Utilization of Solar Panels to Distribute Clean Water in Saibi Samukop Village

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ABSTRACT

The purpose of this research is to design a clean water distribution system by utilizing solar energy as an energy source to drive DC pumps in the village of Saibi Samukop which is located in the Mentawai Islands with minimal development including the construction of clean water facilities for community needs. In this design, 2 solar panels with 100 Wp are used to charge 2 batteries as power storage. The pump specifications used have a maximum power of 180 Watts with a head of 15 meters and a voltage of 12 Volts. From the results of the design then carried out testing, the pump head 8.1 operating for 6.4 hours/day with a power requirement of 100.5 watts and an electric current of 53.6 Ah. The pump is capable of distributing water to the Pangasaat hamlet community in the range of 100.50 liters/per day.

INTRODUCTION

Water as an important element of life is a problem in its availability in nature. The availability of water used, namely fresh water, is very small compared to abundant seawater. Fresh water is only 3% of all water on earth [1].

A village located in Mentawai always has difficulty getting clean water, namely in Pangasaat and Masoggunei Village, Mentawai Islands, West Sumatra [2]. Based on the results of interviews from the local community they only rely on water in a well dug manually near the hill at the end of the village, and the two hamlets were found to have only two wells [3]. The results of the interviews also obtained the need for 355 households, a minimum of 10,500 liters of water per day was needed.

According to information from the local community, this well has never experienced a drought despite the dry season, so this improvement can be done by providing a solar power plant to drive the pump [4]. Because of the potential that exists in Saibi village, so the author designed the distribution of clean water using solar panels.[5]

Solar Energy is energy that has no limits or will not run out. This energy can also be used as alternative energy that can be converted into electrical energy. Solar energy is energy in the form of light and heat that comes from the sun. This energy can be utilized directly or converted into other forms of energy using technology, before being reused. So the use of solar energy to provide clean water is very helpful in using renewable energy such as solar energy [6].

RESEARCH METHOD

The purpose of designing clean water distribution using solar panels in Saibi Samukop village is to meet the adequacy of clean water needs and design an electrical system schematic as well as analyze the feasibility of DC pumps using solar panels shown in Figure 1 [7].
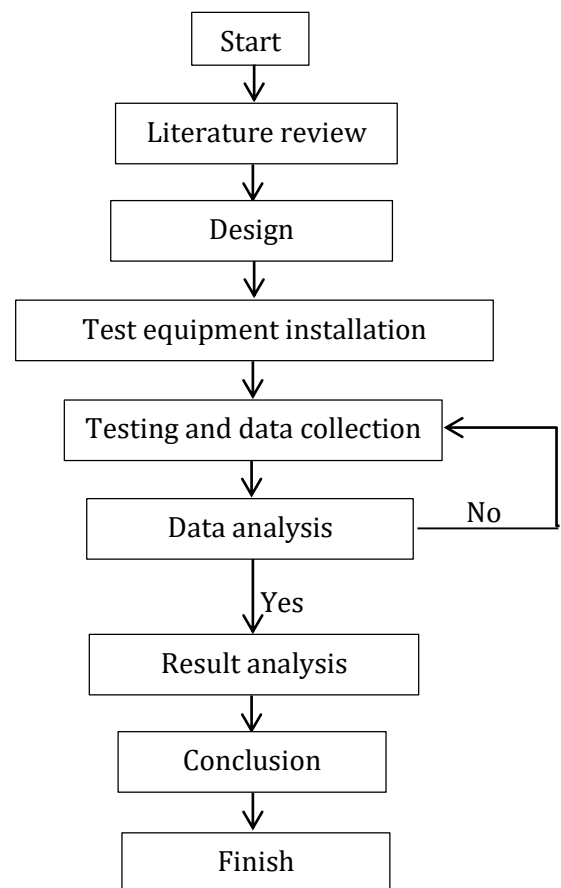

Figure 1. Research flowchart

Before doing the test, first designed the electrical system schematic as shown in Figure 2.
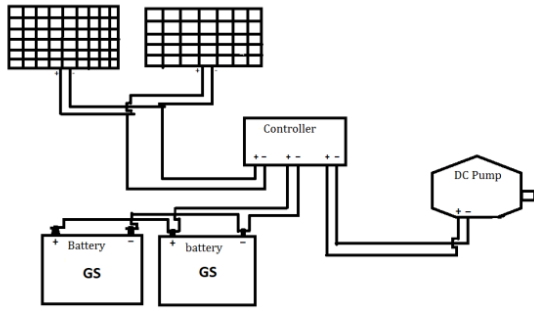
Figure 2. Electrical system schematic

In this design, the initial data or tools used are shown in the table 1 [8].

Table 1. Auxiliary tools are needed.

Material	Size	Amount
Solar Panel	100 WP	2 Pcs
Battery	12 Volt, 70 Ampere hour	2 Pcs
DC pump	12 Volt	1 pcs
Solar controller	MY20-Lu	1 Pcs
Solar power water	220 Volt	1 Pcs
Straight pipe for dicharge side	3/4 in	18 m
Straight pipe for suction side	1 in	1 m
Valve	1,5 in	1 Pcs
Elbow	1,5 in	1 Pcs
Suction filter	1,5 in	1 Pcs
Water drum	200 Liters	2 Pcs
Flowmeter	50 LPM	1 Pcs

RESULT AND DISCUSSION

Daily water needs can be calculated based on how many liters of water are used by the community to meet their daily needs shown by the formula $Q_{md} = P_n \times q$, where P_n is the number of the head of the family, q is the water consumption requirement assumed to be 30 liters for (family/day), then the need for clean water for Masoggunei hamlet which amounted to 335 households is 10,050 liters/day, and for Pangasaat hamlet with 314 households the water requirement is 9420 liters/day [9].

Pump Installation

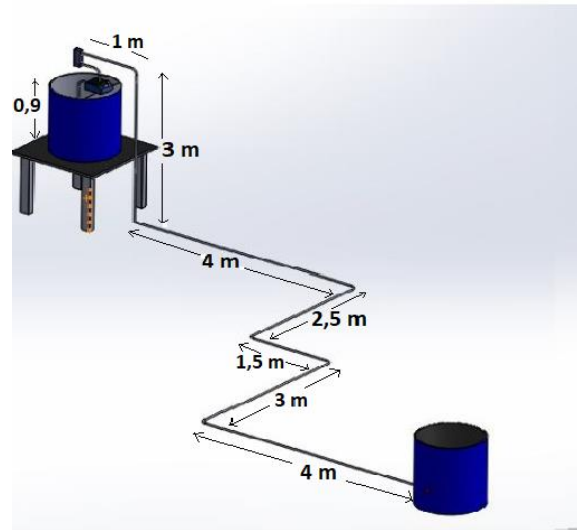The designed pipe and pump installation is shown in Figure 3.

Figure 3. Pipe and pump installation

Based on the water needs in Saibi Samukop village, the pump chosen is a solar pump with a 12 V LSWQB model with a discharge specification of $Q = 1,5 \, m^3 H$ or 1500 liters/hour or 0.42 liters/second, pump power P=180 Watts, and Head H=15m. By knowing the pump specifications, the pump efficiency is $\eta_p = \frac{\rho \times g \times H \times Q}{P} = 34\%$ [10]. The pipe chosen is a pipe with a diameter of 1,5 in, the pump capacity is 25 liters/minute or 1500 liters/hour so that the pump operating time in one day for the hamlet of Massogunei is $\frac{10.050 \text{ liters/day}}{1.560 \text{ liters/hour}} = 6,4$ hours/day, and for Pangasaat hamlet it is $\frac{9.420 \text{ liters/day}}{1.560 \text{ liters/hour}} = 6,03$ hours/day .

Discharge Side Pipe

Based on the discharge side, it takes a vertical pipe length of 15 meters and a horizontal pipe length of 3 meter, so the total length of the discharge side pipe is 18 meters [11]. Because the selected pipe 1,5 inch, so the cross-sectional area of the pipe is $A = \frac{\pi}{4}d^2 = 0,03$ dm² and the velocity of the water in the pipe at the discharge side is $V = \frac{Q}{A} = 14,3$ dm/s or 1.43 m/s [12].

To calculate the head loss on the discharge side pipe, it must be determined that the coefficient of friction is 0,02 [13], so the head loss on the discharge side pipe is $H_{fdp} = f \times \frac{L \times V^2}{d \times 2g} = 1,8$ m.[14]

The discharge side pipe has 1 valve with a friction factor of 0,02 so the valve losses are $H_{fv} = n \times f \times \frac{V^2}{2g} = 0,002$ m, and 7 elbows on the discharge side with a friction factor of 0.294 so that the total losses on the elbows are $H_{f\,el} = n\,f \times \frac{V^2}{2\cdot g} = 0,2$ m. With the head loss obtained for each pipe and accessories on the discharge side, the total head loss on the discharge side pipe is $H_{fdp} + H_{fv} + H_{fell} = 2$ m.

The discharge side pipe also has 9 auxiliary materials with a friction factor of 0,19, so the head loss on the auxiliary material is $H_{fass} = n \times k \times \frac{V^2}{2\cdot g} = 0,17$ m, Then the total head loss on the pump is $H_{fTot} = H_{fdp} + H_{fass} = 5$ meter.

Suction Side Pipe

On the suction side, the total suction height is the difference between the height of the pump and the depth of the well. On the suction side, the length of the vertical pipe is 0,1 meters and the horizontal pipe is 0,9 meters. The selected pipe is a 1 inch pipe, the surface area is $A = \frac{\pi}{4}d^2 = 0,05$ dm² and the water velocity is $V = \frac{Q}{A} = 0,86$ m/s [15].

The head loss on the suction side pipe along 1 meter is $H_{fhp} = f \times \frac{L}{D} \times \frac{V^2}{2g} = 0,02$ m where the coefficient of friction for the pipe is 0,02. [16]

On the suction side, one 90⁰ elbow is used with the elbow losses $H_{fell} = n \times f \times \frac{V^2}{2g} = 0,005$ m, where the factor friction is 1,97. The suction side has 1 filter and the filter friction factor is 1,97 so the friction losses on the filter are $H_{fsar} = n \times f \times \frac{V^2}{2g} = 0,07$ m. By obtaining losses on the pipe and losses on accessories used on the suction side, the total head loss on the suction side is $H_{fhp} + H_{fell} + H_{fsar} = 0,09$ m.

Total Head

The total pump head is the maximum pressure capability at the working point of the pump so that the pump is able to flow water from one place to another.

The location of the well is near a hill, so the position of the well is higher than the community water reservoir, which is 5,1

meters above sea level then the total H is $\Delta_{el} - H_{total} = 8,1$ m [17].

Pump Power

The pump power required for water distribution is $P = \frac{\rho \times g \times H \times Q}{\eta_p} = 100,5$ Watt. The power capacity required by the pump to distribute the water is $I_{Total} = \frac{100,5 \text{ Watt}}{12 \text{ volt}} \times 6,5$ hours $= 54,4$ Ah, with total load and safety factor is 54,4 Ah x 1,20 = 65,3 Ah [18].

In this test using 2 batteries, in this test the battery while being charged by power from the solar panel. While the current efficiency used in the battery is 70% in order to avoid damage to the battery. The battery charging time for load is 100,5 watts and the battery voltage for 2 pieces is 12 volts or 140 Ah, then the battery discharging time is $I_{battery} = \frac{100,5 \text{ watt}}{12 \text{ volt}} = 8,3$ A or $\frac{140 \text{ Ah X } 70\%}{8,3 \text{ A}} = 9,8$ hours [19].

Test Result

Based on the data from the design and manufacture of testing tools, then testing is carried out for water distribution using solar panels. The test results are shown in the table 2 and 3.

The results of the test on the first day that the power that is filled into the battery is getting less while the pump remains on or operates for 10 hours with the pump condition still turn on [20].

Table 2. The test results for the first day

Time	Voltage (V)	Current (A)	Light intensity (W/m²)	Power (W)
9:00	12.16	8.5	284	103,36
10:00	12.26	8.76	296.6	107.39
11:00	12.15	8.54	407.8	103.76
12:00	12.08	7.8	495.5	94.22
13:00	12.04	7.5	408.2	90.3
14:00	11.02	8.1	420.5	89.26
15:00	11.87	7.9	17.3	93.7
16:00	11.8	7.7	15.3	90.86
17:00	11.75	7.4	14	86.95
18:00	11.68	7.1	14	82.92
19:00	11.57	6.8	14	78.67

This table also shows that the test on the first day with the current supplied from the solar panel obtained a battery voltage of 12,16 volts, a current of 8,5 Ampere with a water capacity of 26 liters/minute. Until 12:00 noon the sun's rays are getting hotter to 495,5 W/m2, the sun's rays are not so long that the sun's intensity is decreasing, and when the time shows 17:00 in the afternoon the weather starts to cool and the sun's intensity drops drastically to 14 W/m², voltage 11,5 volts, current 7,4 Ampere.

Table 3. The test results for the second day

Time	Voltage (V)	Current (A)	Light intensity (W/m²)	Power (W)
9:00	11.78	8,6	284.8	100.13
10:00	11.77	8,76	283.4	103.1
11:00	11.73	8.5	299.1	100.17
12:00	11.65	7.8	258.5	90.87
13:00	11.52	7.5	269.5	86.4
14:00	11.36	7.3	230.8	82.9
15:00	11.29	6, 7	292.8	75.6
9:00	11.78	8,6	284.8	69.44

The test results on the second day with the weather conditions not too good or still cloudy, using the remaining current from the first day of testing and the current is still being

supplied from solar panels with a voltage on the battery 11,78 Volts, current 8,6 Ampere. At 10:00 am the current slightly increases because the intensity of the sun starts to heat up, the longer it takes, the more the battery runs out because the power supply from solar power is less than the power used by the pump. Until 16:00 with a voltage of 11,2 volts, the current 6,2 Ampere the pump stops flowing water or the pump stops.

CONCLUSION

From the test results of solar energy 2 pieces of 100 Wp, each is to flow to 2 batteries with 12 Volt connected in parallel to drive the pump. Data from the test results obtained a water capacity of 26 liters/minute with a pump efficiency of 34% on the first day of testing, the pump lasts for more than 10 hours, and the batteries used are 2 pieces arranged in parallel. On the second day of testing where the weather was cloudy and the pump could still last for 7 hours using the remaining power in the first test. The energy supply from solar panels is quite safe to use in the distribution of water in the village of Saibi Samukop.

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