Cikandang river discharge as a micro-hydropower plant

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Abstract. Garut Regency is flanked by three mountains, namely Papandayan, Guntur, Cikuray. Some are coastal areas in the south of the Garut Regency. Cikandang River has the potential to meet the needs of micro-hydropower plants. The utilization of the Cikandang river is used as a micro-hydropower plant with a power of 1 MW to 10 MW. The locations of the Cikandang 1 and Cikandang 2 micro-hydropower plants nearby use the same potential discharge from the Cikandangriver. In practice, the use of this river has a difference between PLTM Cikandang 1 of 6 MegaWatts and Cikandang 2 of 3 MW. The method is based on a pre-planned design layout. The calculated discharge is the mainstay discharge or the availability discharge calculated based on the FJ Mock method with a probability of 85% with ten years of rain data. Available discharge on the Cikandang river is 12.88 m3/sec, and the head is 32.7 m with head losses 0.86 m, and system efficiency is 0.69. The output power of the Cikandang 2 micro-hydropower plant is 2.88 MW. The difference between the Cikandang 1 and 2 micro-hydropower plants lies in the height of the head.

1. Introduction

Water is a basic need for living things, especially humans, which God Almighty gave to all nations of the world. The river is one of the recipient bodies of water in the face of the earth. The river flows following the contour from the highest elevation to the lowest point that is often known from upstream to downstream. The flow of water in the upstream of the river has a more swift current than the flow of the river, which is in the downstream. That was caused by the large enough upstream and downstream elevation differences.

Energy is a major factor in supporting economic and social development in a country[1]. The use of renewable energy sources, such as hydro, wind, biomass, and solar, has rapidly increased to become a power plant in rural areas [2]. The river has economic value, so its utilization is often done by the Government, the private sector, and the surrounding community. In general, rivers are used for irrigation, raw water, tourism, sports, fish farming, and electricity generation. Some rural populations depend on biomass as their main fuel[3]. Indonesia has many renewable energy sources, but still has problems in getting targets energy development[4]. The development of power plants that can be accessed using renewable resources with low cost and environmentally friendly electricity[5]. In certain areas, especially in areas that have large rivers, many are used as transportation infrastructure and as a floating market that conducts buying and selling activities like markets in general.

The current population of Indonesia is approximately 265 million people, with a large population of the Indonesian Government faced with the problem of water resources that are quite complex. In regulating the existence of these water resources, the Government of Indonesia already has a law
governing water resources, namely Law No. 17 of 2019 concerning Water Resources. In dealing with
the imbalance between water availability that tends to decrease and water demand that is increasing,
water resources need to be managed by paying attention to social, environmental and economic
functions in harmony to realize synergy and integration between regions, between sectors and between
generations to meet the needs people over water[6].

Garut Regency is located in West Java Province, which is flanked by three mountains, namely
Papandayan, Guntur, Cikuray. Garut Regency is a mountainous and tropical area, has many rivers that
are widely used by the community, including Cimanuk River and Cikandang. Cikandang River is a river
located in the southern part of Garut Regency, with a fairly swift flow of water used for the needs of
electricity generation. Power plant hydro functions to change the potential of hydropower, which has a
high fall (head) to produce energy electricity[7]. Hydropower plays a significant role in supplying
electricity demand[8]. At present, the demand for electricity continues to increase, thus requiring more
different power plants and grid construction[9]. The state electricity company, in cooperation with the
private sector, has built a Cikandang 1 micro-hydro power plant with a power capacity of 6 MegaWatts.
In its development, the same river also built Cikandang 2 micro-hydro power plant with electricity
generated by 3 MegaWatts. The current research location is Cikandang 2, which is located downstream
of Cikandang 1, with a distance of approximately 1 km. The difference in Cikandang 1 and Cikandang
2 is only in energy loss.

2. Methods
The research is focused on the construction of the Cikandang 2 micro-hydropower plant located in
Depok Village, Pakenjeng District, Garut Regency. The location of the main building is located at
coordinates 107 ° 40'6.89 "E, 7 ° 27'52.79" S. The data used to support this research primary data is to
look directly at the condition of water flow in the field and conduct interviews with the community about
the flow conditions during the rainy season and dry season while secondary data are rainfall data from
2005 to 2016 and climatology data.

The rainfall data used is ten years of rainfall data with two rain posts, namely obtained from the
Cibatarua manual rain station contained in the Sedep plantation managed by PT Perkebunan Nusantara
VIII (Persero) and the Cirompang rain station managed by the Regional Technical Implementation Unit
Public Works and Spatial Planning in Bungulang District. The calculation of average rainfall used the
average algebraic method. Climatological data such as solar irradiation time, air humidity, daily average
air temperature, and wind speed were taken from Cirompang station. The calculation of the
evapotranspiration value is used by the Penman method. Regional maps and geological maps of
Pakenjeng Sub-District, Garut Regency.

Secondary data is used to calculate the debit using the FJ Mock method, while the mainstay debit
uses the probability calculation by the Weibull method, which is sorted from the largest to get the
mainstay discharge that will be used. The mainstay discharge is set at 85%, which means that there will
be a risk of discharge smaller than the mainstay discharge of 15%. This power is generated when there
is enough water and ahead in the river. But in a small area, there is only one choice to build micro-
ydopower plants to provide electricity for the community[10].

In this study, the land use map serves to determine the percentage of plantation land and paddy fields
in the Cikandang watershed. Based on the land use map, the percentage of plantation land and paddy
fields is 30%, community settlements 10%, and forests 60%. The Cikandang watershed is dominated by
forests whose distribution of forests is pine forests and production forests. The land use map of the
Cikandang watershed two is shown in Figure 1.
Figure 1. The land use map of the Cikandang watershed 2.

Water from the river flows through the intake at the weir. Water then enters the tank, which is located between the intake and penstock, to store water[11]. Head is the water pressure due to differences in height between the water intake and the turbine. Field measurements are usually carried out using survey techniques[12]. Compliance with electricity regulations is very important so that its application can meet the minimum electricity requirements[13].

3. Results and discussion
Rainfall data is needed to calculate and analyze water availability if there are no relatively long discharge observations or none at all. Rainfall data is taken from 2 rainfall stations, namely Cibatarua and Cirompang stations, for ten years. In general, at the station location, it rains throughout the year. The highest rainy season occurred in 2010, the average rainfall in the Cikandang watershed was 302.2 mm, while the smallest average annual rainfall occurred in 2015 amounted to 222.5 mm.

Climatology data analysis is needed in the calculation of evapotranspiration, where temperature data is obtained from the rain station used. The average temperature data from the Cirompang rainfall station is 26.05°C. The average relative humidity value of Cirompang station is 92.05%. Wind speed is 7.74 knots-solar radiation by 49.54%.

The water level can be measured using a tool called AWLR (Automatic Water Level Recorder). This tool is usually available in various streams or strategic rivers. The results of water level elevation measurements are converted to discharge. But in the research area, the tool was not available. Therefore a calculation is needed to determine the amount of flowing with the FJ Mock method, a method that is often used in Indonesia. River debit that has been calculated is sorted from the largest to the smallest value, and the mainstay discharge is taken Q85%. Based on the calculation obtained a reliable discharge of 12.88 m³/sec.

Mini hydropower plants will have an impact on people's lives and the environment[14]. Loss of energy in the trashrack, which is one component for which serves to prevent the entry of floating objects. The energy loss in the trashrack is 0.021 m. Energy loss in the carrier channel (headrace) consists of enlargement and reduction of the channel in the sandtrap that is equal to 0.061 m, energy loss at the headrace turn is 0.126 m. Energy loss at curves at the penstock is 0.290 m. Energy loss due to friction is 0.3576 m. The total energy loss is 0.86 m.
Hydroelectric power plants use potential energy water to produce electricity[15]. The power generated is calculated to calculate the electric power generated at the Cikandang 2 micro-hydro power plant, with the following equation:

\[ P = \rho \times g \times Q \times H \times E_o \]  

(1)

where:
- \( P \) = electric power (Watt)
- \( g \) = acceleration due to gravity (9.81 m/sec²)
- \( \rho \) = water mass density (1000 kg/m³)
- \( Q \) = discharge (m³/sec)
- \( H \) = fall height (m)
- \( E_o \) = efficiency (0.69)

Based on the calculation, the electrical power is 2.8 MW.

4. Conclusion
The state electricity company is cooperating with the private sector to build Cikandang 2 micro-hydropower plant with the planned 3 MegaWatts electricity. The construction site is in Pakenjeng Sub-District, Garut Regency. The amount of flow is calculated by the FJ method. Mock, and the mainstay discharge using Weibull Q85% probability calculation with a discharge of 12.88 m³/sec. The electric power generated is 2.8 MegaWatts.

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