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# Feasibility Analysis of Micro Hydro Development in Abenaho District, Papua, Indonesia

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***Abstract****—This study investigates the feasibility of the location for the construction of a micro-hydro power plant in Landikma Village, Abenaho District, in relation to the district government's plans. The specific objectives of this study are to determine the potential location of a power plant based on the applicable technical principles, as well as to compile a feasibility study for the construction of a micro-hydro power plant to support lighting/electricity services. The survey method was applied to identify the description of the existing conditions, with reference to the criteria for power plant development. Data analysis was carried out using quantitative and qualitative methods. Based on the research results, the power plant construction site in Landikma Village, Abenaho District, Yalimo Regency meets the eligibility to build a 177kW power plant. The river discharge at the location of the development plan is 0.950 $m^3/s$, so the result of calculating the potential electric power generated by the power plant is 326.2 kW. This electrical energy is capable of meeting the lighting needs of 521 houses, assuming that each house gets 450 watts of electric power. Strategic environmental studies need to be carried out to ensure that this development does not have the potential to cause negative impacts on the environment. The power plant development process must also be accompanied by a comprehensive Detail Engineering Design (DED). In addition, local communities must also be involved in the process of reviewing the development, evaluation and supervision to ensure the sustainability of development and the sustainability of natural resources around the power plant construction site.*

***Keywords****—Feasibility Study, Power Generation, Micro Hydro, Turbine.*

## I. Introduction

Natural resources in Indonesia is currently undeerutilized in some region. Indonesia is endowed with a lot of new, renewable energy. According to the data, these resources have a total potential of 441.7 GW, but currently only around 8.89 GW have been built (Wardani, 2017). Indonesia has the potential for water energy reaching approximately 75 GW (16.98 percent of the total potential of renewable energy), while currently 5,124 GW have been built by the hydroelectric power center (Ferial, 2014). Indonesia has abundant potential for renewable energy resources, including wind, solar, water, geothermal and biomass. For water resources, Indonesia has great potential based on Indonesia's geographical conditions which have many rivers and topography consisting of hills to mountains (Ma'Ali, 2017).

Electricity is a crucial need for almost every human activity. But for now, there are still remote areas that have not enjoyed electricity supply, therefore the government continues to strive to build s on a large or small scale (Nasrul, 2016). Nowadays, electricity needs continue to increase in line with economic growth, population growth, and development growth. Based on data from the State Electricity Company, there is an increase in national electricity demand by 8.5% per year. This increase, if not followed by the provision of s, could potentially lead to an electricity crisis which in turn could affect national economic growth. This is because the need for electrical energy has become a basic need not only for the community but also for companies that are one of the driving forces of national economic growth. (Ma'Ali, 2017).

Yalimo District in Papua, Indonesia is a mountainous area that has abundant water sources and is included in the Mamberamo Watershed area. In general, areas in the Central Highlands Regency of Papua have a lot of potential for water resources, so it is very possible to use it to generate electricity, as is the case in Landikma Village, Abenaho District, Yalimo Regency.

Micro-hydro is a small-scale installation that uses water power as its driving force such as irrigation canals, rivers or natural waterfalls by utilizing the height of the waterfall (head) and the amount of water discharge. In other words, micro-hydro is a that utilizes water as the main power to produce electricity. Micro hydro is a name with two word elements, namely micro means small while hydro means water (Dwiyanto et al., 2016).

The development of Micro-hydro is suitable for application in highland and mountainous areas which have very abundant natural water sources and always flow through many rivers which are rarely dry all year round. The river flow which has a height can also be used as a Micro-hydro . This is very beneficial because Micro-hydro can be a solution for rural electricity, especially in the highlands and mountains which are generally difficult to reach by the national company of electricity power lines. In addition, Micro-hydro is also an environmentally friendly technology that has minimal emissions and pollution. Thus, the use of renewable resources is expected to reduce the rate of global warming which continues to increase throughout the time.

The principle of micro-hydro operation is to channel water through a penstock into a powerhouse which is generally built on the banks of a river to drive a turbine or micro-hydro water wheel. Mechanical energy that comes from the rotation of the turbine shaft will be converted into electrical energy by a generator. A hydro is a form of changing power from hydropower with a certain height and discharge into electric power, using a water turbine and generator. The forms of micro-hydro s vary, but the working principle is the same, namely the change of potential energy into electric energy (electricity). The potential energy itself is water power because it is at a height. Kinetic energy is water power because it has speed. Mechanical power is the speed of water that continues to rotate the turbine.



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Electric power is the result of a generator that rotates due to the rotation of the turbine.

The assessment of river feasibility is an initial activity to collect data and information about the possibility of a watershed to be used as a . From the results of the potential study, a conclusion can be obtained which is used as a material consideration for determining the sustainability of the power plant planning study. If one region has several potential locations for power plant. According to Kurniawan et al. (2009), a river is suitable as a location or placement of a micro-hydro  if it has the following characteristics:

1. Availability of water is guaranteed
2. Small water discharge fluctuations
3. The biggest flood that has ever happened does not have the potential to damage the components of the power plant
4. The effect of flow on river or canal erosion can be minimized technically
5. The location of the exhaust and spillway channels does not harm the surrounding environment.

Meanwhile, Damanik (2009) emphasizes that the selection of a  placement location must consider the following criteria:

1. The length of the distribution network if using low voltage the generator distance to the load, the maximum radius is 2 km
2. There are potential consumers around the generator
3. The electric power potential does not exceed 100 kW
4. Availability of river water flow throughout the year
5. Access to the  location can be reached or can be reached with inexpensive technology
6. The location of the  is not in a nature reserve area, does not damage the environment and culture and complies with applicable regulations.

This study examines the feasibility of the location for the construction of a micro hydro  in Landikma Village, Abenaho District, in relation to the district government's plans. This study considers the importance of the need for lighting for the people of the Abenaho district, so that the Yalimo district government through the housing and area management agency plans to build a Micro-hydro . Specifically, this research has two objectives, namely determining the potential location of a Micro-hydro based on the applicable technical principles, and preparing a feasibility study for the construction of a Micro-hydro  to support lighting/electricity services. The output of this research will benefit the local government and local communities in Yalimo District, Papua. The local government plans to build a Micro-hydro  on one of the rivers in Kampung Landikma. The discharge potential of the existing  can generate electricity with a power of 326.2 kW.

## II. Method

This research was conducted in Landikma Village, Abenaho District, Yalimo Regency, Papua (Figure 1). The survey method was applied to identify the description of the existing conditions, with reference to the criteria for power plant development. Furthermore, the data obtained can be analyzed based on the civil and mechanical-electrical building components of the power plant. Primary data in this study include river specifications such as river body width and cross-sectional area, river water discharge, and head of the dam. Meanwhile, secondary data includes location maps, population numbers, rainfall, and other supporting data needed in the analysis of this study. Data analysis was carried out using quantitative and qualitative methods. Quantitative analysis, for example, is in calculating river water discharge, while qualitative analysis is carried out in the analysis of existing and environmental baselines. Furthermore, the mechanical equipment of the power plant includes turbines, where the type is determined based on the relationship between the design discharge and the head. Electrical equipment consists of a generator, control panel and ballast load. Determination of electrical equipment is carried out by referring to the technical guidelines for MHP equipment and components.

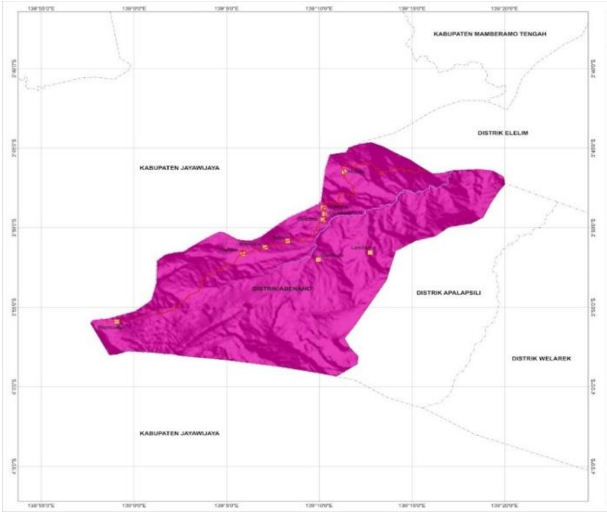


Fig. 1. Research location

## III. Results and Discussion

### A. Existing and Environmental Analysis

A micro-hydro  is planned to be built on the river of Kampung Landikma, Abenaho District, namely by utilizing a source of raw water that has great potential to generate electrical energy. Access to the power plant planned location can be reached from Yalimo Regency with relatively good road conditions.

Fig. 2. The condition of the river for  development



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Overall, the state of the natural environment is mostly mountains which are still very natural and beautiful. Based on natural elements, the condition of the watershed in the planned location is directly adjacent to the community's plantation or agricultural area and some of it is still classified as secondary forest. The condition of the soil or the type of soil around it is alluvial soil which is gray to brown in color and textured and clay-shaped and easily absorbs water, thus it can be noted that the water is clear.

The topography around the site generally consists of quite steep rocks. This shows that the soil structure is not soggy. As for the characteristics of the river, according to its flow pattern, it is permanent/does not change, because the community's activities are still limited to gardening in relatively small quantities so that it does not affect the flow pattern of the river. However, in order to maintain and minimize risks that may occur in the future, talud must be built along the river to prevent erosion and flooding during high rainfall (rainy season). In terms of soil quality, Yalimo Regency is a large area that is very fertile, making it suitable for various types of agricultural commodities that can be developed without chemical fertilizers.

Analysis of the existing conditions and environmental baseline resulted in identifying the strengths and weaknesses of the power plant construction site. Specifically, it is explained as follows:

TABLE I. Pros and cons of development in research location

| Pros (+) | Cons (-) |
|---|---|
| 1. Abundant water resources<br>2. Power plant does not produce waste and pollution<br>3. Development of power plant as well as educating the public regarding the use of natural resources<br>4. Increasing the economy and social welfare<br>5. Support community empowerment<br>6. Can be synergized with agricultural irrigation or aquaculture<br>7. Maximizing the function of the catchment area<br>8. Simplicity of technology and ease of operation | 1. Lack of outreach to the community regarding development programs<br>2. The electric power generated is limited<br>3. The location of the construction is quite far from settlements or target consumers<br>4. The community's assumption that electricity from the power plant can be obtained free of charge<br>5. Requires a fairly high investment cost |

### *B. River Feasibility Analysis*

The first analysis to be carried out is the feasibility of the river to serve as a power plant placement point. Analysis of the feasibility or potential of the river in this study was based on the criteria set by Damanik (2009) and Kurniawan et al. (2009). Based on literature studies and field observations, the location of the planned power plant placement in Landikma Village, Abenaho District, Yalimo Regency has the following qualifications:

1. Have sufficient water discharge
2. There is a large fall height
3. Topographical conditions that allow for the placement of building facilities
4. Located not far from the service area
5. Does not affect the existing irrigation system

Fulfillment of the specifications above makes the river in Landikma Village, Abenaho District, Yalimo Regency meet the eligibility to be used as a micro-hydro placement point. In order to be more mature, the analysis must be carried out by calculating the river water discharge and calculating the potential electric power that can be generated by the river.

### *C. Water Discharge Analysis*

The discharge analyzed in this study is field measurement discharge, namely to determine the potential of river flow in generating electrical energy. The method used to measure water discharge is the floating method. The channel width in this study was 2.20 m with an average channel depth of 0.54 m. Thus, the cross-sectional area of the channel is 1.192 m2. Furthermore, the long distance of the floating track is 3 m. Then the water flow velocity is obtained at 0.797 m/s.

The water discharge value can be obtained by multiplying the river flow velocity (v) with the cross-sectional area of the river (A). The calculation results show that the river water discharge is 0.950 m3/s, with a head from the dam to the powerhouse of 50 m. This fall height will later be corrected again with design factors and efficiency factors so that the effective fall height can be obtained. The following is a table of summary data for calculating river water discharge in Landikma Village, Abenaho District, Yalimo Regency. More specifically, the calculation of the analysis is explained mathematically as follows:

TABLE II. Data and calculation of the cross section of river

| Measurement | 1 | 2 | 3 | 4 | 5 | 6 | Mean |
|---|---|---|---|---|---|---|---|
| River depth (meter) | 0,50 | 0,47 | 0,53 | 0,56 | 0,58 | 0,61 | 0,54 |
| River width (meter) | 2,20 | | | | | | |
| Cross section ($m^2$) | Mean of river depth x River width<br>0,54 x 2,2<br>1,1917 $m^2$ | | | | | | |

TABLE III. Data and calculation of water discharge

| Measurement | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Distance (m) | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 |
| Time (s) | 4,09 | 3,79 | 3,62 | 3,89 | 3,69 | 4,29 | 3,89 | 3,56 | 3,36 | 3,44 | 3,76 |
| Water current (V) | Distance x Time<br>3.00 : 3.76<br>0,7974 m/s | | | | | | | | | | |


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| | |
|---|---|
| Water discharge (Q) | Water current x Cross section<br>0,7974 x 1,1917<br>0,950 $m^3/s$ |

Micro-hydro s are very dependent on the discharge of water flowing in the river. In other words, the quantity of water determines the capacity of the to produce electricity. Water discharge is the first variable that determines the potential feasibility of a river to be used as a medium for power generation. The water discharge in a river is influenced by several factors, such as rainfall and the area of infiltration around the river. For this reason, a thorough hydrological analysis is needed. Hydrological analysis is also required for the calculation of the electric power potential.

### D. Electric Power Potential Analysis

Potential electric power or generated power (P) is calculated by multiplying several variables, namely the density of water (ρ), gravity (g), water discharge (Q), effective height (Heff), and efficiency (η). Field measurements show that the head from the dam to the power house is 50 meters. If the water discharge is 0.950 m3/s, then the electric power potential can be calculated as follows:

$P = \rho \cdot g \cdot Q \cdot Heff \cdot \eta$

$P = 1000\ kg/m^3 \cdot 9{,}81\ m^3/s \cdot 0{,}950\ m^3/s \cdot 50\ m \cdot 0.70$

P = 326.182,5 Watt

P = 326,2 kW

Furthermore, the selection of power rating on the generator (kVA) is as follows:

$S = P/\cos\phi$

S = 326,2/0,8

S = 407,75 kVA

Therefore, the water potential and head of the river in Abenaho District produce a power capacity of 326.2 kW / 407.75 kVA. The distance from the source of raw water to the nearest service area or settlement is approximately 200 m to 600 m. The electric power capacity of 326.2 kW is estimated to be able to illuminate approximately 521 houses and other supporting infrastructure, such as churches, schools, district offices, village offices, police stations and local health service centers (puskesmas).

In general, the results of field studies indicate that the location for the power plant construction has met the eligibility requirements. For this reason, development can be carried out by the relevant person in charge. The river which is planned as a power plant point in Landikma Village, Abenaho District, Yalimo Regency has a water discharge of 0.950 m3/s, so the result of calculating the potential electric power generated by the power plant is 326.2 kW. This electrical energy is capable of meeting the lighting needs of 521 houses, assuming that each house gets 450 watts of electric power. This conclusion applies if the construction implementer fulfills several obligations, such as conducting a strategic environmental assessment to ensure that the development does not have an adverse impact on the environment and natural resources at the construction site. This process certainly needs to involve the community as the party that is most familiar with the characteristics of the location.

## IV. Conclusion

This research confirms that the location for the power plant construction; Landikma Village, Abenaho District, Yalimo Regency, meets the eligibility to build a 177kW micro-hydro . This conclusion is based on several findings in the field. The river discharge at the location of the development plan is 0.950 m3/s, so the result of calculating the potential electric power generated by the power plant is 326.2 kW. This electrical energy is capable of meeting the lighting needs of 521 houses, assuming that each house gets 450 watts of electric power. Construction of this power station needs to be done with several considerations. Among other things, the central government and regional governments must carry out strategic environmental studies to ensure that this development does not have the potential to cause negative impacts on the environment. The power plant development process must also be accompanied by a comprehensive Detail Engineering Design (DED). In addition, local communities must also be involved in the process of reviewing the development, evaluation and supervision to ensure the sustainability of development and the sustainability of natural resources around the power plant onstruction site.

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