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Analysis of the Effect of Discharge Needs on Pesangan Hydropower Plant in Central Aceh Regency

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Abstract. The Peusangan Hydropower Plant has a power capacity of 2 x 44 MW, or 88 MW from two turbines. In the context of hydropower, turbine requirements include high efficiency, capacity, appropriate power, reliability over an extended period of time, operational flexibility, ease of maintenance, and environmental considerations such as natural habitat. Discharge requirements are a significant factor that must be considered in the planning and operation of hydropower plants. In the event that the discharge requirements are not met, the hydropower plant may be damaged and unable to operate as intended. The objective of this study was to ascertain the discharge requirements of the four sectors surrounding the river and the discharge requirements for the continued availability of the Peusangan Hydropower Plant. This research process was conducted through the analysis of MHP parameters, water needs, discharge scenarios, and zoning scenarios. The results of the analysis of the effect of discharge requirements on Peusangan Hydroelectric Power Plant indicate that the discharge requirements for the four sectors in the river are divided into three. In the 500 m zoning, the required discharge is 113.42 m³/s. In the 1 km zoning, the required discharge is 138.70 m³/s, while in the 2 km zoning, the required discharge is 138.50 m³/s. The minimum discharge requirement for the Peusangan Hydroelectric Power Plant is 138.50 m³/s. The minimum discharge requirement for Peusangan Hydroelectric Power Plant in the 500 m zoning is 199.70 m³/s, while the maximum discharge is 487.78 m³/s. In the 1 km zoning, the minimum discharge requirement is 175.43 m³/s. The maximum discharge is 463.50 m³/s, while the minimum discharge in the 2 km zoning is 174.63 m³/s, with a maximum of 462.70 m³/s. These values ensure that the discharge requirements for hydropower can be met properly.

Introduction

Water is a basic need for the life of living things on earth, both for direct needs such as drinking water, industrial water, sanitation, and indirect needs such as livestock, irrigation, and power generation. Hydropower Plant or known as PLTA is an electrical energy generation system that can convert potential energy into energy by turbines. The increasing number of people in Indonesia, resulting in the increasing need for electricity which is getting bigger every day. This is because the need for electricity is increasing in the community [2]. The Peusangan hydropower development is located along the Peusangan river in the northwestern part of the Tawar Lake in Aceh, about 320 km southeast of Banda Aceh. Its power capacity is 2 x 44 or 88 MW from two turbines. One of the devices used to convert water into mechanical energy is a turbine. Appropriate discharge requirements will ensure that the hydropower plant can operate optimally and produce electricity with high efficiency. In addition, discharge requirements also affect the stability of hydropower plants in the long term. If the discharge requirement is not met, the hydropower plant can be damaged and cannot operate properly. This research will focus on the impact of river needs for various sectors and discharge requirements on the stability and operational efficiency of hydropower plants, as well as explore methods to determine the optimal discharge requirements and overcome the problem of discharge shortages that may occur at Peusangan Hydropower Plant. This study hypothesis that the variations in discharge requipment at different zoning distance have a significant impact on the operational effeciency and environmental sustainability of the Peusangan Hydropower Plant. The research also aims to identify optimal discharge management strategies to ensure both community water needs and plant operations are sustainably.

Literature Review.

Conventional Hydropower. The most common form of hydropower plant. Conventional hydropower usually consists of a dam built on a river or lake to settle water, a turbine that converts water energy into mechanical energy and a generator that converts mechanical energy into electrical energy.

Mini Hydropower. a smaller form of hydropower plant compared to conventional and micro hydropower. Mini-hydropower is usually used to supply electricity to communities or individuals, and is often built in areas that are not connected to the national grid. Mini hydropower consists of a small dam or reservoir, a turbine and a generator.

MHP. Micro Hydro Power Plant is a power plant that comes from renewable energy because the availability of water will remain with the condition of the ecosystem maintained. MHP can also be called an environmentally friendly technology because of its non-polluting system. Water that flows with a certain capacity through a pipe, then the water will hit the turbine so that it will produce mechanical energy in the form of rotating the turbine shaft. The rotation of the turbine shaft will rotate the generator so that electrical energy is produced [1]. The efficiency or performance of a turbin is not fixed in value, depending on the load conditions and the type of turbine. Teh performance of a tuebine can be expressed in several conditions, namely, maximum plunge height, minimum plunge height, normal plunge height and design plunge height. At he design heiht the turbine will give its best speed so that its effeciency reaches its maximum. [3]

Water Power. The power entering the francis turbine is the potential power of the water.

$$P_{hid} = \rho \; x \; g \; x \; Q \; x \; H$$

Where :

P_{hid} = Water hydraulic power (Watt)
P = Density of water (kg/m^3)
g = Gravity acceleration (m/s^2)
Q = Mass flow rate (m^3/s)
H = Head of falling water height (mH2O)

Turbine Exit Power. The power released by the turbine is shaft power due to the purpose of the turbine which converts kinetic energy into mechanical energy.

$$P_{tur} = \frac{2 \; x \; \pi \; x \; n \; x \; T}{60}$$

Where :

P_{tur} = Mechanical power (Watt)
n = Turbine rotation speed (rpm)
T = Torque (Nm)

Turbine Efficiency. Turbine efficiency is obtained from comparing mechanical power with water power.

$$\eta = \frac{P_{hid}}{P_{tur}} \; x \; 100\%$$

Where :

Ƞ = Turbine efficiency
Phid = Water hydraulic power (Watt)
Ptur = Water power (Watt)

Domestic Water needs. To calculate the need for clean water, population data is needed and then multiplied by the standard clean water requirement per liter per person per day of 144 liters / day [3].

$$Q_{ave} = Pn \; x \; q$$

Where :
Q_{ave} = Clean water needs (liters / day)
Pn = Total population in year n (people)
Q = Clean water needs (liters/person/day)

Non-Domestic Water Needs. To calculate non-domestic water needs, the following formula is used: [5]

$$Q_{fave} = Pf\ x\ Q\ x\ Ap$$

Where :
Q_{fave} = Clean water needs (liter/day)
Pf = Number of Facilities
Ap = Assumed usage (person/unit)
Q = Discharge (liter/person/day)

Water Requirement for Cages. Based on the river water level elevation of 1,229.9 m which is the minimum elevation value maintained in the river. Some factors that need to be considered in determining the water requirement for floating net cages consist of; water quality, water quantity, water flow, water source, and water level. The depth of the cage used is about 2-3.5 m with a size of 8x4m.

Discharge Scenario. Discharge scenarios are conducted to calculate or predict the amount of water flowing through a channel or specific area. Discharge scenarios involve calculating the amount of water needed to meet the needs of the community or industrial activities. Before calculating the discharge scenario, the cross-sectional area of the regulating weir must be calculated using the following formula:

$$A = (b + my)y$$

Where:
A = Cross-sectional area (m2)
b = Basic channel width (m)
m = Channel slope
y = Water level (m)

To calculate the discharge scenario used 2 comparisons with the minimum and maximum flow velocity using the following formula:

$$Q_{skenario} = Q - Q_1 - Q_2 - Q_3 - Q_4$$

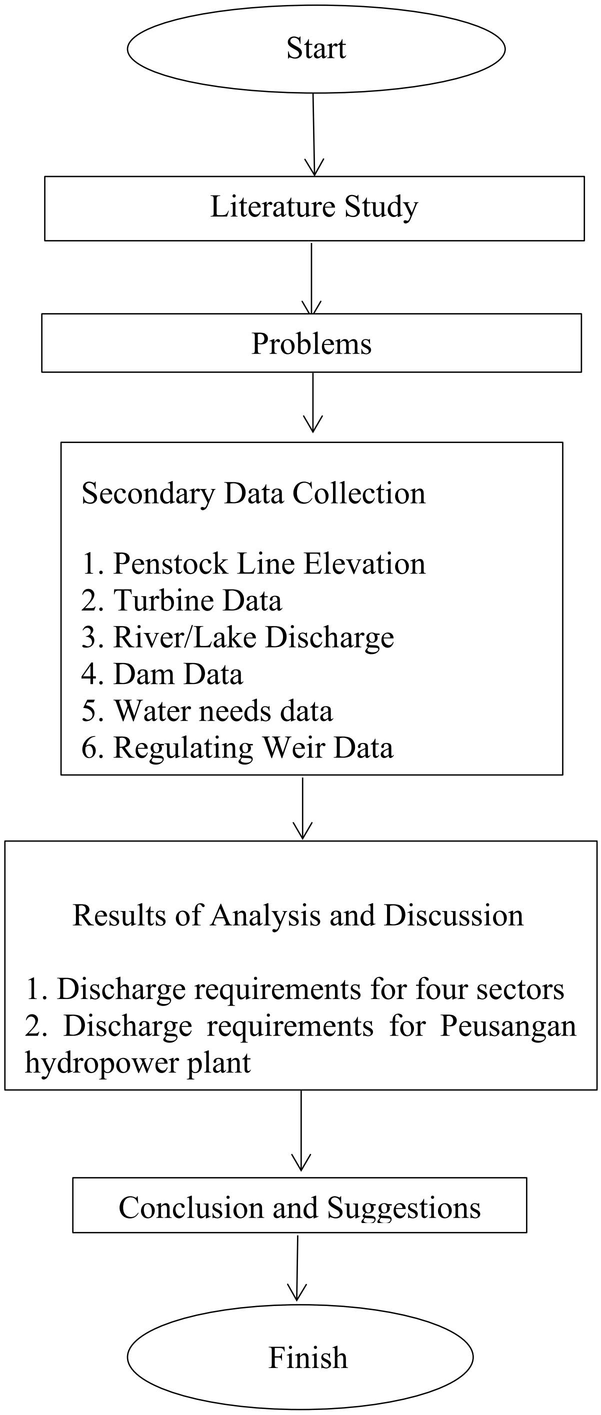
Where:
Q = Regulating weir discharge
Q1 = Discharge of school needs
Q2 = Discharge of prayer room needs
Q3 = Debit market needs
Q4 = Discharge of household needs.

Zonation Scenario. At present, many residents around the river use water sourced from PDAM Central Aceh Regency, so it is necessary to assume the use of facilities that still use Peusangan river water. Facilities that use water sourced from the river consist of; schools, houses of worship, markets and households, but zoning scenarios are only used in school facilities and houses of worship. The zoning scenario is divided into three, namely at a distance of 500 m, 1 km, 2 km.

Reasearch Methodologies

Research Location. Research on the Analysis of the Effect of Debit needs on Hydroelectric Power Plants (PLTA) the author conducts direct observation and data collection at PT PLN (Persero) which is directly in charge as the owner of the PLTA on the Peusangan river, Central Aceh Regency. This river has a depth of ± 4.6 m. The depth of water that must be maintained is at 4 - 2.5 m so that the elevation that must be maintained in the river is at 1,230.4 m - 1,228.9 m. Meanwhile, the depth of the fish cages is at 3.5 m from the maximum surface of the river water. The chosen Zoning distances of 500 m, 1 km and 2km where based on their proximity to key facilities using river water, such as school and house of worship. These distance also reflect common zoning practices in Hydropower planning to balance operational needs and communuty water usage. The selection of zoning distance (500 m, 1 km, and 2 km) reflects standard hydropower planning practices, ensuring a balance between plant operations and community water need. Potential biases, such as reliance on institutional data, are acknowledged, and future studies are encouraged to include independent surveys for greater accuracy.

Stages of Research.



Data Analysis. The data analysis carried out is to calculate the MHP meters with predetermined equations, then calculate the water needs, finally do the discharge and zonation scenarios.

Review

Water Power. From the existing equation, the result is 50,298,500 Watts from turbine 1 while in turbine 2 the result is 47,825,960 Watts.

Turbine Exit Power. Based on the data available from PLN, the output power of turbine 1 is 23,100 kW while for turbine 2 the result is 22,000 kW.

Turbine Efficiency. The results obtained from the calculation of turbine efficiency 1 amounted to 46% while turbine 2 obtained a result of 46%.

Domestic Water Needs. Domestic water needs in the Peusangan river environment is 994,942 l / person / day.

Table 1 Non-domestic water Needs at 500 m zonation

No	Type of Facility	Amount of Facilities	Discharge	Standard (l)	Water Needs	
					(l)	(m^3/s)
1	School	45	10	198.99	89544.79	89.54
2	House of Worship	57	2	198.99	22684.68	22.68
3	Market	1	1	198.99	198.99	0.20
4	Total				112428.46	112.43

Table 2 Non-domestic water needs at 1 km zonation

No	Type of Facility	Amount of Facilities	Discharge	Standard (l)	Water Needs	
					(l)	(m^3/s)
1	School	55	10	198.99	109443.64	109.44
2	House of Worship	68	2	198.99	27062.43	27.06
3	Market	1	1	198.99	198.99	0.20
4	Total				136705.05	136.71

Table 2 Non-domestic water needs at 2 km zonation

No	Type of Facility	Amount of Facilities	Discharge	Standard (l)	Water Needs	
					(l)	(m^3/s)
1	School	55	10	198.99	109443.64	109.44
2	House of Worship	70	2	198.99	27858.38	27.86
3	Market	1	1	198.99	198.99	0.20
4	Total				137501.00	137.50

Discharge Scenario. Analysis of release regulating weir based on cross section with average flow velocity data of 8.35 m/s obtained minimum and maximum discharge in Peusangan river. Calculation of the minimum discharge scenario obtained a result of 313.13 m3 / s. As for the maximum discharge, the result is 601.2 m3 / s.

Zonation Scenario.

Table 4 Discharge needs at 500 m zonation (buffer zone)

No	Type of Facility	Amount of Facilities	Discharge	Standard (l)	Water Needs	
					(l)	(m^3/s)
1	School	45	10	198.99	89544.79	89.54
2	House of Worship	57	2	198.99	22684.68	22.68
3	Market	1	1	198.99	198.99	0.20
4	Household				994.94	0.99
5	Total				11228.46	113.42

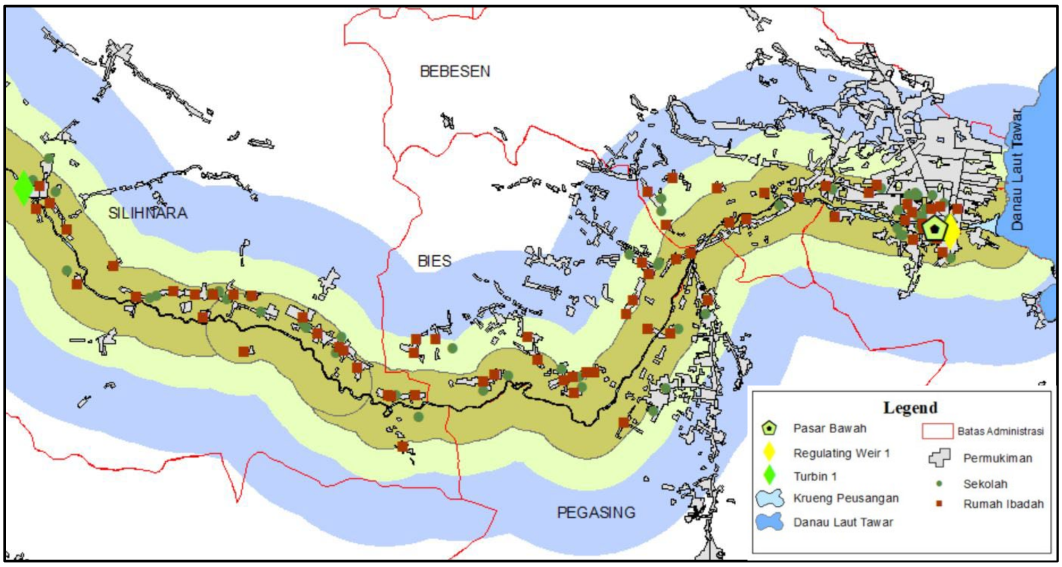
Table 5 Discharge needs at 1 km zonation (buffer zone)

No	Type of Facility	Amount of Facilities	Discharge	Standard (l)	Water Needs	
					(l)	(m³/s)
1	School	55	10	198.99	109443.64	109.44
2	House of Worship	68	2	198.99	27062.43	27.06
3	Market	1	1	198.99	198.99	0.20
4	Household				994.94	0.99
5	Total				136705.05	137.70

Table 6 Discharge needs at 2 km zonation (buffer zone)

No	Type of Facility	Amount of Facilities	Discharge	Standard (l)	Water Needs	
					(l)	(m³/s)
1	School	55	10	198.99	109443.64	109.44
2	House of Worship	70	2	198.99	27858.38	27.86
3	Market	1	1	198.99	198.99	0.20
4	Household				994.94	0.99
5	Total				137501.00	137.50

Discussion. The higher discharge requirements in the 1 km and 2 km zones indicate that these areas have a more significant impact on the operational stability of the Peusangan Hydropower Plant. Given the variation in dischare requirements, proper management is neede to maintain the plant's operational stability and prevent potential envuromental impact. The finding suggest that zones closer to hydropower plant (such as the 500 zone) have lower discharge requirements but m,ay have a more significant impact on local ecosystem if not managed properly. Additional, zones futher away (such as the 1 km and 2 km zones) require higher discharge to meet the community's needs ensure the hydropower plant's operations. These zones should be carefully monitored and managed to avoid distruping the ecological balance.



Picture 1 Zonation Skenario

Summary

Based on the discussion of the analysis of the effect of discharge requirements on Peusangan Hydroelectric Power Plant, there are several conclusions, namely:

1. The discharge requirements for the four sectors around the river are divided into 3, in the 500 m zoning the required discharge is 113.42 m3 / s, in the 1 km zoning the required discharge is 137.70 m3 / s, and in the 2 km zoning the required discharge is 138.50 m3 / s.

2. The minimum discharge requirement for Peusangan Hydroelectric Power Plant at 500 m zoning is 199.70 m3/s while the maximum discharge is 487.78 m3/s, the minimum discharge for Peusangan Hydroelectric Power Plant at 1 km zoning is 175.43 m3/s, while the maximum discharge is 463.50 m3/s, and for the minimum discharge at 2 km zoning is 174.63 m3/s while the maximum discharge is 462.70 m3/s. Thus, the discharge needed to rotate the existing turbines at Peusangan Hydroelectric Power Plant can be fulfilled.
3. The results indicate that discharge requirements increase with distance from the hydropower plant, with zones at 2 km needing significantly higher discharge rates. These findings align with previous studies, highlighting the need for efficient discharge management to prevent disruptions to plant operations and local ecosystems.

Suggestions

After conducting research on the analysis of discharge requirements at Peusangan Hydroelectric Power Plant, the following suggestions can be given:
1. For further research, it is hoped that it can analyze more completely about hydropower such as disturbances, loads and productivity in hydropower.
2. Turbines in PLTA require more attention and maintenance, because the efficiency value does not meet the existing standards, which are 70-90%.
3. Can be input material for related agencies regarding turbine efficiency at Peusangan Hydropower Plant.
4. Implement advance turbine technologies to enchance efficiency and reduce enviromental stress.
5. Conduct regular impact assessment on local ecosystems to ensure sustainable operation.

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