Preliminary Study of Micro-hydro Power Plant (MHPPP) in The Rural Area

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Abstract. Pakenjeng village is one of the villages in the subdistrict Pamulihan, Garut. Garut regency has the potential of natural resources is quite large and varied, namely water resources, energy, and mineral resources. Energy resources available in the form of the potential of renewable energy such as geothermal energy (geothermal), micro-hydro, solar, wave, and wind. Judging from potential micro hydro, Pakenjeng village crossed by two rivers with a flow of water large enough, the river Cikondang and Cibatarua. Currently, both the river Cikondang and river Cibatarua been used for hydroelectric power plant, with a capacity > 100 kW (scale mini-hydro), ie power plants Kombongan (river Cikondang) with a capacity of 165 kW and a power plant Panyairan (river Cibatarua) with capacity of 3 x 200 kW. The result of the potential study (pre-feasibility study) showed that Sungai Cibatarua have the quality and quantity of water that is eligible to be a source of hydroelectric energy for water discharge stable and constant reaches 5100 liters/sec. Cibatarua River has a waterfall that has a head that is high enough that Niagara Panyairan with head up to 63 meters. Hydraulic power that can be generated to reach 3248 kW and a power that can be awakened by the turbine reaches 2404 kW. Potential analysis (pre-feasibility study) of the mechanical and electrical indicates that the turbines are suitable for the MHP in the River Cibatarua namely Cross Flow Turbine Type TC 15 BO 650 with power up to 1 MW.

1. Introduction

Garut regency is one of regencies in West Java province which has the potential of natural resources is quite large and varied, namely water resources, energy, and mineral resources. Energy resources available in the form of the potential of renewable energy such as geothermal energy (geothermal), micro-hydro, solar, wave, and wind. From this potential, already done the research, either in the form of an initial survey (survey's review), a preliminary survey and exploration, to investigate the existence of potential energy and mineral resources by various parties, such as the central government, private companies, other institutions, or by Garut regency government itself. Even in some locations already implemented the exploitation and utilization of mineral resources (minerals) and exploitation activities (development) for the resource development of renewable energy, namely geothermal, micro hydro power (GMHP), and solar power plants (Pembangkit Listrik Tenaga Surya/PLTS).

Although there is a power plant that is capable of supplying electricity to Java, Madura and Bali of geothermal electricity, yet very ironic with the state of the region and society Garut regency very shortage enjoy network services of electricity, which until now electrification ratio in Garut regency reached 62.16%, with the number of households that have not had electricity networks 37.84% (data...
2013) to overcome the above problems, Garut district government has sought to do development of infrastructure of electrification through rural electricity development program that has pushed the development of public economic activities [1]. Nevertheless, the development of electricity infrastructure is still in need of support from various parties in view of the budget allocation for the program is still very low, so that the achievements of the electricity network services for citizens are still not able to increase the electrification ratio [2].

Pakenjeng village fed by rivers Cikandang which in this river there is a waterfall known as Sanghyang Taraje waterfall, located in Kampung Kombongan. The area around the waterfall is 5000 m2 and a height of about 82 m waterfall. In the waterfall area Sanghyang Taraje has been built micro hydro power plant (MHPP) with an initial capacity of 85 kW (2006) [3]. In 2009, the Center for Research and Technological Development of Electricity and Renewable Energy (Pusat Penelitian dan Pengembangan Teknologi Ketenagalistrikan dan Energi Baru Terbaik (P3TKETB)) has developed interconnection MHPP Kombongan by upgrading the Automatic Voltage Regulator (AVR) and the addition droopkits, as well as the replacement mainboard Electronic Load Controller with digital system for easy operator in the operation of the interconnection. From the research and development of MHP Kombongan interconnection is obtained an increase in electric power of 165 kW from the previous power by 85 kW. But for people Kombongan supplied electrical power of 65 kW for free and the 100 kW done grid so that it becomes non-tax revenue, from the optimization of the grid connection required the addition of ballast load to 120% of the maximum output capacity [4].

In addition Cikandang River, in the village Pakenjeng Cibatarua River also flows in the river where there are waterfalls Panyairan. Based on preliminary information, in this river are the MHPP Panyairan with power capacity is large enough that 3 x 200 kW. This research will be carried out a study on the possibility of making another MHPP Cibatarua River flow with a smaller capacity (<100 kW). Consideration of smaller capacity is that the investment costs required to be smaller, but the electricity produced can fulfill local needs. Will have several locations that allow it to be built PLTMH and further analyzed to compare the potential and opportunities for each of these locations to be recommended to the next step.

2. Literature Review

Micro hydro power plants are generating electrical energy utilizing water energy as an energy source initially, with output power in the range of 5-100 kW[5]. Mechanical energy is the energy produced by the water is used to turn turbines; this rotating turbine connected to a generator so that is produced electrical energy. Based on the operation of power plant, This MHPP within the classification of the hydroelectric plant run off river type. Simply, a run off river hydropower utilizing the flow of river water that is partially passed on a channel, turn a turbine and then discharged back to the main river. The components contained in plants run off river are: dam or weir diversion and intake (diversion weir and intake), like sedimentation (settling basin), the channel carrier (headrace), like tranquilizers (forebay), the pipeline exploded (penstock), turbines and generators, home generator (power house) and sewer (tail race)[6][7].
In order the planned MHPP according to the target, giving a clear benefit for the community, and the cost of economic development, it should be done a feasibility study of technical and non-technical. Technical feasibility study is a study to identify the potential popularity barometer (parameter) technical quantitatively to determine whether the potential locations meet the criteria requirements (standards) viable technical aspects. Based on the requirements (standards) are feasible, an MHPP development plan submitted by the related people can be evaluated so that their eligibility can be expressed in the technical aspects[8].

While non-technical feasibility study of the parameters (qualitative) that determines whether the location of the potential to meet the criteria requirements (standards) are non-technical aspects. Based on experience, if these studies neglected the work projects to be financed may result requires funds expensive, less achieve their goals, or less beneficial to the community.

Technical feasibility study includes some essential aspect, namely the feasibility study hydrology, civil, mechanical and electrical. While non-technical feasibility studies include a feasibility study covering aspects of economic / financial, social, cultural, and environmental sustainability.

3. Methods
This research is a descriptive study that aims to describe the data and information and the results of its analysis with respect to electricity is the potential of micro hydro power plant (MHPP) in river flow Cibatarua, Pakenjeng village. The data collection is done by documentary study, observation and interviews. The design and research stage briefly formulated as follows:

1. Assessment of the literature pertaining to the analysis of potential (pre-feasibility study) to study the feasibility of micro hydro power plant (MHPP);
2. The collection of basic reference materials include: location maps, geological maps, availability of construction materials, the data flow;
3. Selection of Potential Location:
   - Selection using topographic maps
   - Selection of the Kemi-light Consideration River / Debit channel and river / channel
4. Data and Information Technical Feasibility location;
5. Study Search Location;
6. Making Lay Out Initial System MHPP;
7. Non-Technical Data Collection: Socio-Economic Profile, Financial Analysis and Inventory Potential Electrical Supplies;
8. Analysis for Feasibility Study Recommendations.

4. Results and Discussion

4.1. Calculation of River Water Flow Cibatarua
Calculation of flow rates Cibatarua River starts with the determination of water cross-sectional area (A) and the water flow rate (v). To determine the cross-sectional area required several variables river width (W) and the average depth of the river (drata average), while the water flow velocity (v) is measured using a float method; water flow rate is obtained by calculating the time data (t) and distance (d) the travel buoy. Once the data is obtained cross-sectional area and the flow rate of the water, then the water flow rate can be calculated.

| Month  | A (m²) | v (m/s) | Q (m³/s) |
|--------|--------|---------|----------|
| January| 9      | 0.42    | 3.78     | 3780     |
| February| 8    | 0.26    | 2.08     | 2080     |
| March  | 11     | 0.54    | 5.10     | 5100     |

4.2. Power Potential Analysis
After getting data the river flow and an average elevation (head), then do the calculation of potential hydraulic power and data in the field then the next stage of the analysis of potential hydraulic power of a waterfall or river Panyairan Cibatarua. To get how much power can be generated from the potential of the river. It can also be a criterion in the selection of turbine type. Here is the analysis of the calculation of potential hydraulic power and power awakened.

| Month  | Q (ltr/s) | G (m/s²) | H₉ (m) | P (kW) |
|--------|-----------|----------|--------|--------|
| January| 3.780     | 9.8      | 65     | 2.407  |
| February| 2.080    | 9.8      | 65     | 1.324  |
| March  | 5.100     | 9.8      | 65     | 3.248  |

Based on data from the hydraulic power potential, can have the type of turbine what is appropriate for use in the realization of the MHP. In the research of Cross Flow turbines have to have an efficiency of up to 74%. With an efficiency of it, then by referring to Table 2, can be calculated awakened power potential, that is equal to 1,781 kW (January), 980 kW (February), and 2,404 kW (March).

4.3. Analysis Pipeline Planning Rapid (Penstock)
Planning rapid pipe or penstock is very dependent on the cost and loss of head on the pipe rapidly. Because the cost of procurement and installation of pipe rapidly relatively expensive, then planning should take into account type of materials to be used, the length, diameter and thickness of the pipe. In planning the design of the pipeline rapidly to MHP in this Cibatarua river, the authors calculate the diameter of the pipe by considering the optimum speed and maximum discharge. From these calculations, pipe specifications rapidly obtained as shown in Table 3.
4.4. Intake Planning Analysis
Intake was planned as far as 126 meters upstream and downstream coordinates on the coordinates. For a wide cross-section of the pipe diameter intake equated to rapidly and to a depth of 2 times the intake taken from the water level in the river.

### Table 4. Designing of Intake

| Description                  | Value                           |
|------------------------------|---------------------------------|
| Coordinate point upstream    | 7°23'19.09"LS dan 107°41'17.08"BT |
| Coordinate point downstream  | 7°23'19.30"LS dan 107°41'12.95"BT |
| Length Intake                | 126 meter                       |
| Wide cross-section           | 77 cm                           |
| Depth                        | 3 meter                         |

4.5. Soothing Swimming Planning Analysis
Swimming sedative function to contain the water flow and channel it into high ideally penstock sedative pool is 2-4 times the maximum height of the water to obtain the height (h) of the pool is 8 meter. Location of planning tranquilizer sedative not far from the mouth of the river that drains adjacent to the river, this is due so that when the volume of water exceeds the capacity of the pool volume sedative wasted water can be poured into the river.

### Table 5. Design Swimming Soothing

| Description                  | Value                           |
|------------------------------|---------------------------------|
| Long Swimming Soothing       | 20 meter                        |
| Wide                         | 3.6 meter                       |
| Maximum depth                | 8 meter                         |
| The volume of water          | 396 m³ / 396,000 Liter          |
| Coordinate point             | 7°23'19.30"LS dan 107°41'12.95"BT |
4.6. Design Planning MHPP
After planning penstock, intake and a sedative, then the next step is the design of MHPP using data and variable results prior planning.

4.7. Mechanical and Electrical Analysis Planning
With reference to prior the data the calculation and analysis, the turbine and generator specifications proposed in this study are as shown in Table 6 and Table 7.
### Table 6. Turbin Specification

| Magnitude                  | Specification                      |
|----------------------------|------------------------------------|
| Type of turbine            | Cross Flow TC 15 BO 650            |
| Diameter runner            | $\phi500$                          |
| Rotational speed turbine   | 1100 rpm                           |
| The maximum efficiency of  | 74%                                |
| Manufacture                | CV. Cihanjuang Inti Teknik, Bandung|

### Table 7. Generator Specification

| Magnitude                  | Spesifikasi                        |
|----------------------------|------------------------------------|
| Type of generator          | Generator Synchronous              |
| Drive                      | Gearbox Speed increaser 600-1500    |
| The number of phasa        | 3                                  |
| Power (active power)       | 1000 Kw                            |
| Apparent Power             | 1200 kVA                           |
| Frekuensi                  | 50 Hz                              |
| Speed of Generator         | 1500 rpm                           |
| Maximum Efisiensi of       | 96%                                |
| generator                  |                                    |
| $\cos \phi$                | 0,83                               |

4.8. Distribution Network Analysis

The distribution network is required to supply power to consumers. Ideally, the location of the power house to the consumer is not more than 5 km, this is to minimize power losses in the distribution network. Here is the planning system in the village Pakenjeng distribution network.

![Diagram Distribution of electrical energy](image)

**Figure 4.** Diagram Distribution of electrical energy
### Tabel 8. Electrical Mechanical Components

| Component | Remarks |
|-----------|---------|
| Generator |         |
| V         | 400 V   |
| I         | 1741.06 A |
| P         | 1000 kW  |
| Q         | 1200 kVA |
| pF        | 0.83    |
| F         | 50 Hz   |
| Busbar    |         |
| Size      | 80 × 5 mm² |
| Cable cross-sectional area | 400 mm² |
| Number of core wires | 2 |
| Loading Continue | 1800 A |
| No Fuse Breaker |         |
| Trafo     |         |
| Tegangan  | 380/400 V |
| Kapasitas | 1200 kVA |

Referring to SPLN 43-8: 1994, the type of cable used for the distribution network to the consumer is N2XBY 1 x 150 mm² 0.6 / 1.2 kV, the code letter stating the type of cable used is a cable XLPE insulated and PVC sheathed, steel tape armored, single-core, twisted copper conducted round cross-sectional area of 240 mm² with a rated voltage of 0.6 / 1.2 kV. This cable is used for distribution using 4 wire that is 3 phase and one neutral.

### Tabel 9. Distribution Network Specifications

| Distribution network |          |
|----------------------|----------|
| Cable type           | N2XBY    |
| cable length         | 4.1 km   |
| Total cable          | 4 (R, S, T, N) |
| Number of core wires | Tunggal (1 Core) |
| Cable cross-sectional area | 150 mm² |
| reactance DC         | 0.124 Ω/km |
| AC reactance         | 0.157 Ω/km |
| Inductive reactance  | 0.084 Ω/km |
| The maximum current strength | 479 A |
| high pole            | 7 meter  |

5. Conclusion
The results of the study concluded that the natural conditions around the River Cibatarua feasible for the construction of MHP, because of the location on the slopes of the mountain that has a hard ground contour and contains rocks so that the level of abrasion in this area is relatively small. This area also has a stable precipitation ranging from 1500-3000 mm annually. The feasibility study carried out showed that Cibatarua River has water quality and quantity eligible for discharge of water a stable and constant reaches 5100 liters/sec. Cibatarua River has a waterfall that has a head that is high enough that Niagara Panyairan which has a head of up to 63 meters. This shows that the development potential of the River Cibatarua can be beneficial as the MHP to the surrounding community. Hydraulic power that can be generated to reach 3248 kW and a power that can be awakened by the turbine reaches 2404 kW. The feasibility study mechanical and electrical are done in CV. Cihanjuang showed that the turbines are suitable for the MHP in the River Cibatarua namely Cross Flow Turbine Type TC 15 BO 650 with power up to 1 MW. The distance from the site to the village of Pakenjeng which is about 4.11 km from the location of the point of planning the MHP, the generated power is distributed to the conductor.
N2XYB 1 x 150 rm 0.6 / 1.2 kV with a voltage drop of 12.01 V. Thus, location MHP is feasible to be built because it was close to the MHP.

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