Cost Analysis of Battery Coupling of Photovoltaic Source to Water Pumping Irrigation System in Barangay San. Antonio, Lubao, Pampanga

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Abstract: Two Diesel Powered Pump are used to pump water in San Antonio Lubao, Pampanga Corn and Rice Farm. Total diesel consumed by those motors is huge in the area. By implementing a renewable energy source to run those motors can save diesel cost. The purpose of this paper is to provide information about planning and installation of solar powered water pumping systems by using PV (Photo Voltaic) Module. 20 panels of 650 Watt are mounted by using concrete pillar that is elevated to be safe from flood. A 3D design was created by using Paint 3D to bring perfection in mounting solar panels. An 8 HP 3-Phase motor was used in this project. The farmers' organization in Barangay San Antonio Lubao, Pampanga, is facing serious problems with their crop water supply. There are many agriculturists who have looking for different way of having a water supply due to the increase of fuel prices, because diesel water pumps are their primary source of water, farmers need to install alternative water-pumping system to irrigate their farm area that around 200 farmer households will benefit. Most families in Lubao rely on agriculture for a living, and having a consistent supply of water for their crops would be extremely beneficial to them. Diesel water pumps are widely used for irrigation purposes. However, due to an increase in the price of oil, harmful emissions from burning of it, high maintenance cost, and short lifetime. Researchers have been forced to find some alternative. Renewable energy has the potential to limit the use of fossil fuel, as researchers are shifting towards a solar-powered water pumping system. As solar is available in large amounts and almost everywhere, which makes a good alternative to the diesel-powered water pump. Solar water pump system is one of system that is applied photovoltaic panel for water pump as power source. In daytime, photovoltaic panel can generate power. Solar water pump has low operation costs since fuel is not needed and system run on sunlight, no dependency on erratic or expensive fuel chain supply, low regular maintenance requirements since solar panels, batteries and inverters have no moving parts. Lastly, no pollution or noise produced. Another benefit from system is to reduce environmental impact compared to traditional diesel water pump. Therefore, this paper aims to design and develop solar water pump. And the cost analysis was made to form an idea about the cost of the project study. This manuscript presents a detailed planning, cost analysis and installation of Battery coupling of Photovoltaic source to Water Pumping Irrigation System in Brgy. San Antonio Lubao, Pampanga.

Key Words: —*Water Pump, PV, Sunlight, Renewable Energy, Beneficial machine.*

I. INTRODUCTION

During day light, the PV module produce electric DC power that is inverted to 3 phases AC by a smart inverter.

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The amount of water pumped is totally dependent on the amount of sunlight hitting the PV panels and the type of pump. Because the intensity of the sun and the angle at which it strikes the PV panel changes throughout the day, the amount of water pumped by this system also changes throughout the day.

For instance, during optimum sunlight periods (late morning to late afternoon on bright sunny days) the pump operates at or near 100 percent capacity with maximum water flow.

However, during early morning and late afternoon, pump capacity may drop by as much as 25 percent or more under these low-light conditions.

During cloudy days, pump performance will drop off even more. To compensate for these variable flow rates, a good match between the pump and PV module(s) is necessary to achieve efficient operation of the system. The inverter also can track the peak values to run the motor with a constant supply During dry season, irrigation is necessary for rice and corn cultivation. In Lubao, Pampanga most of farmers use water pump and is mainly operated by diesel. Two diesel powered pump are used to pump water in San Antonio Lubao, Pampanga Corn and Rice Farm. Total diesel consumed by those motors is huge in the area. A solar powered water pumping system initially costs more than a diesel or electric powered pump but requires far less maintenance and labor. Comparing installation costs (including labor), fuel costs and maintenance costs over 10-year period, it is observed that solar pump is an alternate choice. Pampanga is ideal location for solar energy harvesting.

The farmers' organization in Barangay San Antonio Lubao, Pampanga, is facing serious problems with their crop water supply. Because diesel water pumps are their primary source of water, most farmers are unable to farm due to ongoing fuel price increases. They have a water supply in a dam in Florida Blanca, but it is insufficient for them because many Barangays utilize it. They have a schedule for utilizing it, and it is a risk because they don't know if there will be enough water to meet their needs. Agriculture is one of the most important duties for farmers since it produces food, which is a basic necessity. Pumping is a crucial aspect of irrigation. As a result, choosing the proper sort of agriculture water pumps is critical because they are beneficial machines for farmers.

Water pumps are equipment that moves water; they serve a vital role in agriculture by delivering water from its source to fields and crops. Water pumps can be utilized with a variety of irrigation technologies, including drip, sprinklers, and hoses. Water pumps range in complexity from simple, manually operated pumps to those powered by fossil fuels or electricity.

In the tropics, gasoline and diesel water pumps are still widely used since they seem to be the most affordable alternative. But these pumps have a lot of continuous expenses, which drives up the cost of the pump over its whole lifespan. Fossil fuel pumps have short lives and need routine maintenance from a mechanic in addition to fuel purchases. Additionally, they are quite polluting, causing farm's air quality to deteriorate, and they release carbon dioxide, which contributes to climate change and has been found to have an impact on how frequently the dry and wet seasons occur. In contrast, when utilizing solar water pumps, the solar panels will still be able to power them for free and without any harm because solar energy is available every day of the year.

This suggests that users can acquire more fuel without having to travel or connect to the electrical grid. Additionally, all that is required to maintain the panels is a quick wipe down to remove any lingering dirt and dust. The researchers suggested that the ideal way for farmers to run their water pumps while utilizing sustainable solar energy is with solar water pumps.

Photovoltaic (PV) panels are frequently utilized in agricultural activities, particularly in isolated places or where an alternate energy source is sought. They have repeatedly proven their ability to generate adequate electricity straight from solar panels.

Sunlight is used to power livestock and irrigation systems. The use of solar energy to power agricultural water pump systems has the advantage of synchronizing growing water requirements for livestock and irrigation with seasonal increases in incoming solar energy. When properly constructed, these PV systems can also save money in the long run and have a lower environmental impact than traditional power systems.

Solar water pumps were first used to provide water in off-grid areas. Technology has evolved around many different designs, and the reliability and maintenance requirements of some water pumps have improved over the initial pumps introduced to the market. Solar pumps are simple to install, use no nonrenewable energy, operate autonomously, and are generally beneficial to borehole sustainability due to their low extraction volumes spread over eight to ten hours per day.

In this study, the researchers proposed an alternative method of crop irrigation to the farmers of Barangay San Antonio, Lubao, Pampanga so they can have a reliable water pumping system and lower their expenses since they will no longer depend on fossil fuels and foreign oil.

II. METHODS

The figure 1 explains how the workflow of this study have worked. The step-by-step process was used as guide to create a design base on the present situation of the local. This includes data gathering, formulation of design, specification and calculation of the total cost.

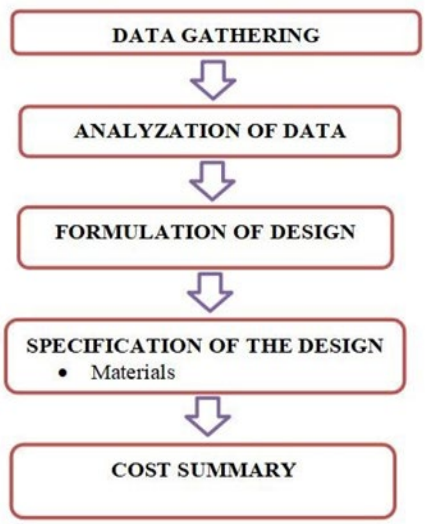


Fig.1. Work Flow

2.1 Data Gathering

Researchers start gathering data using an interview questionnaire on the Farmers Organization to know more about the current situation in San Antonio Lubao, Pampanga

when it comes to water supply for their farm. farmers have existing 2pcs 8 HP Diesel Pump.

2.2 Analyzation of Data

Researchers analyze the data to break a topic or concept down into its parts in order to inspect and understand it, researchers consider floods during rainy days and make the panels elevated using pillars.

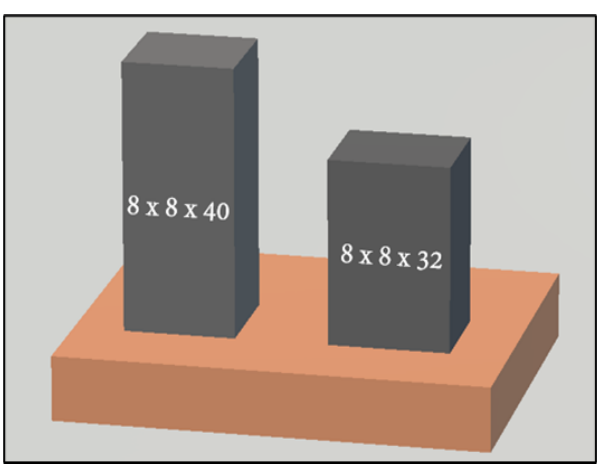


Fig.2. Types of Pillars

Researchers construct 2 different sizes of pillars so that when the PV panel is place. It is in 18.2-degree angle.

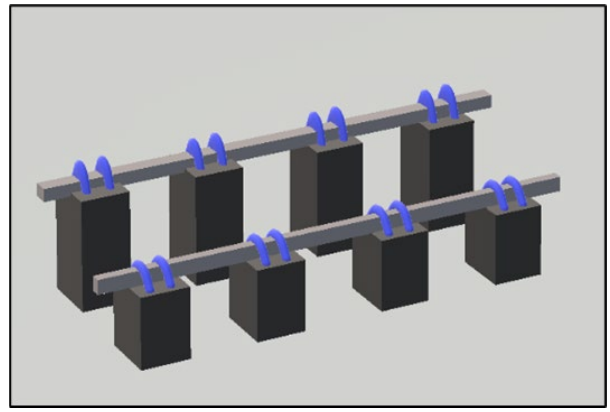


Fig.3. Pillar Design

Figure 3 shows the design that will hold the panels. It is elevated for the PV Panels to be safe from flood in rainy season.

In the front side, pillar size is 8*8*32 inch (Length= 8 inch; Width= 8 inch; Height=32 inch) and the back side is 8*8*40 inch (Length= 8 inch; Width= 8 inch; Height=40 inch). The pillars are constructed in such way so that each panel has an angle of 18.2 degree. 2 angle bar frames used for two panels to mountain them on pillar. We put deformed bars of each pillar to hold the angle bar frame.

2.3 Formulation of Design

After analyzing, Researchers start to formulate the design or final model of the project.

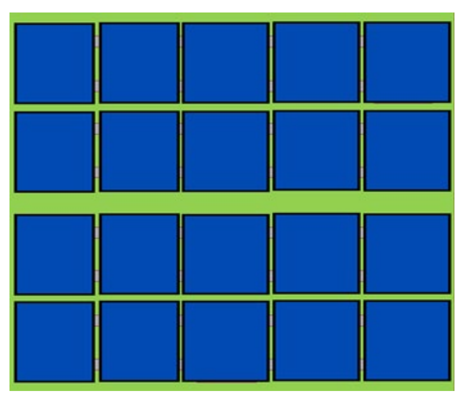


Fig.4. Installed 13kW PV Modules

Figure 4 shows the design of the PV modules. they are divided into 2 panel group; each group consist of 10 PV panels that will supply each motor.

2.4 Specification of the Design

When listing of materials is done, Researchers start to look for the specifications they need or compatible for the project and present it in Table 1, Table 2, and Table 3.

8 HP Motor

1 HP = 746 W

8 HP = 746 W (8) = 5968 W

Number of Panels

Rating: 650 W

5968 W / 650 W = 9.18 pcs pv panels 650 W per Motor

Multiply it by 2 since 2pcs 8 HP motor was used in this proposal

9.18 (2) = 18.36 Panels

Make it 20 panels with 90% efficiency

Inverter Specification

650 W (20 panels) = 13kW

Researchers make it 20kW for future upgrades and it would be great for this system to minimize problem.

Solar battery

Battery bank size (kWh) = Daily energy use (kWh) x Number of days of autonomy / (1 – SOC)

Battery bank size = 11.9 kW x 3 / (1 – 0.5) = 71.4 kWh

Amp-hours = 1000 x Energy storage (kWh) / Battery Voltage (Volt)

Amp-hours = 1000 x 71.4 / 48 = 1487 Ah at 48 Volt

1487 Ah / 200 Ah = 7.435 pcs battery with 200 Ah Capacity

2.5 Cost Summary

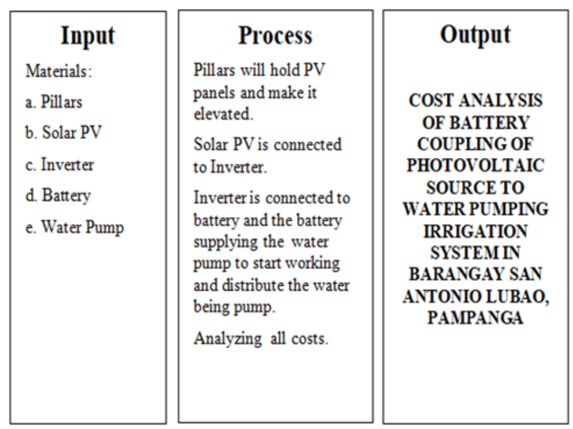
Researchers compute for the cost summary of the design, this includes the materials of constructing the pump, solar panels and constructing the cost of the the pillars that will hold the solar panels. The data was presented in Table 9. to get the cost summary of this study researchers use the formula given below.

Total Cost = Cost for Solar Panels and Batteries + Cost for Mounting Structure + Cost for Motor and Inverter

Fig.5. Aerial View of San. Antonio Lubao, Pampanga

2.6 Conceptual Framework

The conceptual framework, on the figure below, shows how the research notion will progress from its inception to its fulfillment. The purpose of this research is to determine whether a battery- coupled solar water pump can minimize the cost of diesel water pump supply.



III. RESULTS AND DISCUSSION

Table 1: Pillars Specification

Pillar Type	Length	Width	Height	Position
Type 1	8 inches	8 inches	32 inches	Front
Type 2	8 inches	8 inches	40 inches	Back

Table.2. Specification of PV Modules

Specification of PV Modules	
Power	650 W
Open Circuit Voltage	45V
Short Circuit Current	18.39 A
Cell Type	Mono-Crystalline
Size	2.4m x 1.3m

Table.3. Specification of 3-Phase Motor

Specification of 3-Phase Motor	
Brand	Shree Ram Enterprise
Power	8 HP
Speed	2000-6000 RPM
Voltage	415 V
Number of Phase	3-Phase
Frequency	50 Hz
Material	Cast Iron
Suction	50 meters

Table 3 presents the specification of the motor. This motor can suck water 50-meter height. A 3-phase inverter was setup closed to motor. It can handle 15 KW of power for input voltage of 415 V with corresponding 3-phase output. Installing a solar pump is a complex task, combining elements of electrical work, plumbing, and heavy construction. To get a cost-effective solution, all task and installation has done very carefully.

Table.4. Cost for 20 Solar Panels and Batteries

Equipment	Quantity	Unit Price	Rating	Total Price
Solar Panels	20	14,400	650 W (90 %) Efficiency	288,000
48v Battery Lifepo4 Litium Powewall 48V 200Ah Lithium Ion Battery	8	34,500	200 AH 48 V	276,000
				Total: 564,000.00 PHP

Table.5. Cost for Mounting Structure

Equipment	Quantity	Unit Price	Total Price (PHP)
Concrete	18 bags	2,000 / elf	2,000
Sand	18 bags	1,300 / elf	1,300
Cement	6 bags	300	1,800
Labor	3 persons	600 / day	3,600
Angle Bar	12 pcs	900	10,800
Solar Panel Clamp	80 pcs	50	4,000
Conveyance			2,000
			Total: 25,500.00 PHP

The Table 5 show the total cost of the mounting for 20 pcs of solar panels.

The cost of 20 panels and its mounting pillar with water pump and inverter is discussed. It's required an initial high investment. But considering the life time of 20-25 years, the average cost is lower.

Table.6. Cost for 3-Phase Motor and Inverter

Equipment	Quantity	Unit Price	Total Price
Water Pump (3Phase 8HP)	2	39,000	78,000
Inverter (20kW)	1	70,000	71,500
			Total: 149,500.00 PHP

Table 6 presents the total cost of Water Pump and Inverter

Table.7. Maintenance Cost

Problem	Repair Cost
No Voltage	2,000.00
Cracked Panel	8,000.00
Rust	1,500.00
Inverter Not Communicating	5,000.00

Table 7 shows the possible maintenance cost of the project. Depending of the problem that may encounter.

Table.8. Operational Cost

Maintenance Cost	Frequency	Cost
Cleaning Costs	Annually	20,000.00
Inspection Costs	Annually	15,000.00

$$oa = 20{,}000.00 + 15{,}000.00$$

$$oa\ eraoa\ o = 35{,}000.00/\text{year}$$

Table 8 presents the Operational Cost of the Solar Water Pump annually or per year. The Cleaning Cost around 20 thousand pesos per year and the Inspection Costs of 15 thousand pesos annually. The total Operational Cost of Solar water pump is 35,000.00 pesos.

Table.9. Summary of the Costs

Cost	Amount
Cost of Panels and Battery	564,000.00
Cost for Mounting Structure	25,500.00
Cost for Motor and Inverter	149,500.00
	Total: 739,000.00

Table 9 shows the summary of cost starting in designing of panels, cost of mounting structure and cost of 3 phase motor plus the inverter.

Solving for Return of Investment (ROI)

Return of Investment = Total Investment / Harvest Per Year

PV Panel Installed 20 pcs, 650 W

20 x 650 W = 13 kW

Peak Sun Hours 5 - 5.5 hours on an average day

Energy Efficiency = 90 %

Formula for average harvest per day:

Average harvest = PV Panel x Peak Sun Hours x Efficiency Harvest/day

= 13 kW x 5.5 hours x .90

Average harvest = 64.35 KWhr./day

Table.10. Cost using Electricity

Source	Cost	Ratio
PELCO II	13.08	per kWh

Compute the product harvest (per kWhr per day)

Harvest per day = 64.35 kWhr

Change the value of kWhr to 13.08 php

Therefore:

Harvest per day = 13.08 php (64.35) = 841.70 php

To get the savings per month, multiply the harvest per day by 30 days:□

841.70 php x 30 days = 25,251 php

To get the savings or harvest per year, multiply it by 12 months:

25,251 php x 12 months = 303,012 php

To get the ROI, the researcher used the formula below:

Return of Investment = Total Investment / Harvest Per Year

Where:

Total Investment = 739,000.00 php

Total Harvest Per Year = 303,012.00 php

$$ROI = \frac{739{,}000.00\ php}{303{,}012.00\ php}$$

$$\boldsymbol{ROI\ pelco\ rate\ based = 2.44\ years}$$

Table.11. Cost using Diesel

Source	Cost	Ratio
Diesel	1296 php	per farmer

Cost per year of 200 farmers:

1296 php x 200 farmers = 259,200 php

To get the ROI, the researcher used the formula below:

ROI = Total Investment / Diesel Cost Per Year

Where:

Total Investment = 739,000.00 php

Total Diesel Cost Per Year = 259,200.00 php

$$ROI = \frac{739{,}000.00\ php}{259{,}200.00\ php}$$

$$ROI\ diesel\ price\ based = 2.85\ years$$

IV. Conclusion

Design, installation and cost analysis of battery coupling of photovoltaic to water pumping irrigation has been described here. This system may benefit the farmers of Barangay San

Antonio Lubao, Pampanga. This alternative method was proposed to help the farmer's organization, San Antonio Farmers Rice and Corn /HVCC (which consists of approximately 200 farmers). Have a sufficient water supply. Solar water pumps are energy-efficient water solution for many watering applications. Furthermore, water solar pumps can not only be useful for supplying enough water but can also help farmers save more money in the long run. The initial investment of around 739,000.00 pesos. farmers can have a very good water pumping solution for their farm. If the total system design and utilization timing is carefully considered and organized to use the solar energy as efficiently as possible. The output of a solar pumping system is very dependent on good system design derived from accurate site and demand data. Further modification will enable this project to pump water up tin a long period of time the estimated return of investment in this project is around 2 to 3 years and shows that it is worth it to invest this kind of project.

Recommendations:

The findings of this study have implications on the importance of solar water pumps to local farmers. Although the investment on this is somehow expensive, the long-term benefits that the farmers may acquire is much greater than its cost. Thus, the researchers have recommendation about modification of this project that will enable this project to pump water up tin a long period of time by adding additional batteries and PV panels. To implement this alternative method to the local farmers. Additionally, they also recommend, to the future researchers, to conduct an impact analysis to determine the actual benefits of these solar water pumps.

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