumens to the standards of the DOE Roadway Lighting Guidelines, specifically table 6.5.3.

Solar PV Module Sizing
To find out the sizing of the PV module, total peak watt produced was determined. The peak watt (Wp) produced depends on the size of the module and climate of the site location.

- Watt-hours per day needed from the PV modules

After determining the total watt-hours per day of the street lights, multiply by 1.3 as to consider the energy lost in the system. In doing so, total watt-hours per day that needs to be provided by the panels were computed.
W-hr per day needed from the modules = W-hr per day × 1.3

- Watt-peak rating needed for PV modules

To get the total Watt-peak rating needed for the PV panels needed to operate the street light, divide the total Watt-hours per day needed from the PV modules by 3.43.
W-peak rating needed for PV modules = W-hr per day needed from the modules × 3.43

- Number of PV panels for the system

After getting the Watt-peak rating needed for PV modules, divide it by the rated output watt-peak of the PV modules available to the market. If the answer resulted to any fractional part, just increase to the next highest whole number.

$$\text{Number of PV panels for the system} = \frac{W\text{-}peak\ rating\ needed\ for\ PV\ modules}{rated\ output\ w\text{-}peak\ of\ PV\ modules\ available}$$

- Battery Sizing

A deep cycle battery is recommended to be used in PV systems. Specifically designed to be discharged to low energy level and rapid recharge or cycle charged and discharged day after day for years. The following steps were followed to compute the battery size:

- Divide the watt-hours per day used by 0.85 for battery loss.
- Divide the answer from previous step by0.6 for depth of discharge.
- Divide the answer from previous step by the nominal battery voltage.
- Multiply the answer from the previous step with days of autonomy or the number of days the system needs to operate when there is no power produced by PV panels. In doing so, the required ampere-hour capacity of the deep cycle battery was achieved.

Phase3: Canvassing

For the overall price of the system, the proponents consulted with AlphaSolar Incorporated. The canvassed data consists of polycrystalline solar panels, LED flood lights for solar, bracket, pole, and labor/installation cost.

$$Payback\ Period\ = \frac{Total\ Cost\ of\ the\ System}{Total\ Savings}$$

where:

Payback period = length of time it takes to recover the cost of the investment, in years.

The total cost of the system = Total contract price (major components, bill of materials for consumables, grounding, manpower cost for installation, operation & maintenance cost, delivery of materials, net-metering application cost)

Total savings = Total savings per month.

Phase 4: Drafting

The final location of the solar PV road lights will be positioned using a computer aided drafting (CAD) software such as AutoCAD.

IX. RESULTS AND DISCUSSION

Manual Computation

To find out the sizing of the PV module, total peak watt produced was determined. The peak watt (Wp) produced depends on the size of the module and climate of the site location.

To get the peak watt (Wp):

Given:

100 watts

12v = Nominal voltage

solution:

100×12=1200 Peak watts hour

- Watt-hours per day needed from the PV modules

After determining the total watt-hours per day of the street lights, multiply by 1.3 as to consider the energy lost in the system.

1200 peak watts hour × 1.3 = 1560 watt hour

- Watt-peak rating needed for PV modules

To get the total Watt-peak rating needed for the PV panels needed to operate the street light, divide the total Watt-hours per day needed from the PV modules by 3.43.

$$\frac{1560\ watt\ hour}{3.43} = 454.81\ watt\ hour$$

- Number of PV panels for the system

After getting the Watt-peak rating needed for PV modules, divide it by the rated output watt-peak of the PV modules available to the market.

$$\frac{454.81\ watt\ hour}{100} = 4.55\ \ PV\ Panel$$

If the answer resulted to any fractional part, just increase to the next highest whole number.

= So if the answer is 4.55 the next whole number is 5 PV Panel.

- Battery Sizing

Divide the watt-hours per day used by 0.85 for battery loss.

Given:

1200 watt hour

0.85 battery loss

$$\frac{1200}{0.85} = 1411.76\ wattts$$

Divide the answer from previous step by0.6 for depth of discharge.

$$\frac{1411.76\ watt}{0.6} = 2352.93\ watts$$

Divide the answer from previous step by the nominal battery voltage.

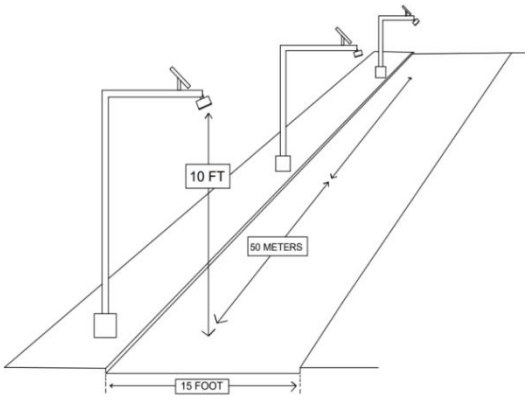
$$\frac{2352.93\ watts}{12} = 196.08\ \ ampere$$

Multiply the answer from the previous step with days of autonomy or the number of days the system needs to operate when there is no power produced by PV panels. In the Philippines usually the duration of rain here is reaching 3-5 days.

In doing so, the required ampere-hour capacity of the deep cycle battery was achieved.

$$196.08 \times 3 = 588\ ampere\ hour\ capacity$$

- Final Design



Drafting of Solar PV Road light

CONCLUSION

Solar streetlights are elevated light sources that are often positioned on the lighting structure and are powered by solar panels. Fluorescent or LED bulb is powered at night by a rechargeable battery that is charged by solar panels. Each street light is autonomous from the other lights and has photovoltaic panels installed on the framework. The majority of solar panels operate automatically by detecting external light with the aid of a light source. Solar lamps are made to operate all night long. If the sun isn't out for a few days, many can stay illuminated for more than one night.

Sun electricity may be produced using solar energy, which is necessary to sustain life on earth. Solar power is a form of low-cost, renewable energy that depends on man-made components like solar panels or solar cells. Due to high demand and limited output, solar energy is becoming a key component of the power supply. It is the simplest method of generating energy. The issue with the solar system is that people are ignorant of this technique and it is expensive.

Solar streetlights operate separately from the power grid. When compared to traditional street lights, adopting solar street lighting requires a larger upfront expenditure. The operation costs are reduced as a result. Compared to traditional street lights, it requires a lot less maintenance. Accident hazards are reduced since external cables are not present. This is an environmentally friendly source of power. Separate solar system components may be readily transported to specific locations, are simple to install and maintain, and offer a less expensive option to wired lighting.

RECOMMENDATION

The office of Barangay Arenas had already considered solar streetlights. To complete a project that required 60 solar street lights for barangay Arenas, Arayat Pampanga. According to studies done by experts, even though installing 60 solar street lights would cost 359,000, the savings from using solar street lights would far outweigh this cost.

According to Sepco (2016), solar street light has a 15-20 years lifespan and may reduce electricity use by up to 85%. (C40 , 2011). Another benefit of utilizing solar lights instead of regular lights is that you may select from the various styles and designs that you want. Design won't be a problem at Intramuros since it is

very careful about the details and patterns it uses to preserve the walled city's Old Spanish feel or theme.

Off-grid solar streetlights are the first type. The majority of solar street light projects are necessary because transmission lines cannot reach the needed area. Installing new infrastructure is costly, particularly when it involves burying wires. In this instance, it is easy enough. Each pole is equipped with a self-contained unit that includes a solar panel for power, a battery, an LED controller, and an LED light. This hardware can be placed anywhere, with the obvious exception of a location without sunlight (Brown,2014). The grid-tie single inverter is the following type. In a single inverter system, a centrally located solar array is used to power a group of LED street lights that are powered by transmission lines. If you want to exhibit a solar array to the public or if you want your solar-powered street lights to blend in with the rest of your street light system's design, this is a wonderful alternative (Brown,2014).

The grid-tie micro inverter is the last kind. Grid-tied LED solar streetlights are made possible by the presence of individual inverters on each pole, which eliminates the need for a larger solar array (Brown,2014). From power usage to design and requirement inclusion, using solar street lights is a good choice.

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