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Re-design stalled solar panel so that can activate water pump for Mentawai community needs especially the middle Siberut sub-district

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Abstract. Re-Design Stalled Water Pump in Middle Siberut sub-district to be used again by using solar panel as an alternative energy source. Solar Panels used in this re-design are 48 pieces with capacity 200 WP. Energy produced from solar panels is stored in batteries with capacity 48 volts 400 Ah. Electrical equipment used is still alternating voltage, an inverter is needed so that can change the voltage in the same direction produced on solar panels be alternating voltage which will then be used as a source of electrical energy for activate water pump as well as other electrical equipment.

1. Preliminary

As technology develops today, human needs are increasing. That is the creation of humans to create tools that can make human work easier to do, one of which is a pump. Temperature pump is a tool that is useful for moving a liquid from a lower place to a higher place by increasing the pressure of the liquid [1].

In order for the pump to be operated, the pump requires power obtained from outside such as a combustion motor or an electric motor [2]. The increasing need for humans to use electricity, humans are trying to find non-consumable energy sources such as energy from rays produced by sunlight, wave energy such as waves of sea water, then energy from the wind, and various other kinds of energy [3].

Energy produced from sunlight, especially in Indonesia, which in fact is a tropical country, is very abundant and also not used up. Pollution caused by sunlight also does not exist so it is very suitable to replace fuel [4]. Energy generated from sunlight cannot be used directly. So that energy from the sun can be used, it must first be converted into electrical energy. So we need tools such as solar panels so that solar energy can be converted into electrical energy [5].

The use of this renewable energy source is a solution to power the water pumps in Saibi Village, Mentawai Regency, West Sumatra Province to meet their water needs.

Saibi, is a village which has an area of 1107.71 km2 and a population of 3181 people, has a water pump that is operated using solar energy which is an aid from the government (PLTS) which was founded around 2007. However, the solar panel that drives the pump does not function due to corrosion so that the resulting current is not able to move the pump. Besides, the solar power generation system does not use batteries to store energy generated from the sun only from 10.00 to 16.00 o'clock.

To meet the demand for electric current to drive the pump, 48 solar panels are installed, each of which has a capacity of 200 watts peak (Wp). The power plant installation is not well maintained and is overgrown with grass, and even 6 panels have been stolen. For this reason, the authors redesigned the pumping system so that the water needs in Saibi and Simulaklak villages could be met.

2. Basic theory

The solar panel, which is also called a solar cell, is an object that is useful for converting sunlight into electrical energy. Solar panels absorb sunlight and then convert it into electrical energy. This process is described as the occurrence of an electric voltage caused by the contact of two electrodes connected to a solid or liquid system when placed in the sun. Radiation generated from sunlight is refracted into photons - photons that have different energy levels from one another. The difference in the energy level of the photons of light will determine the wavelength of the light spectrum. The photons received from the solar panels will trigger electrical energy.

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The inverter is a tool that is useful for converting / converting direct voltage (DC) such as batteries and batteries, into alternating voltage (AC) such as electricity generated from PLN, for example. The inverter has 2 terminals, namely positive which is generally red and negative in black. The current generated from solar panels and batteries is DC current, while the need for electrical equipment in daily needs such as radios, lights, computers, washing machines and so on and water pumps are AC currents. Inverters cannot produce AC electricity, it can only use to change the voltage of the electric current only.

A pump is a machine that can be used to move a liquid from a lower place to a higher place by flowing it through a pipe. In order for the obstacles during the flow of the liquid to run smoothly, it is necessary to increase the pressure on the liquid. Under certain circumstances, a pump can also be used to move solids that look like flour. In order for pump installation to occur, additional equipment such as pipes and other auxiliary devices are required.

3. Research methodology

The data collection carried out in conducting this research is secondary. In this chapter, the writer explains what methods are used in preparing this final project. In preparing this final project, theoretical calculations are used and analyze the results of the calculations obtained to get a conclusion. The research implementation method is described in Figure 1.

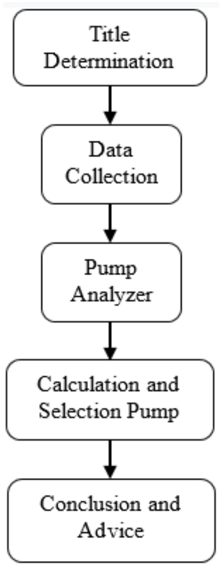

Figure 1. Research implementation method.

4. Results and discussion

4.1. Data collection

The data we can obtain are as follows:

- The number of residents in Saibi Village and Saimulaklak Village who use water is 944 families with a total of 3181 people.
- The difference in the height of the water source to the storage tank is 9 m
- There were 48 solar panels that had been installed, each with a capacity of 200 Wp, but 3 were stolen.
- Estimated number of accessories: 2 elbows 90 o, 4 elbows 45 o, one check valve and 1 gate valve.
- Distance from water pump to tank 105 m.

4.2. Amount of water required and pump discharge

To determine the amount of water needed is to multiply the population by the water needs of each person per day. For Indonesians, according to Sularso's translation of the Pump and Compressor book, page 15, each person needs 200 liters per day, so:

Q = 3181 inhabitans x 200 l/inhabitans/day
= 636.200 l/day

If the pump is considered to work 6 hours a day (from 10 to 16 hours), then the pump capacity:

$$Q = \frac{636200 \, \frac{liter}{day}}{6\frac{hour}{day} \, 3600\frac{second}{hour}} = 29{,}4 \, \frac{liter}{second}$$

$$taken \; 30 \; liters \; per \; second$$

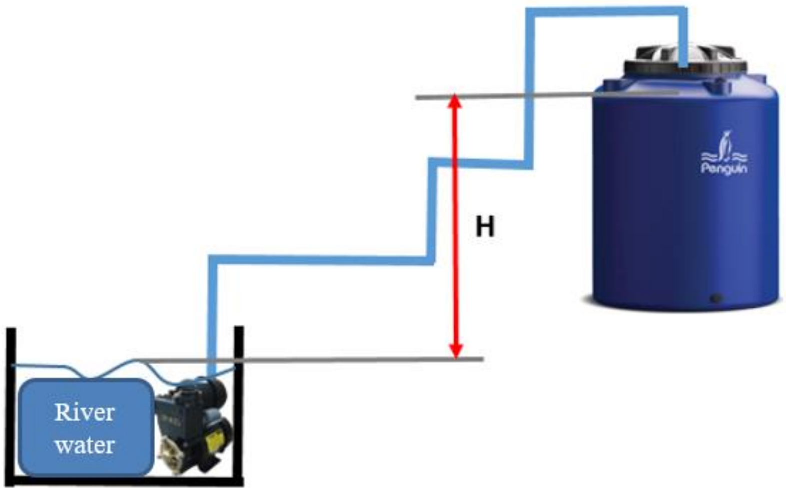

Figure 2. Pipe installation sketch on site.

4.3. Determination of pipe diameter
By determining the water velocity in pipe 2 m/s.

$$Q = A\,x\,V \;\rightarrow A = \frac{Q}{V} = \frac{30\,\frac{dm^3}{second}}{20\,\frac{dm}{second}} = 1{,}5\,dm^2$$

$$A = \frac{\pi}{4}d^2 \rightarrow d = \sqrt{\frac{4\,A}{\pi}} = \sqrt{1{,}91} = 1{,}38\text{ dm}$$

This size is the same as a standard pipe 5 "

Currently, a pipe size of 5 "is difficult to find, so a 6" pipe or pipe with a diameter of 160 mm or 1.6 dm is taken. By using a pipe with a diameter of 1.6 dm, the water velocity in the pipe will be:

$$A = 0{,}785 \text{ x } (1{,}6 \text{ dm})^2 = 2{,}0096 \text{ dm}^2.$$

Then

$$V = \frac{30\,\frac{dm^3}{sec}}{2.0096\,dm^2} = 14{,}92\,\frac{dm}{sec} = 1{,}492\,\frac{m}{sec}$$

4.4. Disadvantages of tank fill pipe head and pump power

4.4.1. Head loss on Elbow 45°

$$H_{fe1} = 4.\,k\,.\,v^2/2g$$

$$H_{fe1} = 4\,.\,0{,}4\,.\,\frac{(1{,}492\,m/s)^2}{2 \times 9{,}81\frac{m}{s^2}} = 0{,}2\text{ m}$$

4.4.2. Head loss on Elbow 90°

$$H_{fe1} = 2.\,k\,.\,v^2/2g$$

$$H_{fe1} = 2\,.\,0{,}9\,.\,\frac{(1{,}492\,m/s)^2}{2 \times 9{,}81\frac{m}{s^2}} = 0{,}26\text{ m}$$

4.4.3. Head loss on check valve

$$H_f = f\ \frac{V^2}{2_g}$$

$$H_f = 2{,}5\ \frac{1{,}492\ m/s^2}{2(9{,}81)} = 0{,}3\ \text{m}$$

4.4.4. Head loss on gate valve

$$H_{fv} = f.\ \frac{V^2}{2_g}\ .\ 1\ \text{pcs}$$

$$H_{fv} = 0{,}19\ .\ \frac{(1{,}492\ m/s)^2}{2 \times 9{,}81\frac{m}{s^2}} = 0{,}02\ \text{m}$$

4.4.5. Head loss in straight pipe 105 m long

$$H_{fp} = f.\frac{L}{d}.\frac{V^2}{2g} = 0{,}015\frac{105}{0{,}16}\frac{1{,}492^2}{2\ x\ 9{,}81} = 1{,}12\ \text{m}$$

4.4.6. Calculate the pump.

$$H = h_a + \Delta\text{h}_\text{p} + h_t + \frac{v_d^2}{2g}$$

$$= 9 + 0\ + 0.2 + 0.26 + 0{,}3 + 0{,}02 + 1{,}12 + \frac{v_d^2}{2g}$$

$$= 11\ \text{m}$$

Then the total pump head loss (Hf total pump) adds up all the losses.

Assuming Hftot = 11 m, the pump power can be calculated:

$$P = \rho.g.\frac{H_{tot}Q}{\mu}$$

$$P = 1000\frac{kg}{m^3}9{,}81\frac{m}{s^2}11\ m.0.03\frac{m^3}{det}/0{,}82$$

$$= 4047\ \text{Watts}$$

Thus the pump used requires an electric energy supply (P) of 4047 Watt.

If the pump runs for 6 hours a day, the current required is:

Q = P x h = 4047 W x 6 hours = 24,282 W / h.

4.5. The type of pump used

To determine the type of pump used is to calculate the specific rotation of the pump using the equation:

$$N_s = n\frac{Q^{0{,}5}}{H^{0{,}75}}$$

Where:

Ns = specific rotation

n = pump rotation

So:

$$N_s = 1450.\frac{0{,}03^{0{,}5}}{11^{0{,}75}} = 41{,}58$$

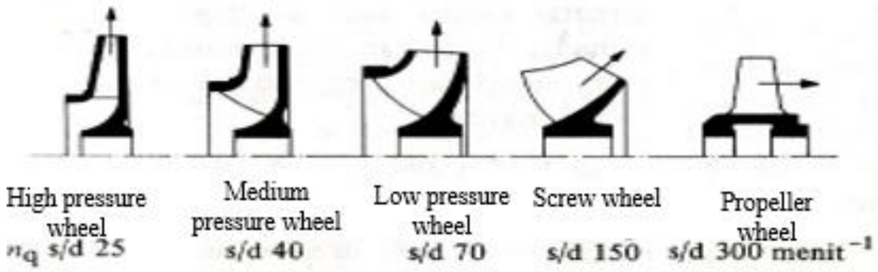

Figure 3. Pump impeller wheel table.

From the figure 3, it can be concluded that the pump used is a low pressure wheel because Ns = 41.58.

4.6. Solar panels

A solar panel with a spec of 200 Wp will produce 200 Watt of electric current at maximum sunlight intensity, this can happen at midday, around 11.30 to 14.00 in sunny weather (about 2.5 hours a day).

If you take an average full charge time of 200 Wp for 6 hours a day, the power obtained by 48 solar panels is:

$$Qps = qp \times Wp \times h = 48 \times 200 \times 6 = 57{,}600 \text{ Wh.}$$

From the calculation of the pump power, it is found that the required current for 6 hours of operation is:

$$Qpump = (4047 \text{ W} \times 6 \text{ h}) \times 1.1 = 26{,}710 \text{ Wh.}$$

Where 1.1 is the loss factor.

Meanwhile, what is produced by the 57,600 Wh panel and booster pump uses an electric current of 26,710 Wh, so that the total demand for electric current is 26,710 Wh a day, this requirement is much smaller when compared to the electric current obtained by solar panels.

4.7. Battery

Solar panels have generated an electric current when the sun begins to rise, but the resulting current is still small and enlarges in proportion to the increase in sunlight and decreases again as the light decreases. The small current obtained in the morning cannot be used to move the pump, for that it needs a battery so that the current obtained is not wasted. How the battery works to store energy from sunlight can be seen in Figure 4.

Figure 4. How the battery works to store energy from sunlight.

The battery capacity used is expected to be able to accommodate the remaining electric current theoretically, namely:

$$Q_{cad} = 57.600 \text{ Wh} - 26.710 \text{ Wh} = 30.890 \text{ Wh.}$$

If the battery voltage used is 48V, then the battery capacity (I_{bat}) required:

$$I_{bat} = \frac{Q_{cad}}{V} = \frac{30.890\, Watt}{48\, Volt} = 643{,}5\, Ah.$$

From the above calculations, you should use a battery with a capacity of 643.5 Ah.

4.8. Inverter

For the inverter itself, there is a rating requirement that is commonly used to serve the power supply to the load from electrical energy sources, namely an increase of around 20% to 25% of the power capacity to be used. So, the solar energy received by the battery or pump is 4.047 W x 20% = 809.4 W. Inverter installation sketch can be seen in Figure 5.

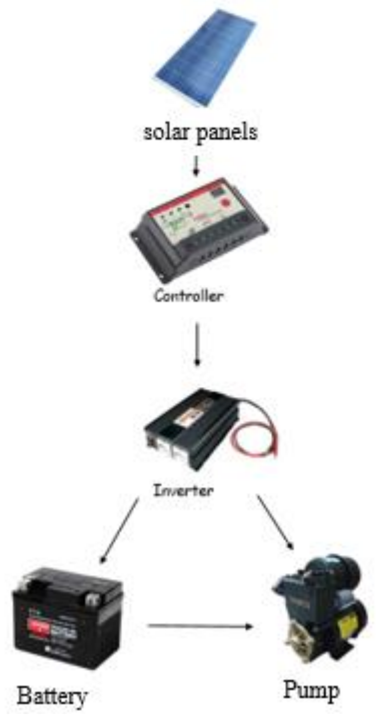

Figure 5. Inverter installation sketch.

5. Conclusion and advice

5.1. Conclusion

After completing the final project regarding the redesign of the solar panels to drive the water pump, the people in the subdistrict of Central Siberut will be able to meet their clean water needs if the equipment for PLTS that has been stalled is redesigned according to the results of the design carried out by the author, namely as follows:

- To meet the water needs of 3181 people, using 200L of water per person / day, the required water discharge is 636,200 L / day.
- A pump that runs for 6 hours a day requires a water flow rate of 30 liters per second.
- By determining the velocity of water in the pipe 2m / sec, the water velocity in the pipe is 1.492m / sec.
- The pump that runs for 6 hours per day requires a current of 24,282 Wh.
- The pump used is a low pressure wheel because of its specific rotation 41.58.
- The power obtained from 48 pieces of solar panels for 6 hours is 57,600Wh.
- Booster pump that uses an electric current of 26,710 Wh.
- For 48 V battery voltage, the required battery capacity is 643.5 Ah.

5.2. Advice

In order for the PLTS that has been redesigned to be used for a long time, the following activities need to be carried out:

- PLTS is fitted with a protective barrier such as a high fence so that the solar panels are not stolen.
- An operator who understands PLTS and pumps is needed so that periodic maintenance can be carried out.

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