Feasibility Study of Micro Hydro Power Plant in Oboi River, Tutuling Village, East Halmahera Regency

Z K Misbah, M Rizal*, & R S M Sahril

Department of Civil Engineering, Faculty of Engineering, Universitas Khairun, Ternate, North Maluku
*Email: adams.rizal@yahoo.co.id

Abstract. Restricted electricity is one of the resistors in improving development and empowering communities, especially in rural areas. The utilize of MHP as an alternative energy because its cost friendly, user friendly, environmentally friendly, and material friendly. Those are expected to be the proper solutions to overcome inadequate accessibility of rural communities, such as in Tutuling village, East Halmahera Regency. This study uses the frequency distribution method and is tested using a probability test to calculate rainfalls. The buoy method for calculating river discharge and Rational method for calculating flood discharge known as Flow Characteristic to calculate the mainstay discharge while Geometric Method aims to calculate the Projection of Population Amount. Based on the results of the research and analysis of calculations on the Feasibility Study of Potential Micro Hydro Power Plants in the Oboi River. It can be concluded that the river discharge available at MHP in Tutuling Village $Q_{river} = 2,3171$ m$^3$/sec with reliable discharge $Q_{reliability} = 2.2545$ m$^3$/sec and effective fall height ($Head$) $H = 30$ meters with the amount of power generated by $P_{net} = 219.2342$ kW. The total number of houses that have been electrified is 894 houses. Moreover, finding how many houses that capable of being raised in the future for about 2 decades ahead is the ultimate aim of this research. As a result, the calculated population is projected to address the number of households (houses), which likely to electrified for over 20 years to come is approximately 661 households.

Keywords: Micro Hydro Power Plant, Stream Flow.

1. Introduction
Electric energy has a vital role in the varied attempts that have been conducting to improve the quality of life and economic growth in Indonesia. Inadequate electricity supplied is one of the challenges for improving development and communities, especially in rural areas. The use of MHP as an alternative energy that is cost friendly, user friendly, environmentally friendly, and material friendly are expected to be even greater use as a solution for addressing the lack of accessibility in rural communities to MHP that can be developed as renewable energy sources[1]. High electricity expense (in some certain areas) can create social changes and economic income, including changes in behavior patterns and patterns of interaction of local people. Micro Hydro Power Plant (MHP) is the small scales power plant (less than 500 kW), which utilizes water (flow) as a source of energy production. MHP is a renewable energy source and deserves to be well-known as clean energy because it is environmentally friendly. In terms of technology, MHP was selected due to its simple construction that easy to operate, maintain and provide spare parts. Economically, the operation and maintenance costs are relatively cheap, while the investment costs are quite competitive with other power plants. Socially, State Electricity Company stated that they some difficulties to supply sufficient electricity needs for both
nationwide and regionally. Moreover, in some parts of East Halmahera still have insufficient electricity. Specifically, in Tutuliung, people cannot access the electricity for 24 hours, one of the hamlets within a far distance at about 5 kilometers from the main Tutuling Jaya road, reaching 50 of 100 homes utilizing electricity that provided by SEC. But none of each house could access electricity normally. Ironically, even though they could not get good standard service from State Electricity Company, they still have to pay the same as its normal cost. As a consequence, people find difficult challenges to carry out their daily activity and works. Meanwhile, Oboi river is one of rivers which has enormous of water resources and it can be used as a source of electrical energy, either a micro scale. This huge source can be utilized to develop a Micro Hydro Power Plant (MHP), for supporting the economic income in rural areas. As required by geomorphological and hydrological characteristics, the role of electricity is very promising. Therefore, one of the appropriate choices is to develop a Micro Hydro Power Plant (MHP).

2. Fundamental Theory

2.1. Hydrological Analysis

Hydrological Analysis aims to determine the average rainfall occurring in the catchment area which has an effect on the magnitude of the current river discharge. The daily rainfall data will then be processed into a planned rainfall data to be processed into a planned flood discharge. Daily rainfall data is obtained from several stations around the location of the planned dam, where the station is included in the river basin. Micro Hydro Power Plant (MHP) planning is very dependent on the water flow of the river. The quantity of running water speed determines the capacity of the MHP. Water discharge in a river is influenced by several factors such as rainfall and catchment area around the river. Through hydrological analysis, reliable discharge is obtained while Mainstay discharge is used to calculate the potential of a location.

2.1.1. Mainstay Debit

Debit is a debit available throughout the year with a certain risk of failure. According to observations and experience, the magnitude of the mainstay discharge for various purposes is as below:

- Drinking water: 99% (often close to 100%)
- Industry: 95% - 98%
- Irrigation: Half moist: 70% - 85%, Dry: 80% - 95%
- Hydroelectric Power: 85% - 90%

For hydropower, 97.30% is generally used because in 1 year turbines and generators usually experience engine over half by 10 days. Thus, within 1 year hydropower plants operate effectively for 355 days.

2.1.2. Measurement of river discharge

There are many methods of measuring water discharge. Large-scale water energy conversion systems measuring discharge can take years. Whereas for small scale water energy conversion systems the measurement time can be shorter, for instance, it requires several different seasons only

\[ Q = AxV \]  

(1)

2.2. MHP

Micro Hydro Power Plant is a small-scale power plant (less than 500 kw), which utilizes water flow power as a source of energy products. MHP is a renewable energy source and deserves to be called as a clean energy because it is environmentally friendly. Hydroelectric power comes from streams of small rivers or lakes that are in dams and then from a certain height has an appropriate discharge that will drive the turbines that are connected to an electric generator. The higher water fall, the greater the potential energy of water can be converted into electrical energy.
Table 1. Micro Hydro Power Plant in Indonesia

| Generation System          | Output   | Effective Head | Water Discharge |
|----------------------------|----------|----------------|-----------------|
| Cross-flow Turbine System  | 10 ~ 200 Kw | 4 ~ 50 m       | 100 ~ 800 l/sec |
| Pumps as Turbine Systems   | Up to 10 Kw  | 10 ~ 40 m      | 5 ~ 100 l/sec   |

2.3. Projection
Projection is a method used to estimate population in the future based on the basis of residents expansion from year to year. There are several approaches (methods) for estimating population growth rates, the basis of which is to solve problems by conducting a study of prior data.

3. Methodology of Research

3.1. Location and Time of The Research
Location of the study was conducted in Tutuling Jaya Village, East Wasile District, East Halmahera Regency. Geographically, through astronomical location is in the equator line and the tropical climate only has two seasons wet and dry seasons.

3.2. Data Collection Techniques
There are two retrievals data that are collected so that each decision will be implemented efficiently. The data obtained in the form of:

3.2.1. Primary Data
Data is obtained from observations, which are direct observations of the research location and research subjects. Primary data collected are:

- Data on high water fall (effective head)
- Data of river discharge

3.2.2. Secondary Data
Data is obtained from related parties / agencies to complete and simplify the process of conducting research, including:

- Data on the number of people
- Data on the number of housing
- Data on the number of public facilities
- Data rainfall
- Statistical data

4. Result and Discussion

4.1. Water Debit
The experimental work on this water debit especially in measuring directly at the location. The basic principle of the implementation of the measurement of discharge is measure of cross-sectional area wet, the speed of water flow and the dept of river at points that had already been fixed at a distance of a cross section 10 meters.
Table 2. Calculation of river discharge in the dry season

| No | Cross Section | Speed (V) | Cross-Area (A) | Debit (Q)     |
|----|---------------|-----------|----------------|---------------|
| 1  | Point A       | 0.8513    | 1.76           | sectional1.4982 |
| 2  | Point B       | 0.3982    | 2.73           | 1.0872        |
| 3  | Point C       | 0.5128    | 3.03           | 1.5538        |
|    | TOTAL         |           |                | 1.3798        |

From the calculation results obtained river discharge for the dry season (Q) = 1.3798 m³/sec

Table 3. Calculation of river discharge in normal season

| No | Cross Section | Speed (V) | Cross-Area (A) | Debit (Q)     |
|----|---------------|-----------|----------------|---------------|
| 1  | Point A       | 0.9413    | 2.53           | sectional2.33815 |
| 2  | Point B       | 0.4415    | 3.41           | 1.5054        |
| 3  | Point C       | 0.5627    | 3.52           | 1.9806        |
|    | TOTAL         |           |                | 1.9558        |

From calculation results obtained river flow for normal season (Q) = 1.9558 m³/sec

Table 4. Calculation of river discharge in the rainy season

| No | Cross-section | Speed (V) | Cross-Area (A) | Debit (Q)     |
|----|---------------|-----------|----------------|---------------|
| 1  | Point A       | sectional1.1487 | 4.06 | 4.6637       |
| 2  | point B       | 0.4853    | 5.49           | 2.6641        |
| 3  | point C       | 0.6554    | 5.37           | 3.5195        |
|    | TOTAL         |           |                | 3.6157        |

From the calculation results obtained for the rainy season the river discharge (Q) = 3, 6157 m³/sec

Table 5. Recapitulation of river discharge calculations for all seasons

| No | Season | Debit (Q) |
|----|--------|-----------|
| 1  | Dry    | 1.3798    |
| 2  | Normal | 1.9558    |
| 3  | Rain   | 3.6157    |
|    | Average| 2.3171    |

From the calculation results obtained an average river flow (Q) = 2.3171 m³-90³/sec

4.2. Dependable Flow
The size of Dependable Flow for MHP is 85-90% but in generally used opportunities 97.3% because in a year Turbine and The Generator will overhaul for 10 days.
4.2. The Output
From the result of survey taken in surrounding communities on the use of electricity by local communities, this could be planned for home unit use to be seen at table 7.

Table 7. Electricity Plans

| Porch          | 25 |
|----------------|----|
| lamps Livestock| 10 |
| lights Room lamps bath | 15 |
| well           | 10 |
| light Main room | 20 |
| lights Kitchen | 20 |
| lamps Parental | 20 |
| bedroom lamps Child bedroom lamps | 15 |
| TV             | 110|
| Total          | 245|

Table 8. Recapitulation of potential rise power

| No. | Debit            | H   | Eo   | Pnet     | Power Revive (House) |
|-----|------------------|-----|------|----------|----------------------|
|     | (m³/sec)         | (m) |      | kW       | Watt                 |
| 1   | River Discharge  | 2.3171 | 30 | 0.3218 | 219.2342 | 219234 | 894 |

From the recapitulation results, it is planned that in each Head of the Family the electricity supply will be 245 watts. So that the number of homes that are electrified is 894 houses out of 452 in the village of Tutuling district. East Halmahera.

4.4. Projection
Projection is a method used to estimate the population in the future on the basis of conditions of population development from year to year.

Table 9. Recapitulation of the Number of member (houses) of Tutuling Village, taken from the Geometric method

| No. | Years | Member of (houses) |
|-----|-------|--------------------|
| 1   | 2011  | 259                |
| 2   | 2012  | 266                |
| 3   | 2013  | 273                |
| 4   | 2014  | 280                |
| 5   | 2015  | 287                |
| 6   | 2016  | 295                |
| No. | Years | Member of (houses) |
|-----|-------|-------------------|
| 7   | 2017  | 302               |
| 8   | 2018  | 310               |
| 9   | 2019  | 318               |
| 10  | 2020  | 326               |
| 11  | 2021  | 335               |
| 12  | 2022  | 343               |
| 13  | 2023  | 352               |
| 14  | 2024  | 361               |
| 15  | 2025  | 370               |
| 16  | 2026  | 380               |
| 17  | 2027  | 390               |
| 18  | 2028  | 400               |
| 19  | 2029  | 410               |
| 20  | 2030  | 421               |
| 21  | 2031  | 432               |
| 22  | 2032  | 443               |
| 23  | 2033  | 454               |
| 24  | 2034  | 466               |
| 25  | 2035  | 478               |
| 26  | 2036  | 490               |
| 27  | 2037  | 503               |
| 28  | 2038  | 516               |
| 29  | 2039  | 529               |

From the recapitulation results are planned in one household (house) containing 5 people, then the results of the projected population in the next 20 years or in 2039 produce the number of households (house) of = 529 households (house) home). Additionally, in one head of each family gets an electricity supply of 245 watts. Moreover, the number of houses that received electricity supply from PLTMH was 894 out of 452 houses in Tutuling Village, East Halmahera Regency. Whereas from the calculation of population projection, for the number of HHs (houses) that can be generated in the next 20 years or in 2039 with the resulting power output that is Pnet = 219234 Watt, can still supply electricity in the next 20 years with the number of HHs (homes) ) = 529 households (houses).

5. Conclusion

Based on the measurement results in the Oboi river, it was obtained \( Q = 2,3171 \text{ m}^3/\text{sec} \) and the effective height \( (\text{Head}) \) with direct measurement was 30 meters. Hence, it can be feasible for MHP. From the calculation of discharge and measurement of effective fall height \( (\text{Head}) \) in this study, the output of power generated, \( P_{\text{net}} = 219234 \text{ Watt} \). Thus, the number of houses that get electricity supply from MHP is 894 houses and from the calculation of population projections, the number of households (house) that can be possibly raised in the next 2 decades, with a number of 661 households (houses). Result in the output power generated can still supply electricity in that year.

6. Reference

[1] A. M. Dimyati, “Study og the potential of Micro Hydro-Power Plant in the Village of Wonogiri District,” vol. 15, no. 02, pp. 1–10, 2003.
[2] H. Djafar, L. M. Limantara, and R. Asmaranto, “According to a Comparative Evaluation of flood and Historical Hydrograph Analysis.”, 2014.

[3] H. Soekarno, M. P.-K. dan Energi, and U. 2016, “The discharge of Hydro Micropower Plant by The Method of TURC and Solomon (Case Study: MHP Puppuring, Alu District)” ketjurnal.p3ktebt.esdm.go.id, 2011.

[4] SNI 8397:2017, “Guide for the feasibility study of Micro Hydro Power Plant (MHP),” BSN, 2017.