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Re-design the use of PV to distribute water from tanks to rural area for Mentawai especially in Central Siberut sub-district

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Re-design the use of PV to distribute water from tanks to rural area for Mentawai especially in Central Siberut sub-district

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Abstract. The redesign of the water pump stuck in the district of Central Siberut is reused by using the Solar Panel as an alternative energy source. The materials and tools used are Booster pump, pipe, air valve, wash out, blow off and gate valve. The booster pump is used to pump high pressure water from the tank so that it can reach Saibi village, where Saibi village is the farthest village compared to Simulaklak village, where the distance from the tank to Simulaklak village is only 1.5 km and the tank to Saibi village is 4.5 km the elevation difference between the tank and the village of Saibi is 25 meters above sea level. The total water demand in Simulaklak and Saibi villages is 17.63 liters / second with flow rates in Simulaklak and Saibi villages of 2.25 m / sec and 1.69 m / sec, for the pump head obtained from the tank to Simulaklak village is 72,1 m and the pump head from the tank to Saibi Village is 120.31 m. The standard atmospheric pressure obtained for Simulaklak village is 10,284 mH₂O and for Saibi village is 10.301 mH₂O. Booster pump is an alternative that can be used for distributing water from the tank to the village.

1. Introduction

Water is the most basic need for humans and the surrounding environment. In accordance with these reasons, various methods are used to utilize alternative energy such as electricity generation from the sun using solar panels and hydroelectric power. Based on an invitation from the Mentawai Bappeda to several lecturers from the Christian University of Indonesia to conduct PKM (Community Service) in the Mentawai District, the Team determined several things that need to be followed up, including: Reactivation of the Water Supply System "Government assistance that is stalled" due to rust and water sources that have stopped due to disrupted electrical power supply and water distribution that is not smooth and evenly distributed (invitation letter from Bappeda Mentawai) From the description above, we know that Simulaklak and Saibi Villages still do not have evenly distributed water supply systems, so it is necessary to plan the use of the already stalled solar panels to be redesigned which aims to help distribute water from the tank to the villages, simulaklak and saibi which source water. this is to meet the needs of the residents of Simulaklak and Saibi Villages.

Central Siberut District is one of 3 sub-districts in the Mentawai Islands. Central Siberut has 2 villages namely Saibi Village as the sub-district capital and Simulaklak village with a population of 3181 people or a total of 944 families. Where in Saibi, is a village which has an area of 1107.71 km² and has a population of 2386 people or 708 families and Simulaklak Village has a smaller area with a population of 795 people or 236 families.



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2. Theory

2.1. Pumps

The pump is a common machine used to move a liquid from a low place to a higher place through a pipeline that has been connected [1]. To remove obstacles Simulacra during the flow of liquid, substances need to increase the pressure on the liquid substance using the pump. For installation It takes some additional equipment such as pipes and other tools. Classification of pumps into two parts:

2.1.1. Centrifugal pumps. Pump is a tool that can move fluid or flow from a low pressure to a higher pressure. A centrifugal pump is composed of an impeller and a central inlet channel. When the impeller rotates, the fluid flows into the casing around the impeller as a result of centrifugal force. These cases work to lower the flow rate and the fixed speed of the impeller turn [2]. Centrifugal pumps can be seen in Figure 1.

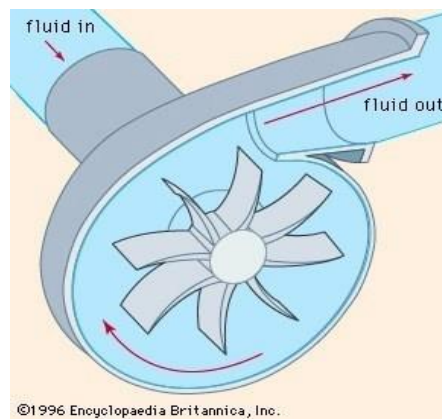


Figure 1. Centrifugal pumps.

2.1.2. Axial pump. An axial pump is a pump that generates most of the pressure from angles to flow. These pumps are often used in drainage and irrigation systems. Axial pumps can be seen in Figure 2.

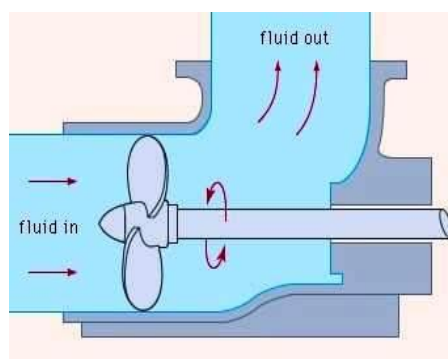


Figure 2. Axial pumps.

2.1.3. Positive displacement pumps. This pump is a pump with a capacity that is produced by intermittent, because the liquid substance that is thrust inside the pump element element with a specified volume. When the fluid enters, the fluid is moved to the discard position to keep it from leaking. For the capacity produced this pump is more or less comparable to the number of alternating movements or lap numbers. For the resulting head of this pump high therapy low liquid capacity [3].

2.2. Kinds of losses on pumps

2.2.1. *Loss caused by leakage.* Loss due to leakage here that is happening in the pump, such as discharge and suction.

2.2.2. *Loss due to friction friction of liquid substances the disadvantage here happens because some things depend on the actual state*

- Fast Flow speed
- Its pipes have a large surface
- Many turns occurring on pipes
- And too much liquid substance viscosities

2.2.3. *Mechanical loss.* This loss is caused by an error when installation or installation of the pump is not correct resulting in leakage, and also too small clearance.

2.3. Calculating water needs and pipeline installation

2.3.1. *Calculate the water need (discharge pump)*

$$\text{Debit (Q)} = \frac{V}{t} \left(\frac{\text{m}^3}{\text{s}} \right)$$

V = water Volume (m³)

T = time (seconds)

Q = Debit (m³/s)

2.3.2. *Calculates total head of pump*

$$H = h_a + \Delta h_p + h_t + \frac{V_d^2}{2g}$$

H = Head Total pump (m)

H_a = Total static Head (m)

ΔH_p = pressure head difference that works both surfaces

H_t = Various head losses in pipes, valves, turns, joints, and more

(V_d²)/2g = Head speed Out (m)

g = gravity acceleration (9.8 m/s²)

2.4. Pressure losses

The losses in the pipeline consist of several losses, such as a friction in the pipe, losses within the turn, reducer losses, and losses that are present in the valve [4].

2.4.1. *Loss of friction head in pipes [5]*

$$h_f = \lambda \frac{L}{D} \frac{v^2}{2g}$$

2.4.2. *Minor head loss*

$$h_{lf} = nk \frac{v^2}{2g}$$

2.4.3. *Loss in pipeline*

$$h_f = f \frac{v^2}{2g}$$

2.4.4. Head loss in valves

$$h_v = f_v \frac{v^2}{2g}$$

2.4.5. K value on the elbow. K value on the elbow can be seen in Figure 3.

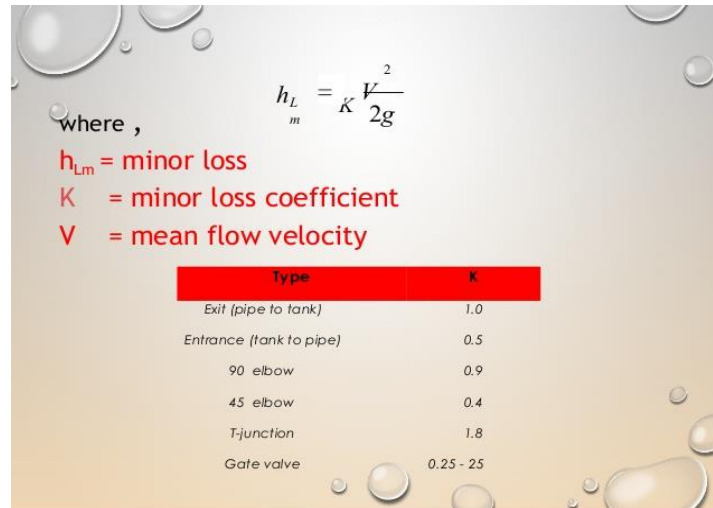


Figure 3. K value on the elbow.

2.4.6. Total losses

$$h_t = f \cdot \frac{L_e}{D} \cdot \frac{v^2}{2g}$$

2.5. Solar panels

Solar cells have several parts in the form of a semiconductor of electrical conductors that are capable of directly converting solar energy into an electrical energy form efficiently. Almost all solar cells are made from single-glazed silicon materials [6]. Radiation generated from sunlight is rededicated into photons-photons that have different energy levels from each other. This difference is what will determine the wavelength of the light spectrum, the photons received from the solar panel and will trigger the occurrence of electrical energy. Illustration solar cells can be seen in Figure 4.



Figure 4. Illustration solar cells.

2.6. Batteries

Battery is a tool that serves to save electrical current power or commonly referred to as DC. The battery can also be called by batteries. And most of the market is still found in wet battery which means it still uses sulfuric acid in the form of liquids. This wet battery has more constraints than dry battery. Battery can be seen in Figure 5.

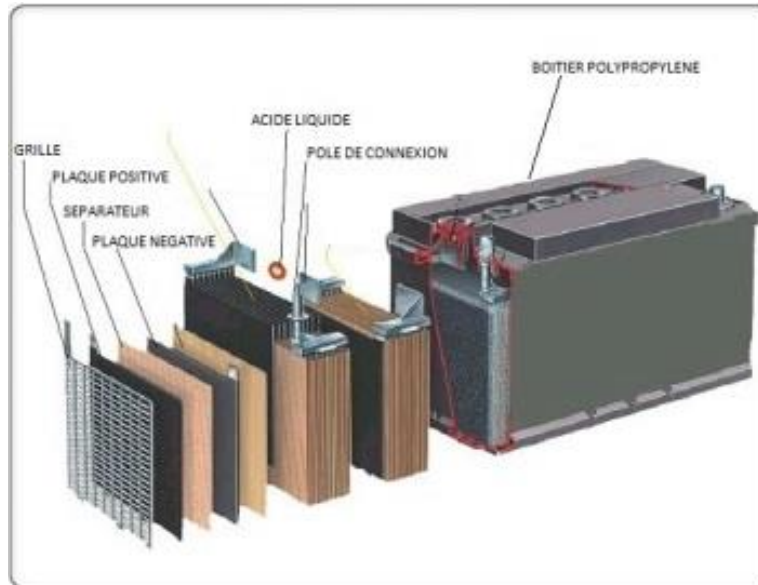


Figure 5. Battery.

2.7. Inverter

The tool called the inverter is a tool that is included in electronics, where this inverter will store and convert DC power into AC. Inverter has 2 terminals, which is a positive that is generally red and negative black color. Inverter can be seen in Figure 6.



Figure 6. Inverter.

2.8. Controller

This Controller is useful as one of the most useful electronic equipment for regulating the direct current of the needle and overseeing the excess usage. Controller can be seen in Figure 7.



Figure 7. Controller.

3. Methodology of research

The stages in conducting this research are as follows (Figure 8).

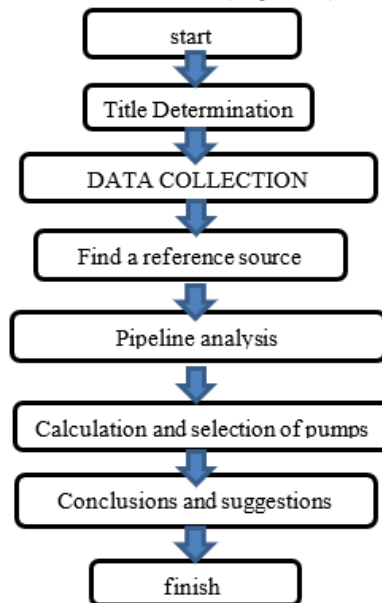


Figure 8. Flowchart.

3.1. Data collection techniques

Techniques used to conduct this research are:

- Library to find books related to piping systems and pump selection analysis, both from subject matter so that a supporting theory is obtained to complete this final task.
- Research directly into the field, where we can see and can find out directly from the installation planning and equipment to be used. By looking for information from several sources that have been to the location of the village Saibi and Simulaklak village or local people who will facilitate the research to get a clear picture and also the data needed during the field for later in analysis to the calculation.
- Discussing discussion with the authors and advisers report to be able to get good results and find step-lanngkah and receive feedback in terms of writing the final task report.

3.2. Data analysis

Analyze the data used using accurate and correct calculations to avoid mistakes in the redesign of the pump in the middle Siberut

3.3. Tools and materials

- Equipment pipe in the installation to the village Saibi and Simulaklak village is by providing wash out aims as reducing the deposits that exist in the pipeline. Water valve also as a reducer of wind pressure that is in the pipeline or removing the existing wind in the pipe so as not to easily damage, blow off and gate valve as a flow discharge regulator during operation.
- Approximate number of accessories that are 5 pieces of elbow 900, 10 pieces of 450 elbow, 15 pieces of water valve

3.4. Place and time

- Place: Saibi Village and Simulaklak village of central Siberut District, Mentawai Islands
- Time: April-July 2020

4. Results

4.1. Data collection

- Total population = 3181 inhabitants
- Saibi Village = 2386 inhabitants
- Village Simulaklak = 795 inhabitants
- The height of the village Saibi from sea level is 5 m and to the tank is 30 m above sea level.
- The difference between the village of Saibi with tank is 25 m, and the difference in height between Simulaklak village with tank is 7 m.
- Elbow 90 = 5 seeds
- Elbow 45 = 10 seeds
- Air valve = 15 seeds
- The distance from the water tank to the village Simulaklak 1500 m and Simulaklak to the village Saibi is 4500 m

Water distribution system from tank to village Simulaklak and Saibi can be seen in Figure 9.

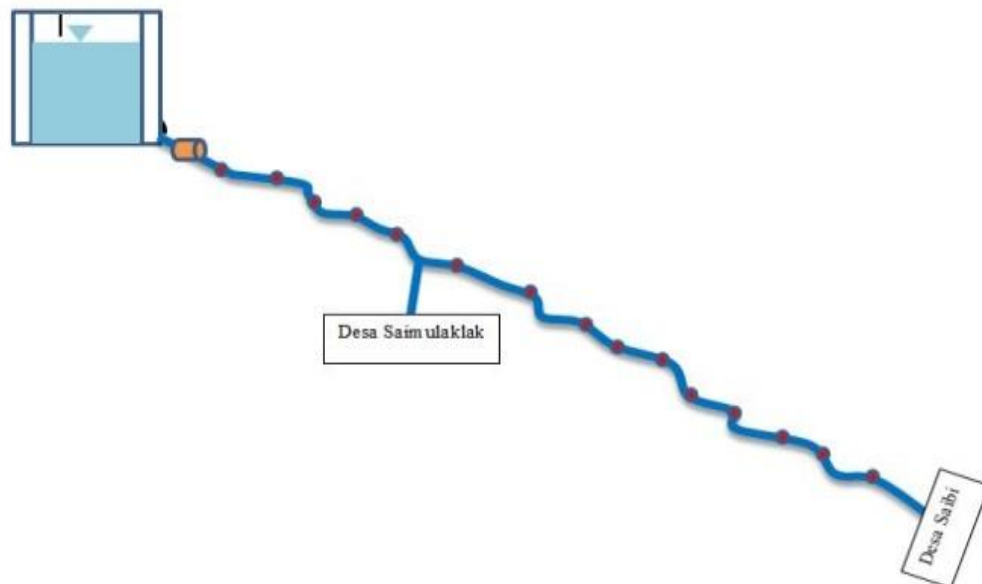


Figure 9. Water distribution system from tank to village Simulaklak and Saibi.

4.2. Water supplies

200 liters/day/person

Pipe Diameter 100 mm or 0.1 m

Operating hours for 10 hours per day

3181 persons x 200 liters/person/day

636200 liter/day = 636.2 m³/day

Use for 10 hours,

$$Q = 63620 \frac{\text{liter}}{\text{jam}} = 17,67 \frac{\text{liter}}{\text{detik}}$$

$$V = \frac{Q}{A}, A = \frac{\pi}{4} d^2 = 0,785 \text{ (dm}^2\text{)}$$

Then:

$$V = \frac{17,67 \text{ dm}^3/\text{detik}}{0,785 \text{ dm}^2}$$

$$V = 22,5 \frac{\text{dm}}{\text{detik}} = 2,25 \frac{\text{m}}{\text{detik}}$$

4.2.1. Head loss on straight pipes

$$H_f = f \frac{L}{D} \frac{v^2}{2g} \quad \text{value (f) is taken 0,015}$$

$$H_f = 0,015 \frac{6000}{0,1} \frac{(2,25)^2}{2 \times 9,81}$$

$$= 0,015 \cdot 60000 \cdot \frac{5,0625}{19,62}$$

$$= 232,22 \text{ m}$$

4.2.2. Head loss on Elbow 450

$$H_f = f \frac{v^2}{2g} = 0,236 \frac{(2,25)^2}{2 \cdot 9,8}$$

$$H_f = 0,061 \text{ m}$$

$$H_f = 0,061 \text{ m (10)} = 0.61 \text{ m}$$

4.2.3. Head loss on elbow 900

$$H_f = f \frac{v^2}{2g} = 1,129 \frac{(2,25)^2}{2 \cdot 9,8} = 0,291 \text{ m}$$

$$H_f = 0,291 \text{ m (5)} = 1.455$$

4.2.4. Valve head losses (check valve)

$$F_v = 2.5$$

$$H_f = f v \frac{v^2}{2g} = 2,5 \frac{(2,25)^2}{19,62} = 0,65 \text{ m}$$

$$H_f = 0,65 \text{ m (15)} = 9,67 \text{ m}$$

4.2.5. Total head pumps

$$H = h_a + \Delta h_p + h_l + \frac{v^2 d}{2g}$$

$$= 25 + 0 + 232,22 + 0,61 + 1,455 + 9,67 \text{ \}$$

$$= 268,96 \text{ m}$$

Table 1. Altitude and atmospheric pressure.

(m)	0	100	200	300	400	500	600
atm	10,3	10,2	10	9,97	9,85	9,62	9,16

4.3. Simulaklak village

$$4.3.1. Q_k = 63620 \frac{\text{liter}}{\text{jam}} = 17,67 \frac{\text{liter}}{\text{detik}}$$

$$V = \frac{Q}{A}, A = \frac{\pi}{4} d^2 = 0,785 (1\text{dm}^2)$$

$$= 0,785 \text{ dm}^2$$

$$V = \frac{17,67 \text{ dm}^3/\text{detik}}{0,785 \text{ dm}^2}$$

$$V = 22,5 \frac{\text{dm}}{\text{detik}} = 2,25 \frac{\text{m}}{\text{detik}}$$

4.3.2. Calculating straight pipe Loss

$$H_f = f \frac{L}{D} \frac{v^2}{2g}$$

$$H_f = 0,015 \cdot 15000 \cdot \frac{2,25^2}{2 \cdot 9,8}$$

$$H_f = 58,056 \text{ m}$$

4.3.3. Calculating head loss on elbow 45°

$$H_f = f \frac{v^2}{2g}$$

$$H_f = 0,236 \frac{2,25^2}{2 \cdot 9,8}$$

$$= 0,061 \text{ m}$$

$$H_f = 0,061 \cdot (5) = 0,304$$

4.3.4. Calculating head loss on elbow 90°

$$H_f = f \frac{v^2}{2g}$$

$$H_f = 1,129 \frac{2,25^2}{2 \cdot 9,8} = 0,02 \text{ m}$$

$$H_f = 0,02 \cdot (2) = 0,29 \text{ m}$$

4.3.5. Calculating losses on valves (check valve)

$$H_f = f v \frac{v^2}{2g}$$

$$H_f = 2,5 \frac{2,25^2}{2 \cdot 9,8} = 1,3 \text{ m}$$

$$H_f = 1,3 \cdot (5) = 6,45 \text{ m}$$

4.3.6. Counting pump head

$$H = h_a + \Delta h_p + h_l + \frac{v^2 d}{2g}$$

$$H = 7 + 0 + 58,056 + 0,304 + 0,29 + 6,45 = 72,1 \text{ m}$$

4.3.7. Standard atmospheric pressure (M H₂O) from the tank end to the Simulaklak village

$$P_a = 10,33 \left[1 - \frac{0,0065h}{288} \right]^{5,256}$$

$$P_a = 10,33 \left[1 - \frac{0,0065(30)}{288} \right]^{5,256}$$

$$P_a = 10,284 \text{ mH}_2\text{O}$$

4.4. Saibi village

$$4.4.1. Q_k = 63620 \frac{\text{liter}}{\text{jam}} = 17,67 \frac{\text{liter}}{\text{detik}}$$

$$V = \frac{Q}{A}, V = \frac{0,75 \cdot 17,67 \text{ dm}^3/\text{detik}}{0,785 \text{ dm}^2}$$

$$V = 16,88 \frac{\text{dm}}{\text{detik}} = 1,69 \frac{\text{m}}{\text{detik}}$$

4.4.2. Calculating straight pipe Loss

$$H_f = f \frac{L}{D} \frac{v^2}{2g}$$

$$Hf = 0,015 \frac{4500}{0,1} \frac{1,69^2}{2 \cdot 9,8}$$

$$Hf = 0,015 \cdot 45000 \cdot \frac{2,8561}{19,62}$$

$$Hf = 98,26 \text{ m}$$

4.4.3. Calculating head loss on elbow 45°

$$Hf = f \frac{v^2}{2g}$$

$$Hf = 0,236 \frac{1,639^2}{2 \cdot 9,8} = 0,034 \text{ m}$$

$$Hf = 0,034(5) = 0,17 \text{ m}$$

4.4.4. Calculating head loss on elbow 90°

$$Hf = f \frac{v^2}{2g}, Hf = 1,129 \frac{1,69^2}{2 \cdot 9,8} = 0,028 \text{ m}$$

$$Hf = 0,2 (3) = 0,6 \text{ m}$$

4.4.5. Calculating losses on valves (check valve)

$$Hf = f v \frac{v^2}{2g}, Hf = 2,25 \frac{1,69^2}{2 \cdot 9,8}$$

$$Hf = 0,328 \text{ m}$$

$$Hf = 0,328 (10) = 3,28 \text{ m}$$

4.4.6. Counting pump head

$$H = h_a + \Delta h_p + h_l + \frac{v^2 d}{2g}$$

$$= 18 + 0 + 98,26 + 0,17 + 0,6 + 3,28$$

$$= 120,31 \text{ m}$$

4.4.7. Standard atmospheric pressure (M H₂O) from the tank end to the Saibi village

$$Pa = 10,33 \left[1 - \frac{0,0065h}{288} \right]^{5,256}$$

$$Pa = 10,33 \left[1 - \frac{0,0065(23)}{288} \right]^{5,256}$$

$$Pa = 10,301 \text{ mH}_2\text{O}$$

Note: From the calculation of the above, the pressure of the pump needed to drain water from the tank to Saimulaklak village and Saibi Village is the registration of Pa.

5. Conclusion

Among the three types of conductors found that:

- Total water needs in the village Simulaklak and the village of Saibi is 17.63 Liter/second where the water needs in the flow rate at Simulaklak village and Saibi village amounted to 2.25 m/sec and 1.69 m/sec.
- The Diameter of the pipe used is 100 mm or 0.1 m
- Along the flow of pipes from the tank to the village Saibi mounted elbow 450 as much as 10 pieces, elbow 900 as much as 5 pieces and water valve as many as 15 pieces.
- Head pump from tank to village Simulaklak is 72.1 m and head pump from tank to village Saibi is 120.31 m

- So the standard atmospheric pressure (mH₂O) is required from the tank to the village Simulaklak is 10.284 m H₂O then from the village of Saibi required atmospheric pressure 10.301 m H₂O.
- With the result, the distribution of water from the tank to the village of Saibi and Saimulaklak Village will be divided and able to serve the water needs of the community in the two villages.

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