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Performance Analysis of Solar Powered Water Well Pump

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Abstract—*The Philippines is abundant in water. In remote areas, sources of water are from wells. The collection of water needs effort and is laborious. Mechanical pumps are available to collect water from the well automatically, but this is impossible in remote areas deprived of electricity. This research addresses the later issue: water pumps are powered with solar. The performance of the solar-powered water well pump is analyzed from their series and parallel connections based on the provided flow rate—data analysis using a two-tailed t-test implemented in Python. The Ho is that there is no significant difference in the flow rate of series and parallel connections of the solar-powered water well pump. The p-value solve is 1.346, which rejects the null hypothesis. Thus, there is a significant difference in the performance of series and parallel connections of the solar-powered water well pump. Efficiently, a parallel connection performed well in implementing a solar-powered water well pump.*

Keywords— *Solar, Water Well Pump, Solar Powered Water Well Pump. T-Test Analysis.*

I. Introduction

Solar energy talks about solar energy. The sun has produced energy for billions of years, and it is the most important source of energy for all life forms [1]. It is an entirely renewable energy source, unlike non-renewable sources such as fossil fuels [2]. The sun provides a consistent and steady source of solar irradiance. Solar Power technologies use the sun's energy to light homes, produce hot water, heat homes, and produce electricity [3].

In the Philippines, the potential is significantly greater than the National Renewable Energy Plan's aspirational aim of 1,528MW for solar through 20130 [4]. According to the DOE's 2009-2030 Power Development Plan (PDP), the country's energy consumption will reach 149,067 gigawatt-hours (GWh) by 2030, from an estimated demand of 86,809 GWh by 2018 and actual demand of 55,417 GWh in 2008 [5]. The yearly monthly daily average irradiance yield received in the horizontal plane of Surigao city is about 7.5 kW h/m2 /day. With the Latitude: +9.8 (9°48'00"N) and Longitude: +125.47 (125°28'12"E) [6].

Photovoltaic (PV) technology converts solar light directly into electricity using semiconductor PV cells [7]. Photovoltaic or solar cells are semiconductor materials, such as silicon, single-crystalline thin films, and polycrystalline thin films [8]. A key feature of solar cells is the built-in electric field [9]. One semiconductor is an n-type with an abundance of electrons with a negative charge [10]. The other semiconductor is a p-type with plenty of "holes" with a positive electrical charge [11]. The two semiconductors are globally neutral, but when they come into contact, a p-n junction forms, creating an electric field [12].

A micro electric diaphragm pump is a positive displacement pump that uses a combination of a reciprocating action and either a flapper valve or ball valve to transfer liquids [13]. This pump is sometimes referred to as a membrane pump. Diaphragm pumps are self-priming and are ideal for viscous liquids. Most models are available in electric, engine manual, air-operated, or hydrail configuration [14].

This research developed solar-powered water well using the micro electric diaphragm pump, analyzed the solar irradiance in the target area and recorded the different configurations of the pump from the solar source based on their flow rate.

II. Related Literature

Across the Saudi remote desert regions, the citizens use traditional systems to draw down water from the wells using internal combustion engines, such as diesel pumps [15]. The yearly monthly daily average irradiance yield received on the horizontal plane is 7.5 kW h/m2 /day. Static mid-levels of water ground sources vary between 40 m and 120 m in Bahram valley (25 km of Madinah city) [16]. A comparative study has been done to select an optimum PVWPS configuration, based on experimental performance results of a helical pump, PV powered by 24 PV modules (75 W) in different configurations [17]. Through the tests of each PVWPS configuration, the daily flow rate, hydraulic energy, and electrical energy are determined [18]. Also, the pump efficiency and the total system efficiency curves are plotted [19]. This work aims to select an optimal combined PVWPS configuration, which can work at the optimum conditions in terms of cost and demand of the load [20].

Over the past few years, UNICEF has explored new and innovative approaches to water supply, with a focus on affordable, scalable, environmentally friendly, and climate-smart systems. Solar-powered water systems have the potential to meet all these criteria [21]. The systems can also help provide a higher quality service to multiple communities using small, piped water schemes and therefore play a key role in helping to accelerate the achievement of the Sustainable Development Goal (SDG) on water and sanitation [22].

Renewable energy sources in general, and solar energy, have the potential to provide energy services with zero or almost zero emissions [23]. Solar energy is abundant, and no other source of renewable energy is like solar energy [24]. The solar-powered pumping system can be used anywhere, but it is particularly well suited to rural places in need of energy [25]. Because of its geographical location, the Sultanate of Oman and the Gulf region receive plenty of sunlight throughout the year, making it an ideal location for solar energy use. Small farms, villages, and animal herds in developing countries require less than a kilowatt of hydraulic output power [26]. Many of these potential users are too far from an electrical grid to economically tap that source of power [27]. Engine-driven pumping tends to be prohibitively expensive and unreliable due to the high cost of purchasing fuel and insufficient maintenance and repair capabilities [28].

Like most other developing countries, Nepal has a highly critical energy situation. So, electricity generation from alternative sources has become the crying need for Nepal [29]. Nepal is blessed with renewable energy resources. Alternative energy's availability opens up possibilities for use in the power sector. Solar energy, among other renewable energy sources such as wind, biomass, and others, is the most promising for Nepal due to its plentiful availability. Nepal is situated at 28 degrees 00' N and 84 degrees 00' E, an ideal location for abundant solar radiation. Nepal's daily average solar radiation is 3.6 to 6.2KWh/m2, which is better than many nations working on solar energy on a large scale [30].

Since the sharp oil price rises of the early 1970s, renewable energy sources have become a significant component of many rural development activities. In these areas, pump operation using renewable energy sources is becoming popular. Worldwide, more than 20,000 solar pumps have been installed [31]. Most of them are small systems for remote homes and communities. Solar pumps are most cost-effective for applications with low power requirements (200 W-5 kW) in remote places. They are therefore well suited in developing countries to rural village applications [32].

III. Conceptual Framework

This section explains the conceptual framework of the study as shown in Figure 1, and the theoretical background of the study is explained.

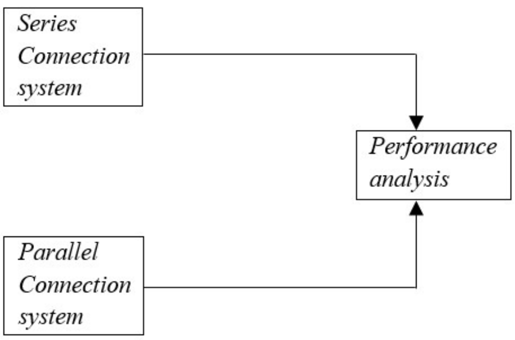

Fig. 1. Conceptual Framework

The general overview of project design comprises three blocks: series connection, Parallel connection, and performance analysis. Series/Parallel will manage the power, voltage, and current. Performance analysis data collected and stored. Consequently, data gathered will determine the Performance analysis of micro-electric diaphragm pump with solar panel connections, as shown in Figure 1.

A. *Theoretical Framework*

Ohm's Law - states that the voltage or potential difference between two points is directly proportional to the current or electricity passing through the resistance and directly proportional to the resistance of the circuit.

$$V = I \times R$$

Where:
V = impressed voltage (volt)
I = current drawn (ampere)
R = resistance (ohm)

Photovoltaic (PV) cell/Solar cell connection.
Parallel Connection - the current of each cell adds up.

$$I_t = I_1 + I_2$$

Series Connection – the voltage of each cell adds up.

$$V_t = V_1 + V_2$$

Electrical power is the energy delivered from the electrical source to the loads.

$$E = P \times t \text{ or } P = I \times V$$

Where:
E = energy (joules)
P = power (watts)
t = time (seconds)
V = voltage (volt)
I = current (ampere)

IV. Methodology

This research is implemented using an experimental design. The performance analysis of the solar-powered water well pump is done by analyzing, designing, implementing, and data evaluation as shown in Figure 2.

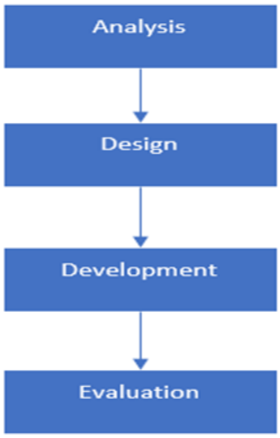

Fig. 2. The flow of the Project Development

This research analyzes the two solar panels with a rate of 50watts, 12volts a mono-crystalline type solar panel, and a micro electric diaphragm pump 80watts 6.6amperes to get the best performances of a micro-electric diaphragm pump in supplying water needed.

A. *Project Design*

The project design uses the input, process, and output where

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it starts analyzing the solar irradiance, which will capture by the solar panel energizing the dc pump, as shown in Figure 3.

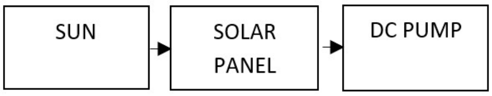

Fig. 3. Project Design

Figure 3 shows that the first block represents the input; through the sun, the Solar panels create energy from the sun to produce different currents. And the solar panel directly to the dc pump.

B. *Project Settings*

The implementation of the developed solar-powered water well pump and data collection is in Barangay Washington, Surigao City, as shown in Figure 4.

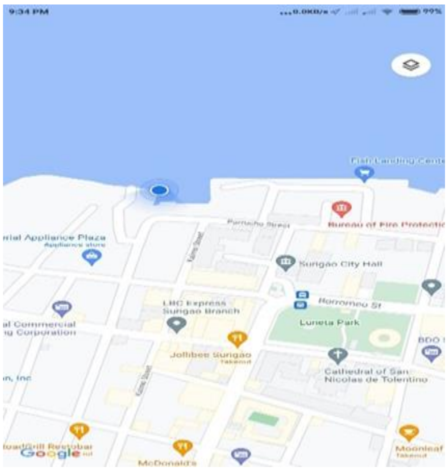

Fig. 4. Location of the Project

The project setting of the project was held in Brgy. Washington, Surigao City, at my boarding house to conduct a series of experiments to get the best connection.

C. *Data Collections and Interpretations*

The two connections are implemented and record the solar irradiance, voltage, current, and flow rate. The recording is done using an hourly recording of the measured irradiance, voltage, current, and flow rate. The data was then processed using two sampled t-test inferential statistics to show the correlations of the data.

V. RESULTS AND DISCUSSION

This section presents the implementation of the solar-powered water well pump, series-parallel connections, and the data gathering of the solar irradiance, voltage, current, and flow rate.

A. *System Implementation*

The solar-powered water well pump is implemented using a series and parallel connections, as shown in Figure 5. Also, the dc micropump at the solar panels is analyzed with load and no-load to monitor and compare the effect of intermittent solar irradiance.

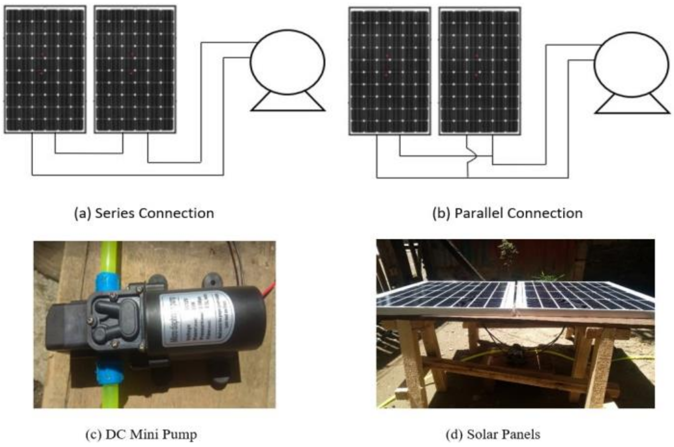

Fig. 5. System Implementation

B. *Data Collected for Solar Power Panels with No Load*

An hourly reading is tabulated to monitor the voltage, current, and power with no load. Using lux meter to measure the irradiance of the sun and basic multi tester to measure the voltage and current with no load.

TABLE I. Parallel Connection No Load

Time (H)	Solar Irradiance (lux) * 10	Voltage (V)	Current (A)	Power (W)
8:00	1380	20	5	100
9:00	7887	21	4.761	100
10:00	8382	21	4.761	100
11:00	8951	20.5	4.878	100
12:00	9217	20.9	4.784	100
1:00	8501	20.5	4.878	100
2:00	9571	21	4.761	100
3:00	8808	20.5	4.878	100
4:00	5845	20	5	100

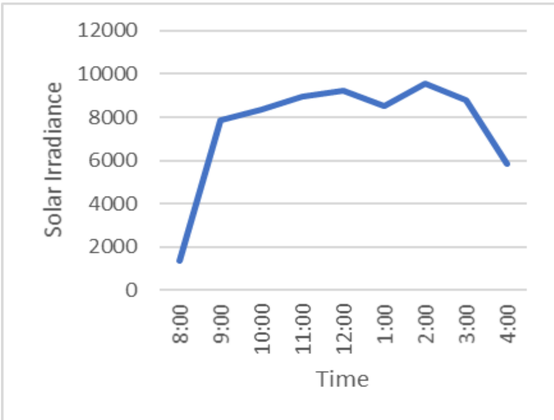

Fig. 6. Graph of Parallel Irradiance of Solar Panel with No Load

TABLE II. Series Connection No Load

Time (H)	Solar Irradiance (lux) * 10	Voltage (V)	Current (A)	Power (W)
8:00	2502	42	2.380	100
9:00	7969	44	2.272	100
10:00	8419	44	2.272	100
11:00	9097	44	2.272	100
12:00	9055	42	2.380	100
1:00	8971	42.5	2.352	100
2:00	9576	42.5	2.352	100
3:00	8487	42	2.380	100
4:00	4489	42	2.380	100

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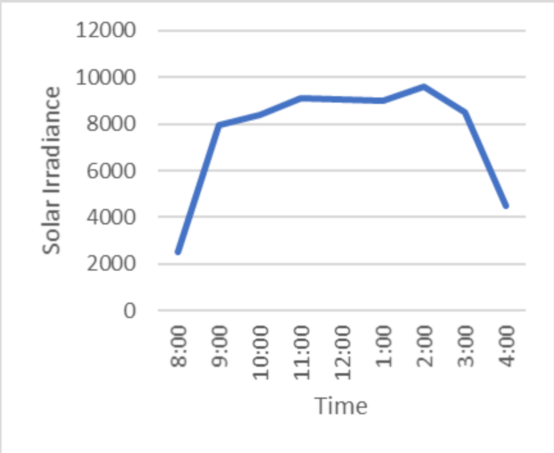

Fig. 7. Graph of Series Irradiance of Solar Panel with no load

Analyzing the data, the highest peak at 12nn to 3:00 pm and the current is higher in the parallel connection than the series connection.

C. Data Collected for Solar Power Panels with Load

An hourly reading is tabulated to monitor the voltage, current, and power with load. We are using a lux meter to measure the irradiance of the sun and a basic multi-tester to measure the voltage and current with the load.

TABLE III. Series Connection with Pump

Time (H)	Voltage (V)	Current (A)	Flow rate (l/m)	Power (W)
8:00	0	0	0	0
9:00	39	2.051282051	3.785	80
10:00	39	2.051282051	3.785	80
11:00	39	2.051282051	3.785	80
12:00	37	2.162162162	4	80
1:00	37.5	2.133333333	4.1	80
2:00	37.5	2.133333333	4.1	80
3:00	37	2.162162162	4	80
4:00	0	0	0	0

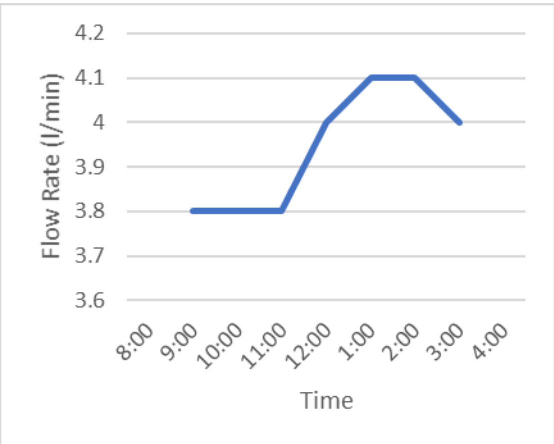

Fig. 8. Graph of Series flowrate for Solar Panel with Pump

Interpretation Table III and Table IV show that the higher the current flowing to the pump, the higher the pump's flow rate.

TABLE IV. Parallel Connection with Pump

Time (H)	Voltage (V)	Current (A)	Flow rate (L/m)	Power (W)
8:00	0	0	0	0
9:00	19	4.210526316	4.8	80
10:00	20	4	4.6	80
11:00	19	4.210526316	4.8	80
12:00	19	4.210526316	4.8	80
1:00	18	4.444444444	5	80
2:00	20	4	4.6	80
3:00	19	4.210526316	4.8	80
4:00	0	0	0	0

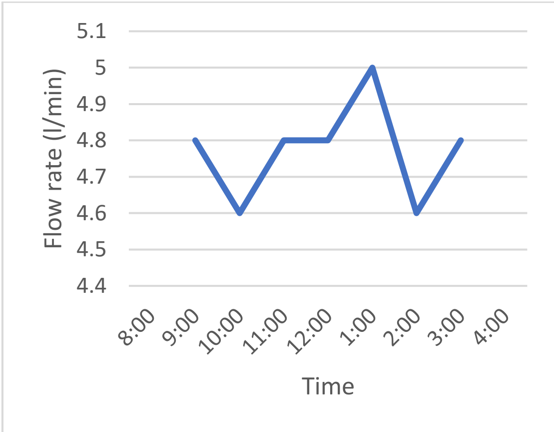

Fig. 9. Graph of Parallel flowrate for Solar Panel with Pump

D. Computation of Two-Tailed T-Test Inferential Statistics Implemented in Python

This section computes the p-value of the two data from the discharge rate of different configurations such as the series and parallel connections, as shown in Figure 10.

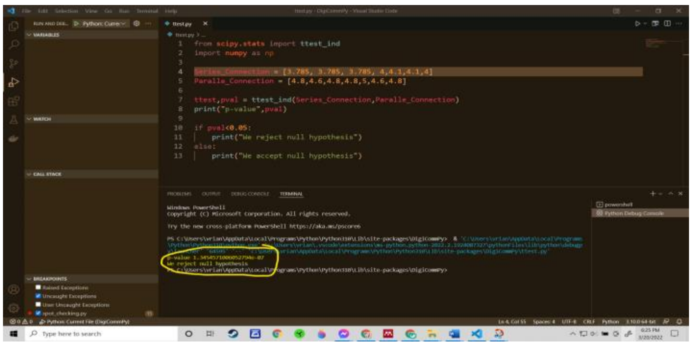

Fig. 10. Inferential Statistics Analysis using Python

The results show that the solve p-value is 1.345 and rejects the null hypothesis. The H_0is that there is no significant difference in the flow rate in series and parallel connection. Because the solution p-values are 5.1, the H_0 is rejected, implying that the two configurations provide different results.

VI. Conclusion

Implementation of the solar-powered water well pump was successfully carried out. Data analysis of the different configuration were examined. Results show that the p-value is 1.345 and rejects the null hypothesis. The H_0there is no significant difference in the flow rate in series and parallel connections. Because the solution p-values are 5.1, the H_0 is rejected, implying that the two configurations provide different results. The parallel configuration of the dc mini pump proves to be efficient when implementing a solar-powered water well pump.

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