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Preliminary design of micro hydro power plant in Enim river, Plakat village

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Abstract

The utilization of renewable energy in meeting electricity needs in Indonesia continues to be carried out, including by utilizing river flow as a source of electrical energy for the community. Micro hydro power plants are one type of power plant that utilizes river flow as a source of energy that is widely used in Indonesia, especially for people in rural areas who have difficulty in accessing the electricity grid and spread throughout Indonesia. One of the rivers in South Sumatra Province, Indonesia that has the potential to be developed as a micro hydro power plant is the Enim River located in Plakat Village. This research was conducted to obtain an estimate of the amount of energy that can be generated from the Enim River. In the methodology, the data needed to calculate the amount of energy produced includes effective the effective fall height data, identification of the intake channel, forebay and penstock pipe obtained from direct observation and then the calculation of water power that can be generated by the Enim River tributary in Plakat Village. In the calculation results, the micro hydro design in Plakat Village, Enim River is as follows: 184 m pipe dimensions, minimum pipe thickness of 0.5 m, effective energy height of 26.1 m, and output power of 35.88 kW.

Keywords: Renewable Energy; Micro Hydro Power Plants; Enim river; Electricity

1. Introduction

As the population grows, the need for electricity in rural areas increases, but, on the other hand, the financial support by the government to expand the electricity network is limited [1]. Energy is one of the important things in human life [2] and energy has an important role in the development of a country if its availability and development are hand in hand and support national development [3]–[5] .Micro-hydro is often considered as a plausible alternative in meeting the electricity needs of rural communities [1]. Utilization of rivers as micro hydro powerplants by utilizing rivers as an energy source has been widely carried out in the territory of Indonesia, considering the number of riveris scattered throughout the waters in Indonesia, including in East Java, West Sumatra, Aceh, South Sumatra, and other area in Indonesia [6]–[10], is more reliable and cheaper than the generator with other raw materials and is included in renewable energy [11], [12].

Prior to the construction of a micro hydro power plant, there are several things that should be done, namely the potential surveys and development feasibility [13]–[15]. South Sumatra Province has areas that have renewable energy potential. Muara Enim Regency has a fairly large area and abundant natural resources with most of its area being a watershed. This area includes Semende Darat Ulu, Semende Darat Laut, Semende Darat Tengah and Tanjung Agung subdistricts. The lowlands are in the middle. In the northwest-north, there is a swamp area directly facing the flow of the Musi River.

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The potential in the Semende Darat Ulu area has tributaries that can be used as energy sources. One of them is Plakat Village, which has the potential for a micro hydro power plant. The PLTMH itself is a source of electricity for the surrounding community which provides many advantages over the limited demand for electricity. This study aims to calculate the initial design of micro hydro power plants on the Enim River.

2. Material and Method

This research was conducted in Plakat Village, which is located in the Semende Darat Ulu sub-district, Muara Enim Regency, South Sumatra Province, Indonesia. Located between 4° to 6° South Latitude and 104° to 106° East Longitude, this sub-district is located on the Bukit Barisan plateau, Plakat Village is one of the villages in Semende Darat Ulu District. It is located at an altitude above 1,420 m above sea level and is located on one of the Barisan hilltops, at a distance of 20 km from the district capital and 112 km from the district capital, Muara Enim. The area of the village reaches 12,000 ha. This village has the potential for micro hydro power plants by utilizing the Enim River which is an estuary or river headwaters in Plakat Village to be used by Plakat Village residents to meet their daily needs. The analysis stage is carried out by calculating and analyzing the micro-hydro potential in Plakat Village.

Figure 1 Plakat village

Figure 2 Tributary of the Enim River

3. Results and discussion

3.1. Falling water height

The effective fall height is obtained by calculating the energy loss. In the initial planning, it was taken that the energy loss of 10% would be the initial assumption.

$$H_{available} = upstream \text{ elevation } - downstream\ elevation$$

$$H_{available} = 1370 \text{ m} - 1341 \text{ m}$$

$$H_{available} = 29\ meters$$

Where the energy loss:

$$H_{loss} = 10\ \%\ H_{available}$$

$$H_{loss} = 10\ \%\ x\ 29\ m$$

$$H_{loss} = 2.9\ meters$$

So the effective fall height:

$$H_{\text{effective}} = H_{available} - H_{loss}$$

$$H_{\text{effective}} = 29\ m - 2.9\ m$$

$$H_{\text{effective}} = 26.1\ meters$$

3.2. Intake channel identification

The intake channel functions to control the water that will flow into the carrier channel. The recapitulation of the intake canal can be seen in Table 1. And the condition of the intake canal can be seen in Figure 3.

Table 1 Intake Channel identification

Parameters	Value	Unit
Height	0.85	m
Width	0.48	m

Keynote: m = meters

Figure 3 The condition of the intake

3.3. Forebay identification

The forebay functions to control the flow of water in the penstock during load fluctuations, calm the flow of water before it enters the penstock, as well as the final filter for waste and solid particle deposits so that it does not enter the turbine. The condition of the forebay can be seen in Figure 4. And the recapitulation of the forebay can be seen in Table 2.

Figure 4 The condition of the forebay

Table 2 Forebay identification

Parameters	**Value**	**Unit**
Length	2	m
Width	3	m
Height	2	m

Keynote: m = meters

3.4. Pipe penstock identification

Penstock is the connecting channel between the forebay to the turbine. This pipe is designed to be able to withstand high pressure. The recapitulation of the penstock pipes can be seen in Table 3. And the condition of the penstock pipes can be seen in Figure 5.

Table 3 Pipe penstock identification

Parameters	**Value**	**Unit**
Diameter	0.5	m
Length	184	m

Figure 5 The condition of the pipe penstock

3.5. Flow discharge calculation

Based on measurement discharge data carried out on the tributary of the Enim River in Plakat Village, Semende Darat Ulu District, Muara Enim Regency, South Sumatra, the water discharge is 180 liters/second. Flow speed is calculated by:

$$V = 0.125 \text{ x } \sqrt{2xgxH_{effective}}$$

$$V = 0.125 \text{ x } \sqrt{2x9.81x26}$$

$$V = 2.8 \text{ m/s}$$

3.6. Energy loss estimation

In the course of water flowing from the intake door to the penstock, energy loss will occur:

3.6.1. Loss of energy due to coarse filter

$$H_r = \varphi \; x \; (\frac{s}{b})^{\frac{4}{3}} - \frac{v^2}{2g} sin\alpha$$

$$H_r = 1.67 \; x \; (\frac{0.01}{0.05})^{\frac{4}{3}} - \frac{2.8^2}{2 \; x \; 9.81} \sin 70$$

$$H_r = 0.183 \text{ x } 0.375$$

$$H_r = 0.06 \; m$$

3.6.2. Entrace Loss of energy at the entrance

$$H_e = K_e \; x \; \left(\frac{V^2}{2g}\right)$$

$$H_e = 0.05 \; x \; (\frac{2.8^2}{2 \; x \; 9.81})$$

$$H_e = 0.01 \; m$$

3.6.3. Loss of energy in friction along the penstock

$$H_f = f \frac{l}{D} \; x \; \left(\frac{V^2}{2g}\right)$$

$$H_f = 0.015 \frac{x184}{0.5} \; x \; (\frac{2.8^2}{2 \; x \; 9.81})$$

$$H_f = 2.2 \; m$$

3.6.4. Loss of energy due to rapid pipe bends

$$H_I = K_b \; x \; \left(\frac{V^2}{2g}\right)$$

$$H_I = 0.025 \; x \; (\frac{2.8^2}{2 \; x \; 9.81})$$

$$H_I = 0.01 \text{ m}$$

From several calculations of the energy loss factor in the penstock, it can be seen that the total energy loss is:

$$H_{total} = H_r + H_e + H_f + H_I$$

$$H_{total} = 0.06 \; m + 0.01 \; m + 2.2 \; m + 0.01 \text{ m}$$

$$H_{total} = 2.28 \; m$$

This value is smaller than 10% of the H_effektif is 26.1 m so that this plan can be used.

3.7. Analysis of the energy produced

From some of the data obtained, the water flow rate can be calculated as follows:

$$P = \rho \text{ x g x Q x H}$$

P = 1000 x 9.81 x 0.18 x 26

P = 45910. 8 watt

P = 46 Kw

With the efficiency used:

Turbine efficiency 〖(η〗_t)=0.87

Generator efficiency 〖(η〗_g)=0.95

Toransformator efficiency 〖(η〗_tr)=0.95

So the total efficiency used is:

$$\eta_{total} = \eta_t \; x \; \eta_g \; x \; \eta_{tr}$$

$$\eta_{total} = 0.87 \; x \; 0.95 \; x \; 0.95$$

$$\eta_{total} = 0.78$$

Then the total power is:

$$P_{total} = P \; x \; \eta_{total}$$

$$P_{total} = 46 \; x \; 0.78$$

$$P_{total} = 35.88 \; Kw$$

From the calculations that have been made, the total power obtained is 35.88 Kw. When compared with data on the results of turbine work in the field which has a generating power of 35 Kw, it is the same as the calculated power. The total power of 35 Kw is used by the residents of Plakat Village to meet their electricity needs.

Table 4 Results of overall calculation

Parameters	**Value**	**Unit**
Height Effective ($H_{effective}$)	26.1	m
Intake Channel (H x W)	0.85 x 0.48	m
Forebay (L x W x H)	2 x 3 x 3	m
Pipe Penstock (D x L)	0.5 x 184	m
Flow Discharge (V)	2.8	m/s
Energy Loss (H_{total})	2.28	m
Energy Total (P_{total})	35.88	Kw

Keynote: m = meters, m/s = meters/sec, kW = kilo Watts

4. Conclusion

From the analysis results, the design of the micro hydro in the Enim River Plakat Village is as follows: pipe dimensions 184 m, rapid pipe thickness at least 0.5 m, effective energy height 26.1 m, runner and the output power are 35.88 kW.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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