An Implementation Design of Pico Hydro Power Plant in Picung Village

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ABSTRACT
This paper briefly presents the experience of designing a pico hydropower plant that was set up in river from Cihurang water springs at Picung Village. To provide an alternative energy source for villagers is important in order to promote economic development of local communities and to strengthen their capability as entrepreneurs in order to increase the welfare of the villagers. In this design, a turbine was coupled with 3Kw, 220V, Four-pole, single phase generator. This generator needs a rotational input exceeding 1500 RPM to generate electric power in 50Hz frequency. The turbine was built from steel and wood materials and was connected to pulley system to achieve the minimal rotation needed to produce the electricity. Based on measurement of power generated, this system produces approximately 2kW of electricity that was distributed with cables in a 2 km radius to power up LED lamps, television, and room standing room fans. According to economic analysis, the payback period of this power plant system is about 12 months based on electricity price in Indonesia government which is Rp.1.500,- for each kWh used, assuming usage of 12 hours per day. This paper also discusses energy management based on feasible system should be implemented in another village.

Keywords - *pico hydro, power plant system, economic analysis, feasibility study*

I. INTRODUCTION

Indonesia, the largest archipelago in the world with more than 70 thousand village spread through 34 provinces, needs to improve community development with the purpose of improving the villager's standard of living [1]. For this purposes, energy is one of the most fundamental elements, it is inevitability for survival and indispensable for development activities that promote education, health, transportation and infrastructure for attaining a reasonable standard of living. It is also a critical factor for economic development and employment [2]. In the last decade, problems related to energy crisis such as oil crisis, climatic change, electrical demand become a major problem especially in rural area such as villages. These difficulties are continuously increasing, which suggest the need for technological alternatives to assure their solution. One of these technological alternatives is generating electricity as near as possible of the consumption site, using the renewable energy sources that do not cause environmental pollutions, such as wind, solar, tidal and hydroelectric power plants [3]. Hydropower is based on the principle that flowing and falling water has a certain amount of kinetic energy potential associated with it. Hydropower comes from converting the energy in flowing water, by means of a water wheel or a turbine, into useful mechanical energy. This energy can be converted into electricity by an electric generator. Base on survey in this village, has several problems: imbalance ecosystem and a high density population. Also, the natural resources are not empowered well as an economic driver. This research presents the electrification of energy from the flowing/falling water by suitable equipment, assuming some efficiency loses of the generator. Recently, small-scale hydropower systems receive a great deal of public interest as a promising, renewable source of electrical power for homes, farms, and remote communities. Pico-hydro systems refer specifically to systems generating power under 5 kW. It is useful in small, remote communities that require only a small amount of electricity – for example, to power one or two fluorescent light bulbs and a TV or radio in homes. Pico-hydro setups typically are run-of-stream and a ram is needed to converge the flow of the river [4].

II. MATERIALS AND METHODS

In this research we showed the application steps of building the power plant such as site assessment, calculating flow rate, calculating the head rate. This research also achieved the objectives of generating power and designing the implementation of power plant in the river to obtain the electric power for the villagers.

2.1 Site Assessment

Picung Village is located in Pamijahan Districts, Bogor, Indonesia. The river flowing through this village has its source from Seribu, Ngumpet, Cadas Ngampar, Cihurang, Nangka and Luhur Waterfalls as shown in Figure 1.

Figure.1 An overview of situation site of Picung River

2.2 Flow Rate Obtaining

By measure the flow rate across the river using bucket as shown in Figure 2 we get the approximate measurement of 2m^3/second, with this flow we will convert the potential energy from water to electricity [5]

Figure 2. A flow of river

2.3 Head Obtaining

In this research we calculated energy planned with basic formula of energy measurement [6]

Planned $P_g = \rho g Q H \eta_o$

=1000.9,8.0,2.8,6.0,5=8428W=8,4kW

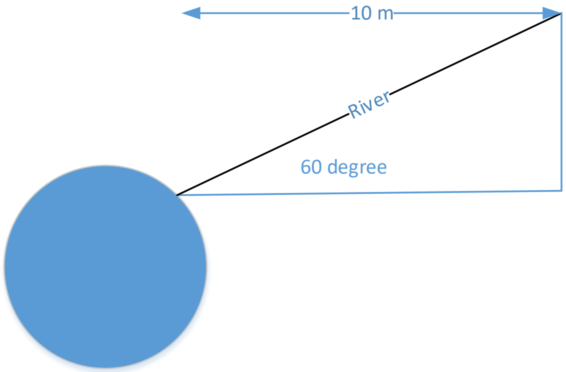

Figure.3 Calculation of obtained head

In this research we design the considerations of pico-hydroelectric power plants to convert the water potential (head) energy from the river as shown in Figure 3.

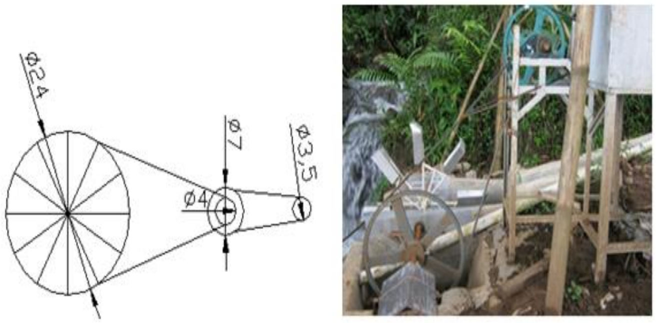

Figure 4. Design for wheels

The calculation of RPM from rotor wheels in river and RPM on generator

$$\frac{24inch}{4inch}\times 150RPM = 900RPM$$

$$\frac{7inch}{3.5inch}\times 900RPM = 1800RPM$$

As shown in Figure 4 we assumed the wheel on the river rotates at 150 RPM and set the rotation to 1800 RPM on the generator rotor. In this condition we had ascertained that the torque will produce sufficient energy to rotate the generator in minimum frequency. To ensure the stability of electric current, we needed to set the frequency on 60hz as required by the 1800 RPM of the generator rotor.

We calculated the frequency of generator as:

$$f = \frac{4\times 1800}{120} = 60hz$$

To stabilize the electricity that generated from the river through dams that shown in Figure 5, in this pico hydro system power plant, we also installed an automatic stabilizer to accommodate three voltage conditions:

•High voltage condition, over 220 V (OVER) / maximum 240 V.

When this happens, the water flow is too large. The indicator light on the stabilizer will turn red, and it is necessary to manually reduce the water flow using the water control door.

•Normal voltage condition, 180 V - 220 V (NORMAL).

This is when the water flow is moderate. The indicator light on the stabilizer will turn green. This is the appropriate condition to operate the electrical system of the micro hydro power plant.

•Low voltage condition, less than 180 V / minimum 150 V (UNDER).

This is when water discharge is too small. The light on the stabilizer will turn yellow, so it is necessary to manually increase the water flow using the water control door.

Figure 5. Dams built in the river

III. RESULTS AND DISCUSSION

In the implementation of this generator system, from the head observation, we calculated the potential power to be 8.4 kW. This system was coupled with 3kW generator and achieved a generated electricity power of 2kW only. This output we measure as shown in Figure 6.

Figure 6. Electricity Output

This drop of power was caused by losses in the belt-and-pulley system and the inefficiency of the generator. But this power is still enough for the villagers to use for daily electricity need and local society can develop entrepreneurship through starting up small and medium enterprise to increase life and social welfare [7]. This calculation of payback cost listed in Table 1.

Table 1. Calculation of payback cost

Type of Cost	Amount
Cost of generator set	Rp1,500,000.00
Padded Steel Wheel	Rp1,500,000.00
Cost of building dams on river	Rp1,000,000.00
Cost of belt and pulley	Rp1,000,000.00
TOTAL COST	Rp5,000,000.00
Payback Calculation	
Cost of each kWh from Government	Rp1,500.00
electricity	
Power generated from river	2 kW
Time used for each day	12 hours
Approximately Payback period	5 months

IV. CONCLUSION

A successful installation and operation of pico hydro system power plant will support local community development, especially increasing local economic activity, at the same time empowering natural resources become a local energy source. When measured, the power produced in this system is approximately 2000 W or 2kW. That power is distributed with cables in radius 2 km of power-up LED lamps, television, and room standing fans. According to economic analysis, the payback period of this power plant system is about 5 months based on electricity price in Indonesia government as Rp.1.500,- for each kWh used for 12 hours in each day. With this pico hydro system power plant, the local society could develop entrepreneur through starting up a small and medium enterprise to increase life and social welfare. This system also has another challenge to stage up to micro hydropower scale for more usability by using good bearing and chain for power transmission from river to the generator.

V. REFERENCES

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