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Analysis of the Effect of Sun Light Intensity on Pump Performance with Photovoltaic System

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A B S T R A C T

Solar energy through conversion is utilized into electrical energy obtained by the photovoltaic system (solar power plant). The results of this study are obtained (1) the intensity of sunlight is very influential on the characteristics of solar cells, if the angle comes small, then the input intensity is even large because of the light that falls almost perpendicular to the surface of the solar cells so that more energy is applied by solar cells and converted into electrical energy (2) Characteristics produced by solar cells to the performance of the pump, in the 300 W/m^2 intenenship to the intensity of 900 W/ m^2 with heads of 1 meter and 2 meters of pumps can be operated while in heads 3 meters and 4 meters of pumps can operate at an intensity of 500 W /m^2 to an intensity of 900 W /m^2

Keywords: Photovoltaic, pump, sunlight intensity

1. Introduction

Water is one of the basic human needs, both for subsistence (drinking and cooking), sanitation (MCK) and for the production process (irrigation). The availability of water that meets the needs of the community above is often a problem, especially in areas where water sources are very limited or very deep ground water.

Although pumping technology and water harvesting equipment are available and easily obtained, the absence of PLN electricity networks in some areas often inhibits the availability of pump driving force. Solar power plants (PLTS) can overcome the obstacles above. In Indonesia, sunlight is available for free throughout the year, even in remote locations. So using PLTS to move the pump is ideal (Otong et al., 2019).

The availability of solar energy and water needs can complement each other during the dry season, when the sun is very hot, the water needs are also very high, at that time the PLTS water pump can pump more water, on the contrary in the dry season. rainy season. Indonesia is in the equator so that it has abundant solar energy with an average insulation intensity of around 4.8 kWh/m^2 per day throughout Indonesia (Bayuaji Kencana et al., 2018; Otong et al., 2019).

Photvoltaic is used to convert the intensity of solar radiation into electrical energy. Heat energy is also obtained from solar radiation and can be collected or centered using collectors (collectors). This heat energy is usually used for solar panels, heating pumps and others. The intensity of solar radiation is reduced by absorption and reflection by the atmosphere before reaching the earth's surface. Ozone in the atmosphere absorbs radiation with short wavelengths (ultraviolet), while carbon dioxide and water vapor absorb radiation with longer wavelengths (infrared) .

1.1 Solar cells

Solar cells, also called photovoltaic cells, any device that directly converts light energy into electrical energy through the effects of photovoltaic. Most solar cells are made from silicon - with an increase in efficiency and decrease in costs because the material ranges from amorphous (non -crystalline) to polycrystalline to the form of silicone crystals (single crystal). Unlike batteries or fuel cells, solar cells do not use chemical reactions or need fuel to produce electricity, and unlike electric generators, solar cells do not have a moving part [2], [6].

When the two electrodes are connected to the wire, the electric current flows from the electrode (+) to the electrode (-). Solar cell diagrams solar cell diagrams as shown in Figure 1

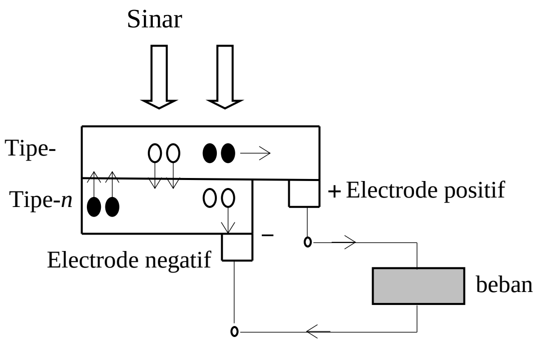

Fig 1. Chart of one solar cell

A solar cell produces a direct current: 20 ÷ 40 mA/cm^2 and a voltage of 0.7 ÷ 0.85 V, in direct sunlight with an intensity of 1000 W/m^2, temperature of 25 ºC. Depending on the material, the area of solar cells ranges from: 1 cm^2 ÷ 4 cm^2. To produce more current and voltage, which is to produce more electric power, some solar cells are connected in series and parallel to form modules or several modules combined.

1.2 Direct current motor (DC)

Electric motors are electric machines that convert electrical energy into mechanical energy. The basic working principle of the DC motor is: "Every time the current conductor is placed in a magnetic field, it has a mechanical force". The direction of this force is given by the rules of Fleming's left hand and the magnitude is given by f = bil. Where, B = magnetic flux density, I = current and L = length of the conductor in the magnetic field.

Rule of Fleming's Left Hand: If we stretch the first finger, the second finger and thumb of our left hand become perpendicular to each other, and the direction of the magnetic field is represented by the first finger, the direction of the current is represented by the second finger, then the thumb states the direction of the force experienced by conductor of current (Rosalina & Sinduningrum, 2019).

1.3 General centrifugal pump

All centrifugal pumps include an impeller that is driven by a rotating shaft (usually in 1750 or 3500 rpm) in the casing. The impeller is always submerged in water, and when the pump operates, the impeller rotates quickly. The centrifugal force applied to the water from rotation forces water to come out of the casing, where it comes out of the drain port. More fluids are inserted through the suction port, or inlet. The speed given to the liquid by the impeller is converted into pressure energy or "head" (Engineers Edge, 2014)

The centrifugal pump is unique because it can provide a high or very high flow rate (much higher than most positive transfer pumps) and because the flow rate varies greatly with changes in total dynamic head (TDH) of a particular piping system. This allows the flow rate to be "strangled" significantly with a simple valve placed into the drain pipe, without causing excessive pressure buildup in the pipe or requires a pressure release valve. Therefore, centrifugal pumps can include a variety of vast fluid pumping applications (Engineers Edge, 2014)

2. Research Method

The research method used the experimental method carried out in the renewable energy laboratory of the Faculty of Mechanical Engineering, Musamus Merauke University. This research will be conducted in November 2022.

Research uses the following equipment:

- Pyranometer, is a tool to measure the intensity of solar radiation globally.
- Multimeter, a tool for measuring voltage and power.
- Measuring cups, tools used to measure the output of the water produced.
- Thermometer, a tool to measure the temperature of the reservoir water.
- Stopwatch

The test equipment used is:

- Solar panels / Single panels of Sharp brand, with maximum power specifications: 80 watts, Open circuit voltage: 21.6 volts short circuit current: 5.15 amp, voltage at maximum power point: 17.3 volts, current at maximum power point: 4.63 ampere
- DC water pump, assembled DC water pump with voltage specifications at the maximum power point: 24 volts, 50 Hz current at the maximum power point: 15 amp, maximum power: 360 watt, capacity of 15 liters/minute, head max. : 6 meters

Measuring instrument

- Multimeters
- Pyranometer

Pyranometer, is used to measure the global radiation intensity (strobe radiation and diffuse radiation) arriving at the surface of the absorber plate. The pyranometer equipment model is LI-18, which has the smallest scale value (NST) of 1 W/m^2

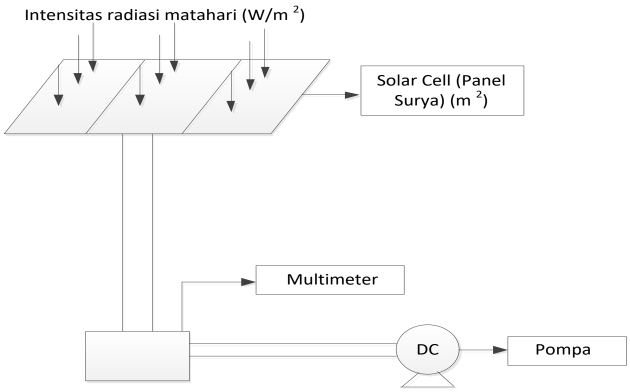

Fig 2. Series of Solar Panels According to Research

3. Results

From the results of data collection and calculation results in the study, it can be seen that the intensity of direct solar radiation that can be converted into electrical energy using solar cells is obtained:

3.1. The relationship showing the power entering the solar cell (Pin) due to solar radiation against time (t).

With a fall height of 1 meter at 08.00 with a solar intensity (Ig) of 400.54 W/m^2, the energy absorbed by the solar cell (pin) is 795.23 watts to the maximum power generated at 12.00 with a solar intensity (Ig) of 1106 0.89 W/m^2 The energy absorbed by solar cells (Pin) is 2197.06 watts. This situation declined at 16.00. with a solar intensity (Ig) of 273.87 W/m^2 and energy (Pin) absorbed by solar cells of 543.595 watts.For a height of 2 meters at 08:00 with an intensity of sunlight (Ig) of 485.40 W/m^2, the energy absorbed by the solar cell (pin) is 963.461 watts until it reaches a maximum state at 12:00, which is the size of a solar cell (pin) is 1972, 921 watts with sunlight intensity (Ig) is 993.97 W/m^2 with a height of 3 meters at 08:00 with a solar intensity (Ig) of 478.53 W/m^2, the energy absorbed by the solar cell (pin) is 943.873 watts to the maximum power generated at 12:00 with a solar intensity (Ig) of 967.99 Energy absorbed by solar cells (Pin) in W/m^2 of 1921.358 watts. This situation declined at 16.00. with a solar intensity (Ig) of 382.70 W/m^2 and energy (Pin) absorbed by solar cells of 759.625 watts.With a height of 4 meters at 08:00 with an insolation intensity (Ig) of 487.93 W/m^2, the energy absorbed by the solar cell (pin) is 968,493 watts until it reaches a maximum state at 12:00, which is the size of a solar cell (pin) of 1889, 600 watts with a sunlight intensity (Ig) of 951.99 W/m^2, at 4 pm the sunlight intensity (Ig) of 382.12 W/m^2 the absorption power of the solar cell (pin) is 754.459 watts.

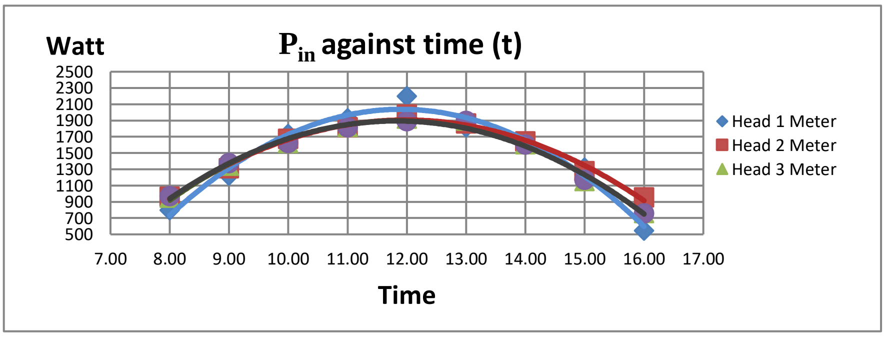

Fig 3. Comparison Between the Power Entered into the Solar Cell (Pin) Due to Solar Radiation Against Time (t)

When the incident angle (θ) is small, the intensity of solar radiation entering the solar cell is large because sunlight also hits the surface of the solar cell almost perpendicularly. The small incident angle (θ) causes the intensity of the sun hitting the surface of the solar cell to be absorbed more into electrical energy. This shows that the intensity of sunlight absorbed by solar panels affects the properties of solar cells because it produces electrical energy to drive pumps. With the increase in absorbed energy, the pump power generated during the day will be even greater

3.2. The relationship between the power generated by the solar cell (Pout) to drive the direct current (DC) pump against time (t).

With a fall height of 1 meter at 08.00 WIB and the power generated by the solar cell (Pout) to drive the pump is 81.025 watts with a solar intensity (Ig) of 400.54 W/m^2, the resulting water discharge (Q) is 0.181 L/m s At 12:00 noon the solar intensity (Ig) was 1106.89 W/m^2, the power generated by the solar cell (Pout) was 87.747 watts and the discharge (Q) was 0.291 L/s. This situation decreased at 16.00 WIB. the intensity of the sun (Ig) is 273.86 W/m^2 the power produced (Pout) is 71.299 watts and the output water produced (Q) is 0.122 L/s. With a fall height of 2 meters at 08.00, the power generated by the solar cell (Pout) to drive the pump is 106,132 watts at a solar intensity (Ig) of 485.40 W/m^2, the resulting water output (Q) is 0.183 l/s. 12:00 noon. sun intensity (Ig) 993.97 W/m^2, power generated by solar cells (Pout) 115.163 watts and water discharge (Q) 0.240 L/s, this situation decreased at 16.00 WIB. solar intensity (Ig) 500.07 W Power generated (Pout)/m2 of 105.163 watts and water output (Q) of 0.180 L/s. As shown in fig 4.

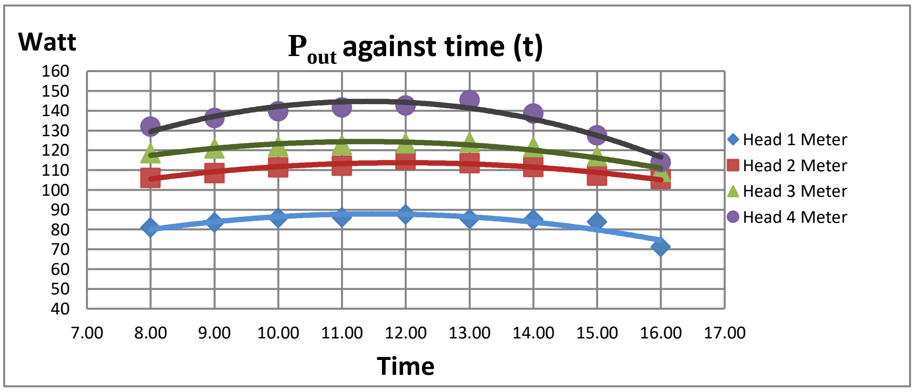

Fig 4. Comparison Between Power Generated By Solar Cells (Pout) to drive the Pump against Time (t)

The graph above shows that at a fall height of 3 meters and 4 meters the power generated by the solar cell (Pout) increases because the load used increases.

3.3. The relationship between system efficiency (η system) against time (t).

At a head of 1 meter at 08.00 with a solar intensity (Ig) of 400.54 W/m^2 the incoming power (Pin) is 795.23 watts, the efficiency of the solar cell (ηsystem) is 0.266% until 12.00 with a solar intensity (Ig) of 1106 .89 W/m^2 incoming power (Pin) of 2197.06 watts with solar cell efficiency (ηsystem) 0.194 % This situation decreases at 16.00 with solar intensity (Ig) 273.87 W/m^2 and incoming power (Pin) to solar cells of 543.595 watts and a solar cell efficiency (ηsystem) of 0.239%. For a head of 2 meters at 08.00 with a sunlight intensity (Ig) of 485.40 W/m^2 the power entering the solar cell (Pin) is 963.461 watts the efficiency of the solar cell (ηsystem) is 0.400% while at 12.00 the power entering the cell (Pin) is 1972.921 watts with sunlight intensity (Ig) is 993.97 W/m2 and the efficiency of solar cells (ηsystem) is 0.268% in fig 5.

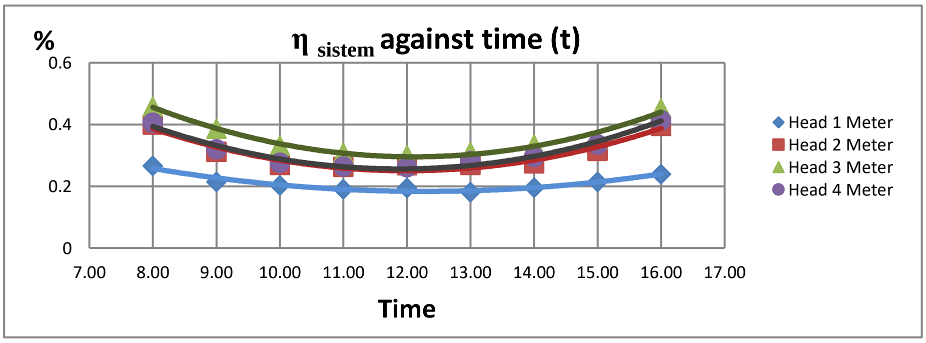

Fig 5. Comparison Between Efficiency By Solar Cells (ηsystem) against Time (t)

Fig 5 above shows that the efficiency of the solar cell (ηSystem) decreases as the intensity of solar radiation increases, because the power absorbed by the solar panel increases, so that the hydraulic power of the fluid is large, so the efficiency of the solar cell also decreases. The efficiency of solar cells is determined by comparing the power that can be generated by solar panels with the input energy obtained from sunlight.

3.4. The relationship between Pump Efficiency (ήp) against time (t).

At a head of 1 meter at 08.00 with the power generated by the solar cell (Pout) to drive the pump of 81.025 watts with a solar intensity (Ig) of 400.54 W/m2, the resulting water discharge (Q) is 0.181 L/s and the efficiency pump (ήp) of 2.614%. At 12.00 the solar intensity (Ig) was 1106.89 W/m^2, the power generated by the solar cell (Pout) was 87.747 watts and the discharge (Q) was 0.291 L/s and the pump efficiency (ήp) was 4.867%, this situation decreased at 16.00 solar intensity (Ig) 273.86 W/m^2 the power generated (Pout) is 71.299 watts and the water discharge produced is (Q) 0.122 L/s, the pump efficiency (ήp) is 1.821%.

Whereas at a head of 2 meters at 08.00 the power generated by the solar cell (Pout) to drive the pump is 106.132 watts with a sun intensity (Ig) of 485.40 W/m^2, the resulting water discharge (Q) is 0.183 L/sec pump efficiency (ήp) of 3.633%. At 12.00 the sun's intensity (Ig) was 993.97 W/m^2, the power generated by the solar cell (Pout) was 115.163 watts and the water discharge (Q) was 0.240 L/s and the pump efficiency was (ήp) 4.596%, then there was a decrease at 16.00 the intensity of the sun (Ig) is 500.07 W/m^2 the power produced (Pout) is 105.163 watts and the water discharge (Q) is 0.180 L/sec. the pump efficiency (ήp) is 3.572%. If the intensity of solar radiation increases, the pump efficiency (ήp) will also increase so that the water discharge (Q) produced by the pump also increases as shown in fig 6.

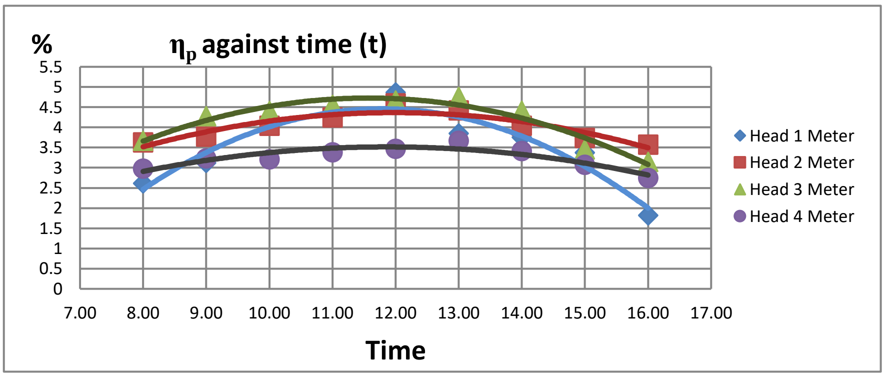

Fig 6. Comparison Between Pump Efficiency (η pump) Against Time (t)

Fig 6 above shows that at a head of 3 meters the pump efficiency (ήp) at 08.00 was 3.670%, then at 12.00 the pump efficiency (ήp) was 4.672% and decreased at 16.00 the pump efficiency (ήp) was 3.145%. Pump efficiency (ήp) will also increase with increasing head because the pump hydraulic power (Pt) is affected by the increase in head and the incoming power to the solar panels while the pump efficiency graph (ήp) at 4 meter head decreases because the power goes to the solar cells less compared to the head of 3 meters, this is due to the lower intensity of the sun on the day of 4 meter data collection.

3.5. Characteristics of the output current (I) and voltage (V) of the solar cell and pump head.

The output current (I) and the voltage (V) produced when the solar cell gets irradiated are the characteristics of the solar cell. These characteristics are presented in the form of relationship curves I and V. The results of this study indicate that the characteristics of solar cells are influenced by the intensity of sunlight. The I - V curve which is the characteristic obtained when measuring the characteristics of solar cells at the time of data collection is presented in graph 5 In Figure 5 it can be seen that the effect of sunlight intensity with an intensity (Ig) of 300 W/m^2 to an intensity of (Ig) of 900 W/m^2 at a head of 1 meter and 2 meters can be operated while at a head of 3 meters and 4 meters the pump can be operated . At Intensity (Ig) 500 W/m^2 to Intensity (Ig) 900 W/m2. At a head of 1 meter, the operational current-voltage performance of the solar cell at (Ig) 300 W/m^2 is 4.30 amperes and 15.55 volts and at a light intensity of 500 W/m^2 the current-voltage is 4.42 volts and 16.35 amperes at an intensity of 700 W/m^2 the operating performance of the pump is a voltage (V) of 17.06 volts and a current (I) of 4.69 Amperes and at an intensity of 900 W/m^2 the operational performance of the pump is a voltage (V) of 17.69 volts and a current (I) 4.96 amperes .

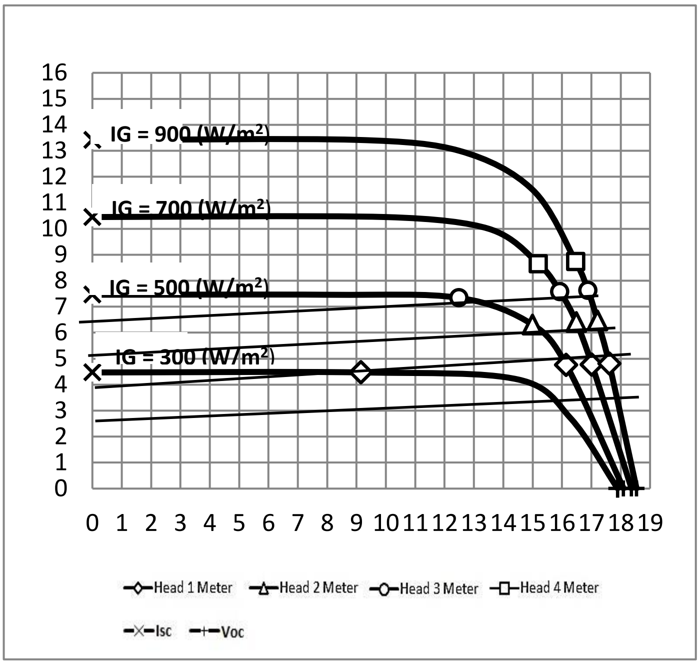

Fig 7. Effect of Solar Intensity on Current – Voltage Characteristics of Solar Cells That Produce Power To Drive DC Pumps

At a head of 2 meters the operational performance of the current-voltage from the Intensity (Ig) 300 W / m^2 solar cell is 4.32 Amperes and 13.03 Volts and at a light intensity of 500 W/m^2 the current-voltage is 4.42 Amperes and 16.35 Volts at an intensity of 700 W/m^2 the operating performance of the pump is a voltage (V) of 16.55 volts and a current (I) of 6.04 Amperes and at an intensity of 900 W/m^2 the operational performance of the pump is a voltage (V) of 17.11 volts and a current (I) 4.44 Amperes. shows that the greater the intensity of sunlight generates electricity to drive the DC pump and produce the amount of water runoff that corresponds to changes in the intensity of sunlight. Solar cell modules can also reach maximum power points (Voc and Isc) when loaded.

4. Conclusion

- Sunlight absorbed by the solar cell is then converted into electrical energy using a photovoltaic system, which generates a certain amount of electricity to drive the pump, as well as the flow rate (Q) of the air from the pump, the efficiency of the pump and the solar cell.
- Effect of sunlight intensity With an intensity (Ig) of 300 W/m^2 up to an intensity (Ig) of 900 W/m^2 at a head of 1 meter and 2 meters, the pump can be operated at a head of 3 meters and 4 meters, the pump can be operated there, the intensity (Ig) 500 W/m^2 to intensity (Ig) 900 W/m^2

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