Water Pump Management Using Photovoltaic Plates in Santa Fe - Amazonas Community

Antônio Jackson Sabino da Silva
jacksonsabino123@gmail.com
Centro Universitário FAMETRO - Brasil

Livia da Silva Oliveira
oliveira.livia@gmail.com
Coordenação de Engenharia do Centro Universitário FAMETRO - Brasil

David Barbosa de Alencar (Corresponding author)
david002870@hotmail.com
Instituto de Tecnologia e Educação Galileo da Amazônia – ITEGAM - Brasil

Antônio Estanislau Sanches
novo.sanches@gmail.com
Universidade do Estado do Amazonas – UEA - Brasil

Abstract

Electricity in today's world is one of the biggest concerns. Through clean sources, photovoltaic systems emerge as an alternative to this kind of problem.This work proposes the development of a photovoltaic system that will be applied to water pumping using a pump. Through the presented data, it will be possible to analyze if the photovoltaic energy is reliable and to propose solutions to the problem of residential water supply in the communities that do not have access to the electricity grid.

key words: photovoltaic systems; pump water; residential supply.

Introduction

We know that in riverside communities there are difficulties in water supply, which causes some problems in the living conditions of the population, such as the difficulty of bringing this resource to the residence, which is usually done through inadequate and even loaded containers. by women and children. Excessive physical effort in the water supply activity can cause damage to the physical health of people, as they may not have adequate physical conditions to perform the activity [1]. Looking for a way to alleviate these problems, it is possible to activate new technologies to improve the quality of life in the riverside community.

Second [2], Through the technological advances experienced in recent years by pumping technology in the course of growthof water supply applications for communities in Brazil and around the world,are seeking to retrieve the most relevant information about the state of the art technology.

The photovoltaic effect was first observed by the French physicist Edmund Becquerel. In 1839, photovoltaic pumping, in turn, experienced its first applications in 1950 and commercially consolidated in the 1970s. More than 10,000,000 systems were installed. throughout Brazil, with its exponential growth over the years. The photovoltaic effect intensified the studies for the implementation of this clean and renewable energy, since its number increased significantly [2].

One reason for the growth of photovoltaic pumping applications is that their prices have dropped over the years as prices were very high and many opted for other technological means. With the reduction, it became feasible to use pumping that benefits the economy and quality of life of residents [2].

The plan of this work aims to carry out a study on photovoltaic energy to manage a water pump, knowing the main components of the system off-grid (Off-grid) and understanding a functionality of each within the system, and design a system of photovoltaic plate for water supply in the riverside community of Santa Fe - Amazonas. The main motivations for the realization of this project are life improvements for the riverine residents of the community.

To carry out this project we have the objective of designing a pump system using photovoltaic plates, for this it is necessary to dimension the place that will receive the water through the pump pipes, perform the sizing of the water pump design and perform the sizing of the photovoltaic plate.

2. Theoretical Referential

1.1. Solar Energy

Solar energy is the name given to any type of radiation capture from the sun and subsequent transformation into some form usable by man, is the source of almost all the energy resources of the earth. There are several ways to convert solar energy into electrical energy, and one of them is through the photovoltaic effect that occurs in devices that are called photovoltaic cells [3].

1.2. Photovoltaic Effects

The photovoltaic effect is to capture the energy coming from the sun and transform it into electrical energy through the photovoltaic cells, which uses a clean and inexhaustible source that is the sun, where everything occurs in a semiconductor material, one of these faces of semiconductor material. has a tendency to receive electrons and the other side a tendency to donate electrons. However this electron movement does not occur spontaneously, it is necessary to have an activation energy that comes from an external environment. This energy is nothing more than the energy contained in the photons of solar radiation, that is, that luminous radiation that is the light we see from the sun [3].

It was first observed by Edmundo Becquerel in 1839 who produced electric current by exposing two silver electrodes to light, and in 1877 was built the first photovoltaic cell which in turn had a low yield and consequently there was no development of it. Only in 1954 was the first article published on silicon photovoltaic cells, which had a yield of 4.5%. The definition of photovoltaic cell performance is the ratio of incident light power to available electrical power at the terminals. In 1956 the production of the photovoltaic cell for silicon cells began, with a value obtained of approximately 24.4% [3].

Silicon is a matter of electricity semiconductors, as it has low electrical conductivity, thus using the doping process that serves to circumvent the conditions under which elements are mixed with silicon crystal, in the case of photovoltaic cells,silicon goes through two doping processes; one with Phosphorus (N-type silicon) and one with Boró (P-type silicon), each of these cells has a thin layer of N and P type material,as can be seen in figure 1 [3].

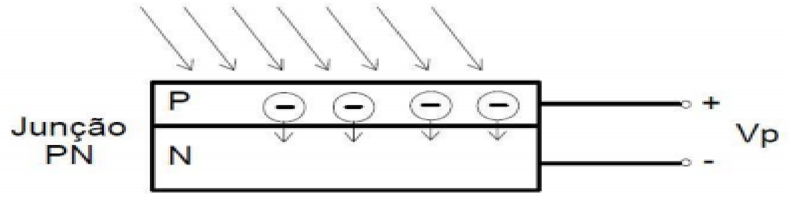

Figure 1. Simplified Scheme of a Photovoltaic Cell.

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When light strikes the photovoltaic cell, an electric field forms between the P and N layers and the electrons are directed to flow from the P layer to the N layer. It is important to note that separately the layers are separately neutral [3].

Each cell with about 100 mm² generates in its terminals a voltage between 0.1 V and 1 V. Thus with low value the cells are assembled in series to reach voltage of 12 Volts. In direct current, depending on the application, the plates can be mounted either in series or in parallel [3].

1.3. Photovoltaic Solar Energy Applications

There are several solar photovoltaic applications, so any kind of electric charge can be supplied via photovoltaic solar energy that just depends on the correctly designed system, but will use the water pumping system to manage the pump where the system will be sized accordingly. with the data obtained by the pump in order to be able to apply Off Grid photovoltaic solar energy. Where Off Grid is the standalone or standalone system that generates off-grid photovoltaic solar energy. It is a solution for the direct supply of appliances or homes where this location does not have access to the mains or for economic and practical reasons, such as specific locations. For example; water pumping systems, where this energy is produced and stored in batteries that guarantee the supply in periods not exposed to the sun [3].

1.4. Bombs

Pumps are machines capable of transforming mechanical energy into hydraulic energy, where it receives electrical energy that causes the pump to move (Mechanical), thus converting it into hydraulic energy for fluid transport, which in turn is withdrawn from the pump. its origin to its destination. Its energy is taken up by the movement of the motor shaft where the electrons will move and create a flow of currents. Fluid is transmitted by increasing the pressure, speed or lift of the pump. For pump sizing realizations, it is necessary to obtain factors that will determine its operation, such as; Repression, Suction, Flow, Head Height and Power [4].

2.4.1 Repression

Settlement refers to the height of the pipe to the reservoir, measured from the water leaving the pump in the storage tank [4].

2.4.2 Suction

It is the calculated height from the water surface to the pump inlet. For example, in a well, the suction height and piping length will be similar as the pipes are vertical. But the catchment of a lake's water may have a pipe larger than the suction height [4].

2.4.3 Flow rate

It is the ratio between water volume and transport time, which can be measured by cubic meters per hour (m^3 / h), liters per hour (l / h) or liters per minute (l / min), remembering that 1 m^3 corresponds to at 1000 liters. So if a tank is 2000 liters, a pump running at a flow rate of 4 m^3 / h will fill it in about 30 minutes [4].

2.4.4 Height Manometric Total

To find the total head height, we add the suction height, the discharge height, the type of connections and piping, and the losses in compliance with the installation. The m.c.a. It is also the measure used here [5].

2.4.5 Power

Horsepower refers to the force of the pump and the measure employed is the horsepower (hp). 1 horsepower corresponds to 735.5 watts of power. Acronyms like 1/4 and 2/4 represent fractions of this power. For example, a 1/4 pump will have 25% 1 horsepower, or about 368 watts. The higher the power, the more energy is spent [4].

2.5 Drums

According to [3] Battery is a device that stores chemical energy and makes it available in the form of electrical energy, can be classified into rechargeable and non-rechargeable. A battery is a chemical-filled container that produces electrons, ie a device that creates electricity through chemical reactions. For off-grid systems, the use of batteries for energy storage systems becomes important to compensate for periods without sufficient solar radiation, for example at night or on cloudy days [6].

2.5.4 Battery For Use In Photovoltaic System

There are several types of batteries, but the most commonly used in photovoltaic systems are stationary batteries that are designed to withstand longer periods of discharge, which can suffer up to 80% without affecting their useful life, so they last much longer. They last around 5 years, with cases where they exceed 10 years, depending on the load cycles, ambient temperature and other factors that impact their useful life [7].

2.5.5 Inverters

The inverter is an electrical device where solar energy is captured by photovoltaic modules and is injected into the inverter from direct current, where the inverter will take the direct current and turn it into alternating current. It usually has 12, 24 or 48 volts input voltage and converts 127 or 220 volts into direct current [3].

2.5.6 Load Controllers

The charge controllers are between the panels and the batteries of the photovoltaic system, they are used to control the input voltage in them, thus avoiding overloads or discharges that could cause equipment damage, thus extending their useful life, are responsible for transferring as much as possible. of power from the photovoltaic array to the battery bank for proper charging [8].

3 METHODOLOGY

The research is of applied scientific character, defined by the application of scientific methods, to associate the theoretical approach with practical applications, that is, to find solutions to everyday problems in a basic and pure way [10]. The type of research will be descriptive in nature, with the objective of designing an Off Grid photovoltaic system to manage a water pump. Descriptive research aims to describe the characteristics of a population, phenomenon or an experience. For data collection, an intensive direct approach will be used, and for analysis and interpretation of the data will be quantitative, ie, this type of research is classified by many authors as a particular case of quantitative research [10].

Para elaboração, será feito um estudo bibliográfico referente a energia solar e a bomba de água, onde foi utilizada fontes secundarias, ou seja, por meio de livros, revistas e artigos científicos.

This study explores a photovoltaic energy project to manage a water pump, located in the Santa Fe - AM community. Santa Fe is a riverside community in the state of Amazonas, northern region of the country, which has an average of 200 inhabitants and is close to the municipality of Puini - AM. To carry out the project it will be necessary to evaluate the location that will be sized the plate and the pump, in turn the location does not have the presence of the electric grid, where it will be necessary to use stationary batteries that will store energy for when there is no sun she act. This system will consist of a photovoltaic arrangement, a charge controller, a battery bank, an inverter and a motor pump. Where the data obtained to perform the sizing was through a partnership with a confidential company that works in the area. The water will be captured through an artesian well and the water will be pumped to a reservoir to be sized for the amount of liters of water.A moto bomba a ser utilizado será a bomba submersa, onde a principal função da bomba é pressionar o fluido durante o processo de bombeamento, esse equipamento funciona dentro da água trabalhando em meio ao composto que será bombeado, ou seja, funcionam de forma permanente dentro da água. Segundo a [9], A escolha do melhor sistema de bombeamento de um poço artesiano depende da análise de vários fatores, onde se incluem: o diâmetro a profundidade do poço, a profundidade do nível de água e seu rebaixamento, a capacidade e duração do bombeamento, a qualidade da água, os custos iniciais e de manutenção, e a potência requerida.

4 RESULTS ANALYSIS AND DISCUSSION

For the pumping of water directed to the residential supply, the site dimensioned in this work was designed a photovoltaic system with analysis according to data obtained in the field, where the system consists of a photovoltaic arrangement, a charge controller, a battery bank, a inverter and a motorbike bomb. Water is collected through an artesian well where water is pumped to a water tank. Soon the design was implemented in the center of the community, where are located the two schools that are right in the center of the zone to be able to serve the riverside population, as shown in figure 2.

Figure 2. Community of Santa Fe - AM.

For the network system deployed for capture and distribution in local homes, the flow was successfully met. For the operation of the water supply system without interruption, preventive system maintenance will be scheduled.

In the Santa Fe riverside community, there are an average of 200 inhabitants. According to NBR 5626 we can consider that in popular or rural homes has an average consumption of 120 L / day per person, thus multiplying the average inhabitant x consumption will be 24,000 L / day or 24 m³ / day.

Foi estabelecido um reservatório com capacidade de 50 m³. A profundidade do poço é de 40 metros até se alcançar o lençol freático.

Knowing the amount of water to be pumped, a Single Phase 2.0 HP Sub15-20S4E14 220V Submersible Pump from SCHNEIDER was chosen, a multistage centrifugal pump, coupled to electric motors specially designed to operate in the water at great depths. and its groundwater pumping into tubular wells with an inner diameter from 4 ”at 220 volts. For this situation the pump flow rate is 4.5 m3 / h, 2hp power, stages 14, its 1 1/4 ”headpressure 60 m.c.a and the 79 mm rotor.

Table 1. Specification of selected pump.

MODEL	POWER (CV)	TENSION (V)	ELECTRIC CURRENT (A)
SUB15-20S4E14	2,0	220	6,69

Source: Own Authorship.

The electric power of the pump is given by the product of the current by the voltage:

$$P_b = V.I = 220\,V\,.6{,}69\,A = 1471{,}8\,VA$$

To perform the photovoltaic dimensioning it was necessary to calculate the energy of the pump and the period in which it remains in operation [3]. Thus knowing the volume (V) and the flow (Q) it is possible to calculate the required pump running time per day.

$$\Delta t = \frac{V}{Q} = \frac{24m^3}{4{,}5\,{}^{m^3}/_{h}} \cong 6\,horas$$

Knowing that the pump will need to run 6 hours a day, it is possible to calculate the energy (E_b)required for pump operation.

$$E_b = P_b.\Delta t = 1.471{,}8\,.\,6 = 8.830{,}8\,Wh/dia$$

From the energy required for the operation of the pump it is possible to design the photovoltaic panel.

Tabela 2. Especificação do painelsolar selecionada.

MODEL	MAXIMUM POWER (W)	MAXIMUM POWER VOLTAGE (V)	MAXIMUM POWER CURRENT (A)
JKM330PP-72	330	37,8	8,74

Source: Own Authorship.

The sizing of the photovoltaic system will be based on the monthly average daily radiation index of 4.5 h / day, measured by **SOLAR FINGER RESOURCE.** Latitude: -3.119 and Longitude: -60.0217.

Tabela 3. Daily Average Monthly

Month	**Radiation**(kWh/m²/dia)
January	4.23
February	4.20
March	4.19
April	4.16
May	4.17
June	4.39
July	4.77
August	5.19
September	5.22
October	5.05
November	4.73
December	4.28
Yearly	4.5

Fonte: **SOLAR FINGER RESOURCE -** https://solarfinger.com.br/radiacao-solar-no-brasil/.

The photovoltaic panel has the following specifications: it will consist of 13 modules JINK SOLAR 330Wp, organized in 13 rows in parallel, each row will be formed by 1 module in series, so we will have to divide the daily pump consumption (E_b)by the average radiation shown in Table 2,which will have the total of 1962,7 KWh,value that the system will consume per hour. For daily consumption you will need a generation system producing 11776,00 Wh/dia.Monthly energy production(E_M)of the system will be:

$$E_M = (Radiation\ .30\ dias\ .Panel\ Power\ .0{,}83)/100$$

$$E_M = \frac{4{,}5\ .30\ .330\ .0{,}83}{100} = 36{,}98\ KWh/mês$$

The result of 36.98 KWh / month is per panel, so it must be multiplied by 13 to know the monthly energy of the system, reaching a total of 480.74 KWh / month.

For the sizing of the battery bank, extreme situations of scarcity of solar radiation were considered, such as on rainy days. The choice of batteries was made considering that it should have deep discharge capacity, with a long service life with development in the application in photovoltaic systems. Following this reasoning, we chose MOURA brand batteries.

Tabela 4. Especificação da bateria.

MODEl	CAPACITY (CN)	CAPACITY (CN)	Discharge Capacity
12MVA-9	105	12	80%

Source: Own Authorship.

The battery bank will consist of 12 batteries Moura - 12MC105, will be connected 6 blocks in parallel, each block will be formed by 2 batteries connected in series.

The inverter was chosen taking into consideration the total load power, the output waveform and the motor starting current. The inverter has to have its power in the range between 210W and 2944W.

The inverter used is manufactured by SWIPOWER SP2500L 2500W 12V 220V 60Hz pure sine wave with maximum efficiency, has 500W peak voltage is easy to install and operate, SWIPOWER SP2500L Pure Sine Wave inverters operate with high efficiency and are for off-grid systems. (No connection to the utility grid).

It operates with high efficiency and requires small installation space, so it is a better choice for space, cost and benefit. For project sizing purposes. Assume the continuous power of the inverter, not the peak power. Inverter Specifications shown below:

Tabela 5 - Specification of the selected inverter.

MODEL	NOMINAL POWER (W)	PEAK POWER (W)	INPUT VOLTAGE (V)	OUTPUT VOLTAGE (V)
SP2500L	2500	500	15,5	220 (+/ - 3%)

Source: Own Authorship.

The charge controllers are manufactured by the brand Y-SOLAR and were chosen according to the short circuit current.

Tabela. Especificação do controlador de carga selecionado.

MODEL	TENSÃO DO SISTEMA(V)	CORRENTE SUPORTADA(A)
Y-SOLAR	RBL-50A	50

Fonte: Autoria Própria.

It is recommended that the charge controllers support an input current of 148.53 (A), so 3 parallel 50 (A) controllers will be required to support the estimated total safety current of 150.00 (A). 1.7 (A).
Controller Features: PWM Technology, High Efficiency, Load Control Diversified. Protections: PV short circuit protection, PV polarity reversal protection, Battery overcharge protection, Discharge earth protection. Technical Specifications: Auto 12V / 24VDC Voltage, 30mA Self-Consumption, 14.4V / 28.8V Overload Protection, 13.5V / 27V Guaranteed Floating Charge, 13.2V / 26.4 Recover, 10.8V / 21.6V Discharge Protection, Work temperature -35.C ~ + 80.C e 2 Exits USB 5V/3A.

Tabela 7.Project investment.

EQUIPMENT	MODEL	QUANTITY	TOTAL (R$)
BOMB 2 CV	SUB15-20S4E14	1	2029,00
SOLAR PLATE 330 WP	JKM330PP-72	13	12348,70
DRUMS	12MC105	12	1642,80
INVERTER	SP2500L	1	1590,00
CONTROLLER	Y-SOLAR	3	477,00
			18087,50

Source: Own Authorship.

5. Conclusion

Photovoltaic pumping systems are an excellent alternative to water supply problems. With the importance of benefiting and bringing life improvements to the riverine residents. Despite the efficiency, it is necessary that the population has in mind the rational use in water consumption, thus avoiding waste.
Photovoltaic water pumping systems may have other applications, but these are advantageous for home supply. Since it is of utmost importance to use the technological means that provide us with improvement in quality of life.
Therefore, it is concluded that the project presented satisfactory results, besides supplying the residents' need to supply water to the Santa Fé riverside community - AM.

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