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Hydroelectric Power Plant for Educational Tourism in Mount Puntang, Bandung Regency, West Java, Indonesia

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Abstract

Mount Puntang is located in Cimaung Village, Banjaran District, Bandung Regency, which has a height of 2,223 m above sea level. Mount Puntang is a tourist area with a variety of visitors to enjoy its natural beauty such as rivers, campsites, caves and other attractive natural scenery. The river in the tourist area of Mount Puntang has the potential to create a hydroelectric power system. This hydroelectric power system can be used as educational tourism and support the energy source of the tourist area. The potential measurement results obtained measured flow of 0.053 m^3/s. For the head of this river, it is obtained 6 m. The choice of turbines and generators for the benefit of especially the education of hydroelectric power plants in the tourist area is not only the amount of the potential electricity generated but also the sustainability of the system with its technology that is easily understood by the general public or students. For this reason, it is necessary to consider alternatives to the choice of turbine type, propeller turbine with 6 m head will get a power potential of 3,122 W. If using a vortex type turbine with 2 m head will get 1,041 W power and with head 1m will get 520 W. Renewable energy power plants that utilize natural potential can be a joint solution in generating energy and for tourism potential. The renewable energy technology of hydropower plants can also be a learning tool for the community to increase their knowledge.

Keywords: *Puntang mountain, hydroelectric, tourism, vortex turbine*

1. Introduction

Mount Puntang which has an altitude of 2,223 m above sea level, offers a natural tourist attraction that is extraordinarily beautiful, complete with various and diverse facilities [1]. Places that can be used as tourists include the Puntang mountain camp, rivers, caves and other interesting natural scenery. Many visitors who come here aim to camp and they consist of groups of family tourists, students to the general public. Location of Mount Puntang Campsite Bandung itself is located at an altitude of 1,300 m above sea level. With the large number of tourists visiting the food stalls selling drinks and popping up. The people in Cempakamulya Village, Cimaung Subdistrict, West Bandung Regency are members of the Bukit Amanah Community Forest Management Institute (LMDH). Because the village of Cempakamulya is located in the mountains and forests, the forest village community institutions are absolutely necessary. The Bukit Amanah LMDH carries out efforts to increase the potential of all citizens. LMDH Bukit Amanah, Cempakamulya village, actively participates in sustainable forest development.

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Many Cempakamulya villagers utilize the tourism potential in their area to open food stalls selling food and beverages. Coffee is also a product that is widely grown by residents. Technology and energy to process the results of the coffee plantations until they are ready to sell is needed in order to obtain profits rather than selling them raw.

Figure 1. Map and Location of Puntang Mountain

Renewable energy power plants that utilize the natural potential in Mount Puntang can be a joint solution in producing energy. Renewable energy technologies such as hydropower can also be a learning tool for the community to increase their knowledge.

2. Methods

The purpose and objective of conducting a water energy survey is to obtain data and information about the potential of hydropower as a basis for planning the development of hydropower utilization for the productive interests of the community. The purpose of this paper is to measure the flow of water and head at a predetermined point and prepare material recommendations for water energy utilization for the Mount Puntang Tourism Area, Bandung Regency, West Java. The target activity is the availability of a potential location for hydroelectric power in the Mount Puntang Tourism Area, Bandung Regency, West Java. The activity is carried out by site survey (field visit) to obtain water potential data which is then analyzed to determine the capacity of electric power that can be generated and the technology and systems to be used. Field study and survey activities are carried out on the river in the Mount Puntang Tourism Area, Bandung Regency, West Java in September 2019.

Micro hydro power plant is designed because of the potential that can be generated due to the difference in height on the river by H in m, the power that can be generated due to the difference in height H can be formulated as [2] [3] [4]:

$$P = \rho g Q H \eta \quad (1)$$

with P = power generated (W), ρ = water density = 1000 kg/m^3, g = gravity = 9.8 m/s^2, Q = discharge (m^3/s), H = head (m), and η = efficiency (%).

3. Results and Discussion

Measurement of the potential of water energy in the tourist area of Mount Puntang, Bandung Regency, West Java, was carried out on September 10, 2019 at coordinates S07°06.929' E107°36.375' at an altitude of 1,350 m above sea level. The weather conditions during sunny measurements at the height of the dry season so that the measured water discharge is the smallest water discharge. At the time of measurement, the width of a river cross section submerged in water was only about 4 m. This is smaller when compared to normal conditions where the width can reach 6 m.

Figure 2. Measurement of Energy Potential in the Mount Puntang River

To facilitate the measurement of the flow rate of the water flowing in the river, the measurement of water flow velocity is chosen in a good position where at that point the transverse width of the river water surface is 2.2 m. The results of water flow velocity measurements and water flow calculations are shown in Table 1.

Table 1. Results of Measurements of Water Velocity and Calculation of Water Discharge in Mount Puntang River

POINT	SEGMENT	H	B	A = H x B	V (m/s)			V_R	Qn = V_R x A
		(m)	(m)	(m^2)	V_1	V_2	V_3	(m/s)	(m^3/s)
1	*2*	*3*	*4*	*5 = 3 x 4*	*6*	*7*	*8*	*9*	*10 = 5 x 9*
1		0.17							
	I	0.150	0.44	0.066	0.1	0.1	0.1	0.100	0.0066
2		0.13							
	II	0.140	0.44	0.062	0.1	0.1	0.2	0.133	0.0082
3		0.15							
	III	0.140	0.44	0.062	0.2	0.2	0.1	0.167	0.0103
4		0.13							
	IV	0.145	0.44	0.064	0.2	0.3	0.3	0.267	0.0170
5		0.16							
	V	0.150	0.44	0.066	0.1	0.2	0.2	0.167	0.0110
6		0.14							
		∑ L=	2.200	0.319				∑ Q =	**0.053**

Note:
H = river depth (m)
B = segment width (m)

A = water cross-sectional area (m^2)
V, V_1, V_2, V_3 = Water flow velocity (m/s)
V_R = average water velocity (m/s)
Qn = water discharge in 1 segment (m^3/s)
Q = total water discharge (m^3/s)

From Table 1 it can be seen that the smallest water flow velocity is 0.1 m/s and the largest is 0.3 m/s. By multiplying the speed of the water and the cross-sectional width of the river, the water flow can be calculated. During the dry season (during measurement), the measured water discharge in the Gunung Puntang river is around 0.053 m^3/s. Using equation, the magnitude of the potential electrical energy that can be generated can be known.

In this paper, several alternative schemes of hydroelectric power are presented, with different heads so that the potential and types of water turbines used are also different. Some schemes of the magnitude of hydroelectric power plants are shown as shown in Table 2.

Table 2. Some Schemes of Potential Electric Power in the Mount Puntang River Flow

No.	Debit (m^3/s)	Head (m)	Potential Power (kW)	Turbine Type
1	0.053	1	0.520	Vortex turbine/ very low head
2	0.053	2	1.041	Vortex turbine/ very low head
3	0.053	6	3.122	Propeller

Based on these three schemes, the greatest power can be obtained by using a 6 m head which is 3,122 W power. Low head turbines can be used as an alternative to choosing turbines to be installed. One type of low head turbine is a vortex turbine, vortex turbine has several advantages including the construction is simpler than other types of turbines. Civil buildings are needed less and are simple so the construction costs are cheap. As well as easy installation and operation [5] [6] [7].

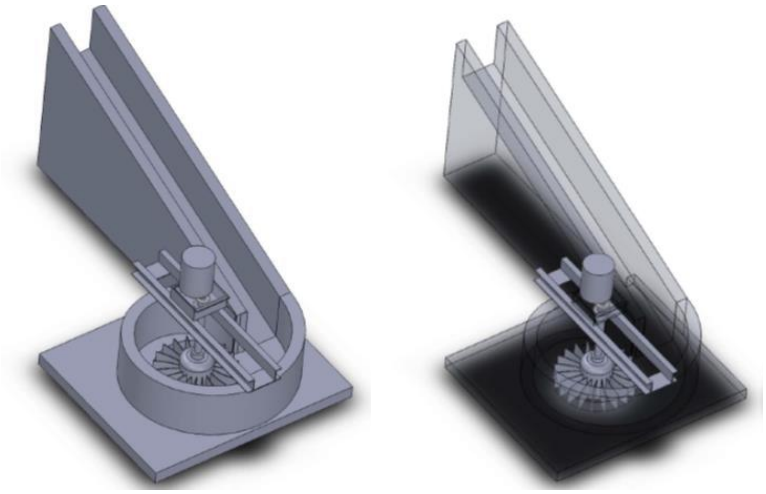

Figure 3. Vortex Type Low Head Turbine Concept

Regarding turbine efficiency, the Vortex turbine efficiency is around 15.1% - 40%. Whereas other turbines such as the Kaplan turbine have an efficiency of

around 76% - 84%, and the Archimedes screw turbine has an efficiency increase of 72% [8]. Nevertheless, turbines produce higher efficiency compared to undershot airmills or exceed traditional with efficiencies in the range of 35% [9]. Vortex turbine efficiency can increase with the size and number of blades used [10]. When the number of blades increases from 2 to 5 blades, the surface area of the blades that is in contact with water becomes larger so as to produce greater torque as well. However, the compilation of blades used is added to 6 or 7 pieces, so the distance between blades becomes less, and this makes the air flow at the blades less and less [11]. The best number of blades is 5 [12]. The power extracted by a vortex turbine will increase if the number of turbine blades also increases to a certain extent, and then efficiency will start to decrease if the number of blades increases further [13]

Renewable energy power plants that utilize the natural potential of Mount Puntang in West Java can be a joint solution in producing energy. Renewable energy technologies such as hydropower can also be a learning tool for the community to increase their knowledge. The energy released from the low head turbine generator system can be used to substitute some electricity needs for culinary business needs. The energy produced can also be used to drive agricultural tools to support post-harvest production. The system installation can be used as a learning facility for tourists about low head turbines that it becomes a useful additional knowledge. For environmental aspects, the hydroelectric power plant development in the Mount Puntang tourism area will not harm the surrounding environment. Water power/ energy for this plant is never used up and is always renewable, because water continues to flow as long as the water source is maintained, contributes greatly to reduce pollution in the air, because hydroelectric power plants is an environmentally friendly power plant/ does not produce air pollution/ exhaust emissions . The development of the power plant on Mount Puntang will reduce carbon dioxide emissions so as to create an environmentally friendly green energy. Utilization of power plants leads to the preservation of ecosystems around the development of hydroelectric power plant and to maintain watershed ecosystems in this area.

4. Conclusion

The water potential for renewable energy in Puntang Mount, West Java obtained measured flow of 0.053 m^3/s. For the head of this river, it is obtained 6m, this have potential energy power: 3122 W. If using a vortex type turbine with 2 m head will get 1,041 W power and with head 1 m will get 520 W. Renewable energy power plants that utilize natural potential can be a joint solution in generating energy and for tourism potential.

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6. References

[1] Jabarprov, *Map of West Java, West Java Province*. Bandung: West Java Provincial Government, 2017.

[2] J.A. Harvey, *Micro-hydro Design Manual: A Guide to Small- Scale Water Power Schemes*. London: ITGD Publishing, 1993.

[3] C. Penche and Minas, *Layman's Guide Book on How to Develop a Small Hydro Site*. Brussel: European Small Hidropower Association, 1998.

[4] C. C. Warnick, *Hydropower Engineering*. Englewood Cliffs, New Jersy: Prentice-Hall. Inc., 1984.

[5] M.M. Rahman and J.H. Tan, "Review on Micro Hydro Gravitational Vortex Power and Turbine Systems," in *International Conference on Materials Technology and Energy*, 2017.

[6] Systems P E. (2014, March) PESWiki. [Online].

http://www.pureenergysystems.com/NEC/conferences/2008/EnvironmentalHallofFameChicago/displays/Zotloterer,pdf

[7] Marian G-M et al., "A Review on the Development of Gravitational Water Vortex Power Plant as Alternative Renewable Energy Resources," in *2012 World Energy System Conf.*, vol. Issue 3, 2012, pp. 219-226.

[8] J. Rohmer, D. Knittel, G. Sturtzer, D. Flieller, and J. Renaud, "Modeling and experimental results of an Archimedes screw turbine," *Renewable Energy*, vol. 94, pp. 136-146, 2016.

[9] E. Quaranta, S. Fontan, P. Cavagnero, and R. Revelli, "Efficiency of traditional water wheels," in *E-proceedings of the 36th IAHR World Congress*, 2015, vol. 28.

[10] C. Power, A. McNabola, and P. Coughlan, "A parametric experimental investigation of the operating conditions of gravitational vortex hydropower (GVHP)," *Journal of Clean Energy Technologies*, vol. 4, no. 2, pp. 112-119, 2016.

[11] P. Sritram and R. Suntivarakorn, "The effects of blade number and turbine baffle plates on the efficiency of free-vortex water turbines," in *IOP Conference Series: Earth and Environmental Science*, 2019, vol. 257, no. 1: IOP Publishing, p. 012040

[12] S. Wanchat, R. Suntivarakorn, S. Wanchat, K. Tonmit, and P. Kayanyiem, "A parametric study of a gravitation vortex power plant," *Advanced Materials Research*, vol. 805-806, pp. 811-817, 2013

[13] S. Dhakal, A. B. Timilsina, R. Dhakal, D. Fuyal, T. R. Bajracharya, and H. P. Pandit, "Effect of dominant parameters for conical basin: Gravitational water vortex power plant," in *Proceedings of IOE graduate conference*, 2014, p. 381