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Study of PLTMH development planning in Sasnek village Sawiat district, South Sorong regency West Papua province

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ABSTRACT

Electricity is needed by the whole society. Sasnek village is one of the villages located in Sawiat District, South Sorong Regency, West Papua Province. Sasnek village is very clear and inhabited around 100KK. This village has not been served by electricity until now. Micro-hydro power plants are small-scale power plants whose capacity presents between 100 W to 100 kW. This study will be used for loading stages with a 12 Volt DC power capacity, because it is one of the most efficient, young and safe ways. Measurement of air discharge, discharged by 2 liters/second from a measurement area of 5 m2 and an average air speed of 00.65 m/d. However, due to the condition of the river water flowing throughout the year in the sense of never dried, then used a correction factor of 0.75. Thus the flow that can be used is equal to 0.65 m3/d. Based on the analysis of the potential contained in Sasnek PLTMH, it can be calculated Distribution Grid sourced from Sasnek PLTMH is 10 KW.With the careful planning so that the results of its implementation will give a positive impact to be meeting the needs of electricity in the village and surrounding villages sasnek.

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1. INTRODUCTION

1.1. Background

Electrical energy is energy that can not be separated from public life. Activities and needs of people in their daily life can not be separated by the absence of electricity. Indonesia is a country that has many potential sources of renewable energy which has not been utilized optimally. The potential of renewable energy has been utilized mostly in the form of its river water tends to be discharged into the sea. Yet every kilometer of the river can be used as a source of energy to drive the micro-hydro power plants.

This renewable energy utilization can be optimized, especially in rural locations or villages, which are generally spread and also not possible to get a service grid. Because it is necessary to do some business that is to build a separate sendri plant from grid. One is a micro-hydro power plants as one of the national energy alternatives.

Through the concept of micro-hydro "Power Pal System", people in the village in the province of West Papua who have not enjoyed electricity can be met. This is a major reason for the limited supply of electricity power can be overcome. For the utilization of hydroelectric power plants are divided into three categories: large, mini, and micro. There are no clear provisions regarding the division of the scale. It seems that each country has different rules. However, in general, water power (hydropower) large scale has a capacity of over 10 MW. Mini capacity of 200 kW to 10 MW, and micro capacity of up to 200 kW [1]. Hydropower potential in Indonesia is theoretically estimated to be around 75,000 MW spread over 1,315 locations. Hydropower is a potential source of energy which is very large, but its use is still far below its potential. And the potential is estimated at 34,000 MW, could be developed for power plants with a large enough capacity, 100 MW [2].

Micro-Hydro Power Plant is one of the concepts of power plants that produced by small-scale hydropower [3]. Where through this concept, the water flow is slightly revised and meet the criteria of "Power Pal System" that will generate electricity, which then supply to consumers. The application of the concept of micro-hydro power, can be useful for people who live in the village and have a good enough water potential, thus providing a solution for the supply of electricity in the region. Through the concept of "power microhydro pal system ", people in the village who until now have not enjoyed minimal lighting or electricity can be met.

1.2. Formulation of the problem

Sasnek village is one of the villages located in Sawiat District, South Sorong Regency, West Papua Province. The village consists of ± 170 KK and is one of the remote villages, which until now have not been able to enjoy the use of electricity. So often people in this village feel the unfairness of the policy electrify PLN in Papua, because until now the village could not be energized electrical power source PLN. Sasnek Village have three (3) waterfall flow sources, which basically have the capacity if used to generate electricity [4-5]. This is the main reason for researchers to be able to contribute knowledge by conducting studies and studies on the development of PLTMH in the Sasnek village, Sawiat District South Sorong Regency, West Papua Province. The results of this study will be used as the material implementation of PLTMH development in the village. This study will assess the maximum limit,

1.3. Purpose and objectives

The purpose and objective of this study is to study planning in setting up a system of electrical energy by utilizing the potential water energy available in Sasnek Village, located in the Sawiat District, South Sorong Regency, West Papua Province. So that in the future implementation of the PLTMH construction, can provide direct benefits to the village Sasnek, in order to increase economic productivity and the survival of the Sasnek village communities.

2. THE PURPOSED METHOD

The method used in this study is the measurement of water flow [6], by measuring the river surface area, and the speed of the river flow. To obtain the area can be calculated using the following formula:

$$X_{average} = \frac{\sum x}{n} \tag{1}$$

So that

$$A\ (Area) = X_{average}\ x\ L \tag{2}$$

Whereas for river speed measurement (v), previously calculated the average travel time with the formula as follows:

$$t_{average} = \frac{\sum t}{n} \tag{3}$$

so v is obtained: (t_0 – t_1)

$$v = \frac{s}{t_{average}} \tag{4}$$

Where *s* is the distance of the river.

After the area and speed of the river are known, the amount of discharge in the river is calculated by the following formula:

$$Q = A\ x\ V\ \ (m^3/sekon) \tag{5}$$

While to increase the electrical power produced by the MHP in this study the researchers used the method of increasing head height. The application is by damming the upstream of the river by building a small dam, so that the total fall height (head) of the plant installation system can be increased, and how much the height of the fall (head) can be increased depending on the size and height of the dam that was built.

3. RESEARCH METHOD
3.1. Stages Research
Stages performed in this study is described in the flowchart in Figure 1.

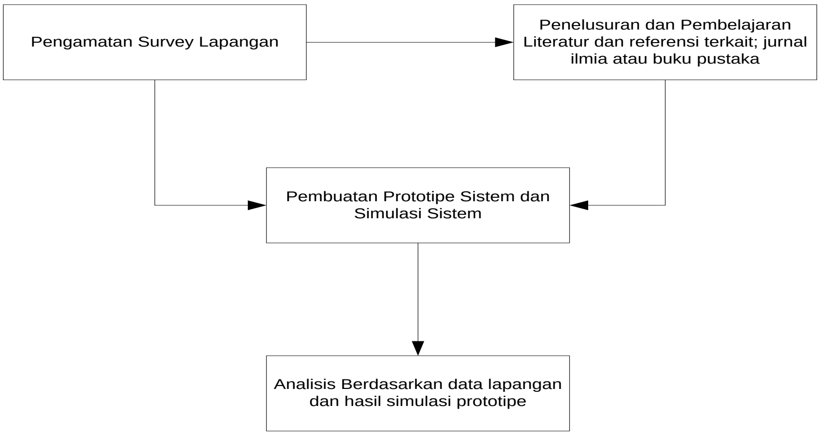

Figure 1. Flow Research

3.2. Research sites
The location of this research take place Sasnek Village Sawiat District South Sorong Regency, West Papua Province, where this village has a number of about 170 kk.

3.3. Prototype Design of PLTMH
The following design prototype design of PLTMH shown in Figure 2.

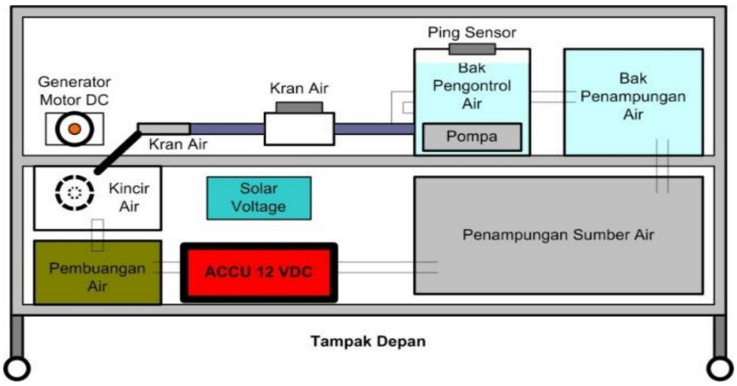

Figure 2. The design of the prototype design for PLTMH

To design the prototype of PLTMH used as a water pump pressure (like a waterfall), water as a source of energy, turbine and dynamo DC. Following the steps of the design of the prototype [7-9].

3.3.1. Design Layout
Design the location or position of pumps, turbines, DC motors, batteries, inverter and the load. Board modules that will be used as a place to put circuits made of mica and iron measuring 3 x 3. The size of the mica board as a series laying container and iron box as a frame work table is as follows:

Table of iron box = 50 x 100cm
Long Boards Mika = 100 x 50 cm
Width Boards Mika = 50 x 100cm
high Board Mica = 100 cm

3.3.2. Design Place

The design of the prototype container is made in two parts in the form of boxes/cabinets, namely [10-15]:

Block I / Floors 1: Consists of Bak precipitator, Valae control 1, the channel carrier, Valve control 2, like tranquilizers, rapid pipe (penstock), DC 12 Volt alternator dynamo, arduino control system and the motor driver, as well as the height of the sensor measuring circuit water level.

Block II / 2: Sump water, aquarium pump engines, Accu, dap pump turbine engines and auxiliary motor.

For the control circuit will be installed separately on a module using mica, the control circuit, shown in Figure 3, consists of the components of the electrical panel.

Figure 3. Control circuit

4. RESULT AND DISCUSSION

4.1. Regional Placement Location

Locations PLTMH being on the river, located in the village Sasnek Sasnek, PLTMH Sasnek obtained by utilizing the height difference (head) and flow rates of the river, where the river sasnek River is one of the region Kampung Sasnek, Sawiat District.

4.2. Socio-Economic Conditions

4.2.1. Community Livelihood

Livelihood of the people can be divided into two groups of people living in the capital districts and communities living around the suburban capital of the district. People living around the capital, in general there who worked as a civil servant, seasonal traders and fishermen. While people living in rural areas in general, farmers, ranchers, fishermen etc. The average income of people who work as farmers and ranchers and nelayanper average day 100,000, - 250,000 per household, while others variation according to their own profession.

4.2.2. Infrastructure Condition

The area of infrastructure development in the District Sawiat, as indicated by the increase in people's houses, besides followed by the development of supporting facilities such as road repairs and so forth. It occurs significantly after the establishment of the District Sawiat.

4.2.3. Electrification Conditions

Eletrifikasi conditions in the study area until time the electricity is not yet available permanen. As for electrity in the study area only from the generator (genset) and Solar Cells owned by individuals or groups scarecrow / specific oraganisasi. It cause meeting electricity needs in the study area is the main requirement, which until now has not been perceived by the public. The existence of the electrical energy produced by the generator are individually owned experiencing problems in operation, otherwise it will not be able to operate for 24 hours, the high price of fuel oil in the region, reaching Rp. 22,000, - 25,000 per liter, is a major obstacle to the electrification conditions in this region, in addition to the issue of accessibility.

4.3. Hydraulic Potential and Plant Capacity

4.3.1. Water Discharge Measurement

The area around the location of the PLTMH are in areas that have a fairly high level of rainfall [16]. Additionally, supported by the local community information that existing river flows throughout the year, so that the availability of water is maintained. To find out how big the river flow measurements [17-19]. The first step is to choose the location of the measurement taking into account the criteria for discharge measurements, once the location of the measurement followed by measurement of river water discharge.

4.3.2. Different High Measurement

The height difference is measured by using a Handheld Level and Analog Altimeter which has a high accuracy rate. Head count of the water level in the tub recana tranquilizers (forebay) to the level of water in the home plan generator (power house), the importance of the size of the head is 3 meters.

4.3.3. Hydraulic Potential

Hydraulic potential is the potential energy generated by water pressure due to gravity. Micro-hydro energy potential available in nature is a hydraulic potential (Ph) in the form of potential energy. The amount is determined by the hydraulic potential of the discharge (Q) and a height / tilt sutau river or head (H). Mathematically can be described in the equation:

$$Ph = gx\ Q \times H \quad (6)$$

Where:
Ph : Potential Hydraulic, kW
g : Gravity, m / sec^2
Q : Water discharge, l / sec
h : Tilt / head, meter

4.3.4. Power Generating Capacity

Not all the energy held in the form of hydraulic potential can be converted into electricity. At the time of the conversion of potential energy into electrical energy part of the energy will be lost as losess. In addition the amount of energy that can be obtained depends on the magnitude of the efficiency of turbine and generator that can be used. However, as a simple baseline power capacity can be calculated by the following equation:

$$Pel = \eta_t\ Ph \quad (7)$$

Where:
pill : power capacity revault, kW
Ph : Potential hydraulic, kW
ɳt : The total efficiency,%
ɳt price was set at 76% is taken from the theory losess on PLTMH. Thus the results of the initial calculation of PLTMH Sawiat power capacity can be seen in the Table 1.

Table 1. Power Capacity Estimation PLTMH Sasnek Village

No	Parameter	Symbol	Unit	Value
1.	debit	Q	Liter / Sec	2
2.	Head	H	meter	3
3.	gravitation	G	Meter / detik2	9.8
4.	efficiency Total	T	%	75%
5.	Power capacity	pill	kw	10,000

4.4. Facility Design

4.4.1. Plans Weir (Weir)

Dam is part of the civil construction built spanning the river that serves to raise the level of air. Bendung also functions as a regulator of the amount of water needed generators.

Dam building equipped with wings and door drain to clean sediment which accumulates in the bottom of the weir. The forces into consideration in the design of the weir is grinding style, the style press downward, gravity, seismic force, power sliding and hydrostatic force.

4.4.2. Tapper Channel Plan (Intake)

Tapper channel known as the intake structure is a building made of stone foundation partner in plaster with a wide rectangulardengan form in accordance with the needs of the water used.

If the condition of the dammed river water is very much rubbish then this building must be equipped with a filter made of steel strip or begel which will serve to filter or filters. Intake can be built on the left or right of the weir building known as the intake side or in front of the dam is called direct intake. Intake structure using stone masonry construction times (1: 3) with cement plaster.

Trashrack intake structure equipped with a series of plate-shaped iron bars as a buffer and filter junk fiber objects that are not expected to carry over with the flow of water.

4.4.3. Bearer Channel Plan (Headrace)

Design lay-out of PLTMH equipped with bearer channel that carries water into the forebay. But in this design uses only as a penstock to the turbine inlet.

4.4.4. Soothing Body Plan (Forebay)

Like a sedative is located near the weir building. Structures like tranquilizers such as masonry times (1: 3) consists of a settling basin (setting basin), spillway (spillway), tranquilizers trashrack and tub [20-23].

The building is commonly known as head tank that serves as a water reservoir located on the top side to flow into the turbine unit which is located at the bottom. The height difference between the water fall is known as the Head.

Bak sedative serves to control the flow of water in the pipe rapidly in the event of load fluctuations, soothing water flow before entering into the pipe rapidly, but it is also as the last screening of trash and sediment solid particles from entering the turbine.

The plan on the PLTMH Sasnek Calming Bath facility in design as well as Bak precipitator with kapasitas 20 - 50 liters / sec.

4.4.5. Rapid Plumbing Plan (Penstock)

Rapid pipe is pressurized pipe that connects the turbine inlet sedative like. The material to be used as a penstock at Sawiat PLTMH is PVC. Factors that should be considered in the design of the penstock is pressure, pipe diameter, thickness, weight and ease of mobilization pipe [24-26]. The parameters necessary to determine rapidly the pipe diameter is: water flow, head, pipe length and the average angle of the pipe.

Having in mind these parameters then using the results of the data output can be determined optimum flow velocity in the pipe, then the pipe diameter and weight rapidly can be calculated.

The Rapid Pipe Length (penstock) for PLTMH Sasnek is 100 meters measured from like sedative - Turbine with diameter penstock 8".

4.4.6. House Plan Generator (Power House)

Home generator in micro hydro schemes designed to protect the mechanical-electrical equipment such as turbines, generators and electronic control equipment on climate change in addition to the home station should also provide space and comfort for the operator. In addition the bottom floor of the house generator connected to sewers (tailrace) towards the river. Position floor of the house plants are at a considerable height from the base tailrace [27-30].

PLTMH plants home layout plan Sasnek is house-type plants on the ground or in the ground with a size of 4 x 8 meters. The foundation is designed for Cross Flow Turbine therefore storey house plants castings reinforced with reinforced concrete structure. As for the construction of buildings in the form of masonry with cement plaster. House building plant is also equipped with sewer (tailrace) along 20-50 meters with a size of 1 x 1 meter.

4.5. Hardware Design Mechanical-Electrical

The equipment included in the mechanical-electrical components on the PLTMH is Turbine, Generator and Control System / Security.

4.5.1. Turbine Plans

Based on the results of design and calculations for the scheme PLTMH Sasnek turbines proposed for use is Turbine Crossflow T-14 D 400 which is a local product (Sorong, Papua) with turbine efficiency reached 0.75%, the shaft speed 2500 rpm and the power of the turbine shaft 50 Kw move generator with an output of 10 kW, 220 V, 50 Hz, the maximum condition. In this turbine consists of: Base frame, Inlet Valve, Hang Regulator and Rotor (Runner). Base frame made of Mild Steel, Profiles "U", equipped with armature planted in the foundation and open-flume to direct wastewater into waterways [31-34].

Turbine housing are made of mild steel, iron plate with a certain thickness so that a sturdy turbine construction. Rotor (runner) made of iron FCD, on the left and right side bearing placed runner attached to the turbine. Turbines in use for PLTMH Sasnek shown in Figure 4. Power capacity calculation results PLTMH Sasnek South Sorong regency based on survey results detail can be seen on Table 2.

Figure 4. Turbines in use for PLTMH Sasnek

Table 2. Power Capacity Calculation Results PLTMH Sasnek South Sorong Regency Based on Survey Results Detail

Parameter	Symbol	Value	Unit
Turbine type	crossflow		-
Type	T-14		-
debit design	Q	20	liters / sec
Head	H	3	M
diameter Runner	D	400	mm
unit Debit	Qmax	20-100	l / sec
Speed unit			-
Runner width, mm		200	mm
Turbine Speed	N	1500	rpm
Turbine efficiency	Ntur	0.75	Fraction
Mechanical Transmission Efficiency	Ntrm	0.95	Fraction
efficiency Generator	Ngen	0.9	Fraction
Hydraulic potential	Ph	3	kW
Turbine Power Capacity	Ptur	50	kW
Power Capacity Generator	Pgen	10	kW

(See Appendix: TURBINE SPECIFICATIONS: crossflow T-14 D400)

4.5.2. Generator Plan

At PLTMH Sasnek rotation of the turbine shaft from the calculation of the flow of water is 2 liters/sec, while the rotation needed a generator to produce electrical power is 1500 rpm then by way increases the flow rate of discharge and the volume of water required body mounting container reserves by raising capacity his shelter. PLTMH Sasnek shaped mechanical transmission pulley with appropriate diameter ratio associated with V-Belt [35-38].

As for the technical specifications of the PLTMH Generator Sasnek is: 1-phase AC Synchronous Generator 220 V, 50 Hz 1500 rpm, the power factor of 1 x 10 kW, generator capacity of 10 kW. The planned form of the generator shown in Figure 5.

Figure 5. Plan Form Generator

4.5.3. Control Systems Plan and Security

Remember about location of PLTMH Sasnek in remote areas, so control system used type of Electronic Load Controller (ELC). With this system load fluctuations will be set and adjusted automatically by the ELC. The construction work of unit PLTMH Sasnek South Sorong Regency can be seen on Tables 3 to 5.

Table 3. Technical Specifications of Work Plan Transmission Construction Work One (1) Unit Pltmh Sasnek South Sorong Regency

Transmission network	
Length Network	3000 meters
Tension	220 Volt
Type / Size Cable	Tic Cables 2 x 70 mm
Type Column	Iron (Standard Network JTM)
Number of Poles	300 Trunk
Accesorries	SPLN
Grounding/ Earthing	SPLN

Table 4. Technical Specifications of Turbines Plan to be in Use Construction Work One Unit Pltmh Sasnek South Sorong Regency

Turbine	
Type	Crossflow T-14 D 300
Power	50 kW
Speed Unit	38.00
Head Gross	3 meters
Water discharge Optimum	20-100 liters / sec
Turbine Speed	2500 rpm
Efficiency	0.75

Table 5. Technical Specifications of Generator Plans, and Transmission Control System Mechanical Construction Work One Unit Sasnek Pltmh-Sawiat South Sorong Regency

Generator	
Type	AC Sync 1 Phase
Power rating	1 x 10 kW
Frequency	50 Hz
AVR	Standard
Phase / Pole	1 Phase
Shaft Speed	1500 rpm
Tension	220 Volt
Power factor	0.8 Frasi
Efficiency	0.9

Control system	
Type	ELC
Power rating	10 kW
Tension	220 Volt

Mechanical transmission	
Round Axis Turbine	rpm
Round Shaft Generator	1500 rpm
Pulley ratio	1.5
Type / Type Belt	V-Belt

4.6. Transmission Network Design

The main parameters in the design of the transmission network on micro-hydro plant is to determine network length, a large voltage (low voltage network or medium voltage network JTR JTM), the type and size of cable, pole type (iron), high mast and pole number [39-42]. PLTMH Sasnek transmission network for use Medium Voltage Networks (JTM) 240v along 3000 meters.

Cables used type of aluminum with a conductance (resistance) at 36.72 MS / m supported by iron pillars (Standard JTM - PLN) with a height of 12 meters as much as ± 300 rods.

4.7. Budget Plan for Rehabilitation PLTMH Sasnek

The budget forecasts for the cost of development of PLTMH activities Sasnek, Sawiat District, South Sorong regency amounted 2.370.046.000.00, Budget Plans is calculated based on the economic conditions in 2016, data is taken from the Basic Price Material issued by the Government of South Sorong Regency in 2016.

For the record the cost of development of PLTMH Sasnek Sawiat District in South Sorong regency due to accessibility goods / services in this region can only be achieved by means of land transportation and marine.

5. CONCLUSION

After the measurement of water discharge, discharge obtained at 2 liters / second of the measurement area 5 m2 and average water velocity 00.65 m / d. However, due to the condition of the river water flowing throughout the year in the sense of never dried, then used a correction factor of 0.75. Thus the flow that can be used is equal to 0.65 m3 / d.

Based on the analysis of the potential contained in Sasnek PLTMH, it can be calculated Distribution Grid sourced from Sasnek PLTMH is 10 KW.

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