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ANNUAL ENERGY BASED ON TIME SIMULATION OF MICROHYDRO POWER PLANT (PLTMH) JAMUS GIRIKERTO VILLAGE, SINE DISTRICT, NGAWI REGENCY

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Abstract

Because of the large operational costs that must be incurred and the environmental impact caused by the fuel oil (fossil) power plant, PT.Candi Loka Jamus switched to using microhydro power plants to meet its electrical energy needs. Currently, the PLTMH has been operating, but during the dry season the energy produced is not able to meet the needs. If the microhydro power plant remains forced to operate, its components will be damaged and may decrease the performance of the power plant. Reviewing the calculation of energy potential based on operational time simulation and season time simulation is a step that can be taken to overcome these problems. Starting with recapitulating rain data and testing the consistency of the data with the double mass curve analysis method, then using the arithmetic mean method to analyze regional rainfall, the discharge throughout the year is calculated using the F.J Mock method and the mainstay discharge is calculated by the basic year method, The energy potential is obtained from processing the survey results which is then calculated with a physical potential formula. Based on calculations, the mainstay discharge energy potentials of Q80, Q70, Q50, and Q30 were successively 569,173.91 KWh; 614,737.01 KWh; 589,640.81 KWh and 619,855.44 KWh. Then the energy potential is calculated using operational time simulation and season time simulation The efficient operating time of the microhydro power plant is determined based on the calculation of the Q80 mainstay discharge energy potential with a simulation of operational time, namely: active microhydro power plants from 15 daily to 1-15 (January 1 - August 15) then deactivated on 15 daily to 16-20 (August 16 - October 31) for maintenance purposes, and reactivated on 15 daily to 21-24 (November 1 – December 31. With an active period of 287 days, jamus microhydro power plant has an energy potential of 488,732.17 KWh in one year.

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1. Introduction

In the industrial field, the use of fuel oil (fossil) as a source of electrical energy is still widely used. Currently, the provision of fossil fuel oil for industrial fields on a large scale is relatively difficult and expensive, this has a direct impact on the swelling of production operational costs. Air pollution is also a bad impact on the environment that can be caused by the use of (fossil) fuel oil. Therefore, to meet the needs of electrical energy in the industrial field, it is necessary to create cheap and environmentally friendly tools, one of which is the Micro Hydro Power Plant.

Micro Hydro Power Plant or often abbreviated as PLTMH, which is a small-scale power plant with a power of less than 100 kW that utilizes hydropower as an energy producing source (Patty, 1995). PLTMH is a new renewable energy source and deserves to be called clean energy because it is environmentally friendly. In terms of technology, PLTMH was chosen because of its simple construction, easy to operate, and easy to maintain and supply spare parts. Economically, its operating and maintenance costs are relatively cheap while the investment costs are quite competitive with other power plants.

Jamus tea plantations and factories are located on the slopes of northern Mount Lawu, precisely in Girikerto Village, Sine District, Ngawi Regency. Fulfilling the needs of electrical energy in Jamus tea plantations and factories which are currently managed by PT. Candi Loka previously used fossil fuel oil sources, because of the large operational costs that must be incurred and the environmental impacts caused made this company switch to using PLTMH to meet its electrical energy needs. The selection of PLTMH as a source of electrical energy is supported by the existence of the Sawahan Source spring water channel which is located in a tea plantation area of 478.20 ha, besides that the Jamus tea plantation and factory have a significant height difference to be able to build PLTMH (located at an altitude of 800 MDPL to 1200 MDPL). (Bambang Sutriyono, 2021). .

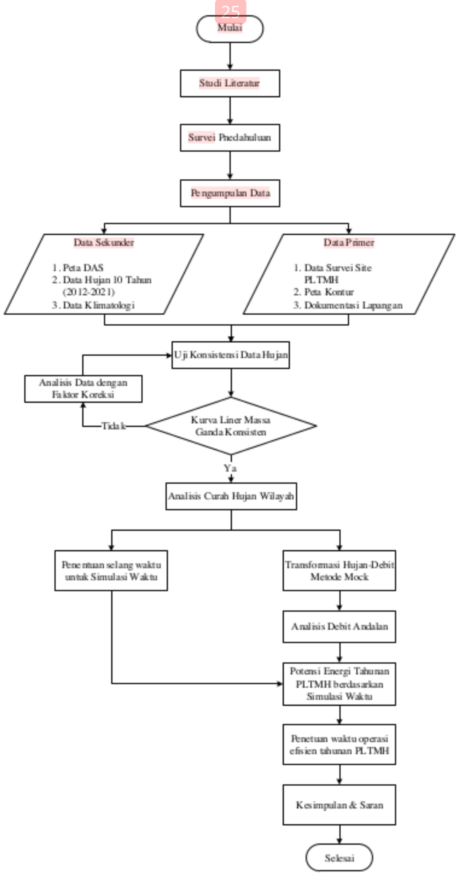
Currently, the PLTMH has been operating, but during the dry season the energy produced is not able to meet the needs. If the microhydro power plant remains forced to operate, its components will be damaged and may decrease the performance of the power plant.

2. Materials and Methods

This study analyzes the energy potential of microhydro power plants based on operational time simulations and seasonal time simulations. The purpose of this study is to determine the magnitude of the annual energy potential of microhydro power plants based on the mainstay discharge of Q80, Q70, Q50, and Q30, the difference in energy potential generated between before and after the operational time simulation and season time simulation and obtaining efficient operating time from jamus microhydro power plants.

This study used 2 types of data, namely primary and secondary data. Primary data is data obtained directly from the field, including: microhydro power plant survey data, contour maps, and field documentation. Meanwhile, secondary data is data obtained from other parties, including: watershed maps, 10-year rain data (2012-2021), and climatological data.

The process flow of this study can be seen in the following flowchart:



2.1 Research Significance

This study analyzes the energy potential of microhydro power plants based on operational time simulations and seasonal time simulations. The purpose of this study is to determine the magnitude of the annual energy potential of microhydro power plants based on the mainstay discharge of Q80, Q70, Q50, and Q30, the difference in energy potential generated between before and after the operational time simulation and season time simulation and obtaining efficient operating time from jamus microhydro power plants.

2.2 Study Area (if any)

The location of this study is at PLTMH Jamus which is located in the Jamus Tea Plantation area, Girikerto Village, Sine District, Ngawi Regency, with location coordinates namely S 07º 33' 37.08" and E 111º 10' 37.2" can be shown in figure 1

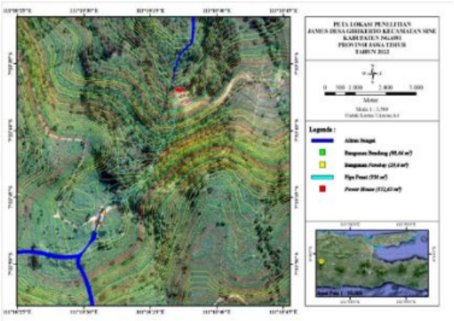


Fig.1 Research location.

2.3 Data

This study used 2 types of data, namely primary and secondary data. Primary data is data obtained directly from the field, including: microhydro power plant survey data, contour maps, and field documentation. Meanwhile, secondary data is data obtained from other parties, including: watershed maps, 10-year rain data (2012-2021), and climatological data..

2.4 Analysis Method

2.4.1 Instantaneous discharge

A Instantaneous Discharge that can be calculated is a discharge that goes through a weir. The discharge through the weir can be calculated by the following equation:

$$Q = \frac{2}{3} Cd \times B \sqrt{2g\left(Yo - P\right)^3} \qquad (1)$$

dengan

Q = debit (m3/dt),

B = lebar bendung (m),

Cd = koefisien debit (batu kali = 0,9),

(Yo-P) = jarak vertikal antara muka air dihulu bendung dengan mercu.

2.4.2 Calculation of height difference

Head height or height difference can be calculated using the Tachymetric Method, with tools when surveying using theodolite tools. Calculations calculated by equations:

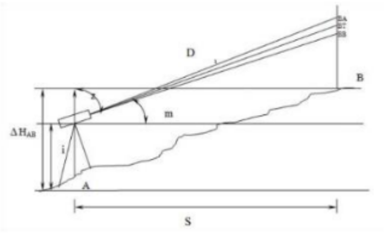


Fig.2 Measurement of height difference by *tachymetry* method.

$$S = D \times \cos m$$
$$= \left(BA - BB\right) \times 100 \times \cos^2 m$$

$$\Delta H = \frac{1}{2}\left(BA - BB\right) \times 100 \sin 2m + i - BT \qquad (2)$$

dengan

S = jarak datar,

ΔH = beda tinggi,

i = tinggi alat,

BA = bacaan benang atas,

BB = bacaan benang bawah,

BT = bacaan benang tengah,

m = sudut miring,

z = sudut zenith = 90º - m,

ΔH = beda tinggi antara titik A dan B,

D = jarak miring.

2.4.3 Evapotranspiration

Evapotranspiration is the amount of total water that is returned to the atmosphere from the ground surface, water bodies, and vegetation by the influence of climatic factors and vegetation physiology (Chay Asdak, 1995). In other words, the magnitude of evapotranspiration is the sum between evaporation (evaporation of water coming from the soil surface), interception (re-evaporation of rainwater from the surface of the vegetation header), and transpiration (evaporation of groundwater into the atmosphere through vegetation).

2.4.4 Filling in lost rain data

Because this study will calculate the discharge in flooded and dry periods, it is necessary to fill in the missing rain data because in the calculation of the next rain-discharge transformation with the F.J Mock method, complete data is needed. Filling in the lost rain data will be done with the Reciprocal method, where this method is considered better than the Normal Ratio method (Bambang Triatmodjo, 2009) to calculate the lost rain data because it takes into account the distance between stations (Li), using the formula in the equation:

$$Px = \frac{\sum_{i=1}^{n} \frac{Pi}{Li^2}}{\sum_{i=1}^{n} \frac{1}{Li^2}} \qquad (3)$$

dengan :

Px = Data hujan yang hilang di stasiun X,

Pi = Data hujan di stasiun sekitarnya pada periode yang sama (mm),

Li = Jarak stasiun X dengan stasiun di sekitarnya (km),

n = Jumlah stasiun hujan di sekitarnya

2.4.5 Test rain data consistency

In this study using the double mass curve method (Double Mass Curve) to test the consistency of rain data, it can be said to be consistent if it is R2~1. Used equations:

$$R^2 = \frac{\sum xiyi - \sum xi \sum \frac{yi}{n^2}}{\sum xi^2 - \frac{\left(\sum xi\right)^2}{n} - \frac{\left(\sum yi\right)^2}{n}} \qquad (4)$$

dengan :

R2 = koefisien deterministik,

n = jumlah data,

xi = nilai kumulatif data hujan ke-,

yi = nilai kumulatif rata-rata data hujan ke-.

2.4.6 Regional rainfall

The rainfall of the region in this study was calculated using the arithmetic mean method. The arithmetic mean method is carried out by measuring all precipitation at the specified station and summing it entirely. Then the summation results are divided by the number of observation rain stations, the average rainfall will be produced in the Jamus PLTMH area.

$$CH_{rerata} = \frac{\sum Ri}{n} \qquad (5)$$

dengan :

CH rerata = curah hujan rerata (mm),

Ri = besarnya CH pada stasiun i (mm),

n = jumlah stasiun hujan

2.4.7 *F.J Mock* method

The Mock method is a water balance model that can calculate monthly discharge from rainfall data, evapotranspiration, soil moisture, and groundwater reservoirs. The Mock water balance model provides a relatively simple calculation method for various components based on watershed research throughout Indonesia (KP-01, 2010).

2.4.8 Mainstay discharge

The mainstay discharge is the minimum discharge of the river with the possibility of the discharge being met in a certain percentage, for example 90%, 80% or other values, so that it can be used for certain needs. The degree of reliability of such discharges can occur, based on the probability of occurrence following the Weibull formula.

$$P = \frac{i}{(n+1)} \times 100\% \qquad (6)$$

dengan :

i = Nomor urut debit,

n = Jumlah data,

P = Probabilitas terjadinya kumpulan nilai yang diharapkan selama periode pengamatan

2.4.9 *Basic year* method

Basic Year analysis is an analysis of rain discharge calculations using annual average data. The steps for calculating the mainstay discharge using the Basic Year method are as follows:

1. Calculating the mainstay discharge data by the method.
2. The data from the discharge is sorted from small to large.
3. Calculate the data used as a reference for calculations with the Basic Year method formula.

$$Ri = \frac{\frac{n}{100\%}}{100\% - i} + 1 \qquad (7)$$

dengan :

Ri = Debit andalan yang dipakai,

n = Jumlah data

2.4.10 Microhydro power plants

PLTMH is defined as a power plant that uses hydropower as the main medium for driving turbines and generators. Micro hydropower, with a power scale that can be generated from 5 kW to 50 kW. In PLTMH, the process of changing kinetic energy in the form of (water speed and pressure), which is used to drive water turbines and electric generators to produce electrical energy (Notosudjono, D., 2002)

2.4.11 Building components of microhydro power plants

A. Weir

Weir is a water building that serves to raise the height of the water level, some of which water remains flowed.

B. forebay

forebay serves to control the difference in discharge in the pipe (penstock).

C. Rapid Pipe (Penstock)

A pipe or penstock is a pipe that functions to drain water from a calming bath that goes down to the turbine. In the planning of rapid pipes include diameter, thickness and material selection.

Pipe Hydrolysis

High-press losses consist of major and minor high-pressure losses, or major head losses and minor head losses. Major head losses are caused by friction losses in the pipes, and minor head losses are caused by losses in turn turns, redusers, valves, and so on (Sularso, 2006).

a. Head losses mayor

To calculate the friction loss between the pipe wall and the fluid flow without any change in the cross-sectional area in the pipe, the Darcy equation can be used

$$hf = f \times L \times v^2 \times D^2 \times g \qquad (8)$$

dengan :

hf = head loss mayor (m),

f = koefisien gesekan (dapatkan dari diagram moody),

L = panjang pipa (m),

D = diameter dalam pipa (m),

v = kecepatan aliran dalam pipa (m/dt),

g = percepatan gravitasi (m/dt2).

b. Head losses minor

In general minor head losses are expressed by the equation

$$h = \frac{K.v^2}{2g} \tag{9}$$

dengan :
h = head loss minor,
K = koefisien tahanan,
v = kecepatan rata-rata aliran dalam pipa (m/dt),
g = percepatan gravitasi (m/dt2).

Table 1. Nilai koefisen tahanan

No.	**Nilai K**	
1	Saluran masuk pipa	0,5
2	Sambungan tikungan tajam	0,9
3	Sambungan tikungan tidak tajam	0,75
4	Katup satu arah	2,5
5	Aksesoris	1,8

Sumber : Ridwan Arief Subekti, (2017)

c. Tinggi netto turbin

$$H_{netto} = H_{statis} - hf_{total} \tag{10}$$

dengan :
Hnetto = tinggi jatuh efektif,
Hstatis = tinggi jatuh bruto,
hftotal = tinggi jatuh dari tekanan air yang hilang.

Rapid pipe diameter

According to the micro planning standard hydro penstock diameter can be calculated by the equation

$$D = 0{,}72 \times (Q_{andalan}) \times 0{,}5 \tag{11}$$

dengan :
D = diameter penstock (m),
Qandalan = debit andalan (m3/dt).

$$d = 2{,}69 \times \left(\frac{n^2 \times Q^2 \times L}{H} \right)^{0{,}1875} \tag{12}$$

dengan :
d = diameter penstock (m),
n = koefisien manning,
Q = debit maksimal melewati penstock (m3/dt),
L = panjang pipa penstock (m),
H = tinggi jatuh (m).

D. Power House

Power house is a place where generators are located that convert hydropower into electric power.

2.4.12 Hydropower capability planning

A. fall height (Head)

The fall height used is the effective falling height obtained from the gross fall height minus the falling height of the water loss pressure

$$H_{eff} = H_{bruto} - H_{losses} \tag{13}$$

dengan :
Heff = tinggi jatuh efektif (m),
Hbruto = tinggi jatuh bruto (m),
Hlosses = tinggi jatuh dari tekanan air yang hilang (m).

B. Usable power

The power generated can be a preliminary estimate calculated from the effective fall height, flagship discharge, and water density and tool efficiency. For tool efficiency depends on the type of turbine used, so for different turbines it will provide different power results (Dietzel Fritz,1990)

$$P = \eta_t \times g \times Q_{andalan} \times H_{eff} \tag{14}$$

dengan :
η_t = efisiensi turbin (%),
P = daya yang dihasilkan (kW),
g = percepatan gravitasi (m/dt2),
Qandalan = debit andalan (m3/dt),
Heff = tinggi jatuh efektif (m).:

2.4.13 Time simulation

The time simulation used as the basis for calculations here is of two types, namely :

A. Time simulation based on the operational time of PLTMH where it will be determined whether or not PLTMH can meet the power needs of plantation operations and Jamus Tea Factory. When PLTMH is unable to meet power needs, the PLTMH will be deactivated for maintenance purposes. After that, the difference in annual energy potential will be calculated if the PLTMH is activated at any time, with the current deactivated PLTMH as mentioned above.

B. Time simulation based on the time of season. The basis for determining the season here is determined based on rainfall at an interval of 3 months. Where the highest rainfall during the 3-month period will be determined as the rainy season, then continued with the interval of the next season. Then later on each time interval of the season will be calculated the energy potential.

3. Result and Discussion (Font 10 pt)

3.1 Test rain data consistency

After filling in the lost rain data, then the rain data consistency test is then carried out to find out whether the rain data to be used for calculation is feasible or not.

Testing the consistency of annual rain data with the Double Mass Curve Analysis method, where the station rain data is said to be consistent when $R^2 \sim 1$. If it does not meet these requirements, the rain data is said to be inconsistent and it is necessary to analyze the calculation with correction factors

Table 2. Rekapitulasi rerata data hujan

Tahun	Stasiun			Rerata	Rerata Kumulatif
	Ngelak	Waduk Gebyar	Dawung		
2012	1631	1753	1403	1596	1596
2013	2854	2767	2011	2544	4140
2014	3136	1776	1035	1982	6122
2015	1910	1240	1265	1472	7594
2016	2490	2077	2184	2250	9844
2017	1851	1618	1648	1706	11550
2018	777	1560	1542	1293	12843
2019	1877	1678	951	1502	14345
2020	2358	1191	1192	1580	15925
2021	1647	1150	1417	1404	17329

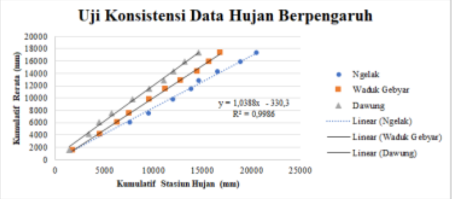


Fig.3 grafik uji konsistensi data hujan berpengaruh

3.2 Regional rainfall analysis

The calculation of the rainfall of the territory of the three stations is calculated using the arithmetic average method. The region's rain data will be calculated in the 15-day period. The calculation steps are as follows:

Used example of rain in January 15 first days in 2012

Data on 15 daily rains I in January 2012

Ngelak = 203 mm

Waduk Gebyar = 254 mm

Dawung = 108 mm

Rainy region method averages:

$$P = \frac{203+254+108}{3} = 188{,}33 \text{ mm}$$

Calculations continued until 2021.

The calculation results are presented on the table

Table 3. Hujan wilayah stasiun hujan yang berpengaruh

TAHUN	15 Harian ke-	BULAN											
		Jan	Feb	Mar	Apr	Mei	Jun	Jul	Agu	Sep	Okt	Nov	Des
2012	I	188	157	92	121	46	100	0	0	0	3	18	138
	II	143	95	50	38	4	13	0	0	0	37	191	161
2013	I	277	179	161	250	0	92	8	0	0	0	84	241
	II	198	109	175	148	159	83	0	0	0	95	73	214
2014	I	205	124	107	111	52	13	46	0	0	0	47	111
	II	279	46	209	138	48	100	16	3	10	0	143	172
2015	I	81	165	143	122	0	0	0	20	0	0	45	82
	II	159	147	253	62	7	0	0	0	0	0	65	120
2016	I	36	210	66	51	20	62	24	44	33	110	179	86
	II	71	205	75	52	55	80	56	30	105	127	426	49
2017	I	50	183	139	136	34	2	0	0	0	86	93	78
	II	217	84	83	111	48	4	0	0	40	57	161	101
2018	I	147	119	159	48	4	0	5	0	0	5	55	56
	II	153	163	113	107	2	19	0	0	0	11	71	54
2019	I	114	162	159	71	49	0	1	0	0	0	16	121
	II	132	186	117	62	8	3	0	0	0	4	27	270
2020	I	143	167	104	100	50	25	12	36	10	39	41	145
	II	65	106	108	37	60	3	10	28	11	114	79	88
2021	I	49	138	78	62	40	48	17	4	8	12	99	78
	II	129	88	159	28	34	65	0	0	18	28	121	102

3.3 Transformasi hujan-debit metode mock

Calculating rain-discharge transformation with mock method based on data from the calculation of 15 daily or monthly rainfall of the region, data from the evapotranspiration calculation, and regional parameter data.

Table 4. Perhitungan debit andalan tahun 2012

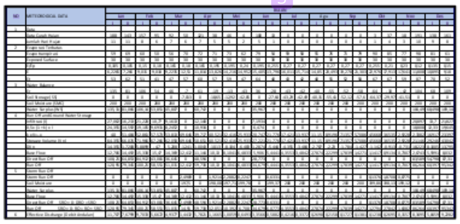


Table 5. Rekapitulasi debit sepanjang tahun metode mock

Table 6. Kontrol perhitungan metode mock

Tahun	Korelasi WS-RO	Keterangan	Tahun	Korelasi WS-RO	Keterangan
2012	0,986	OK	2017	0,9814	OK
2013	0,9887	OK	2018	0,9897	OK
2014	0,9906	OK	2019	0,9932	OK
2015	0,9888	OK	2020	0,9834	OK
2016	0,9938	OK	2021	0,9907	OK

3.4 Mainstay discharge analysis of the basic year method

Mainstay discharge is the amount of discharge available to meet water needs with a calculated risk of failure, so that it is likely to be met and available throughout the year, both during the dry season and the rainy season. The mainstay discharge used is the mainstay discharge with a probability of 80% (Q80), 70% (Q70), 50% (Q50), and 30% (Q30).

The mainstay discharge analysis is calculated based on the flow discharge from 2012 to 2021. The steps and examples of calculating the mainstay discharge using the basic year planning method (Basic Year) are as follows:

1. Calculates the annual average discharge. The discharge used for the calculation is the annual average debit of the flow discharge calculation results using the *Mock* Method and recapitulated as in the following table:

Table 7. Rekapitulasi debit andalan tahunan metode mock (m^3/dt)

Tahun	Debit Andalan
2012	3,301
2013	5,076
2014	3,924
2015	3,084
2016	3,555
2017	2,872
2018	2,139
2019	2,886
2020	2,124
2021	1,914

2. Annual mean discharge sorted from small to large can be seen in Table

Table 8. Debit rerata tahunan yang telah diurutkan

Tahun	Debit Andalan
2021	1,914
2020	2,124
2018	2,139
2017	2,872
2019	2,886
2015	3,084
2012	3,301
2016	3,555
2014	3,924
2013	5,076

3. Determining the year of the flagship discharge to be used as the basis for planning with *the Weibull* probability formula.

   Untuk Q80 $= \frac{10}{\frac{100\,\%}{(100\%-80\%)}} + 1$

   $= 3$ (Tahun 2018)

   The year 2018 was selected as Q80 with an average flagship discharge of 2,139 m^3/s

   Untuk Q70 $= \frac{10}{\frac{100\,\%}{(100\%-70\%)}} + 1$

   $= 4$ (Tahun 2017)

   The year 2017 was selected as Q70 with an average flagship discharge of 2,872 m^3/s

   Untuk Q50 $= \frac{10}{\frac{100\,\%}{(100\%-50\%)}} + 1$

   $= 6$ (Tahun 2015)

   The year 2015 was selected as Q50 with an average flagship discharge of 3,084 m^3/s

   Untuk Q30 $= \frac{10}{\frac{100\,\%}{(100\%-30\%)}} + 1$

   $= 8$ (Tahun 2016)

   The year 2016 was selected as Q30 with an average flagship discharge of 3,555 m^3/s
4. Furthermore by using each year of the probability discharge, a calculation of the power and energy potential of PLTMH Jamus will be carried out
5. The mainstay discharge graph of the Basic Year method is presented in the following figure

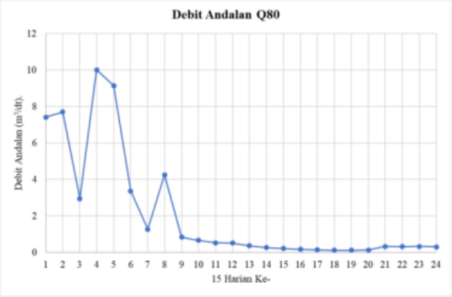


Fig.4 Grafik debit andalan Q80 – tahun 2018

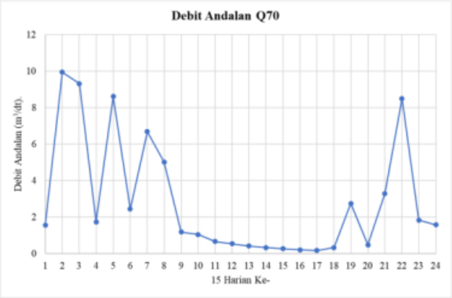


Fig.5 Grafik debit andalan Q70 – tahun 2017

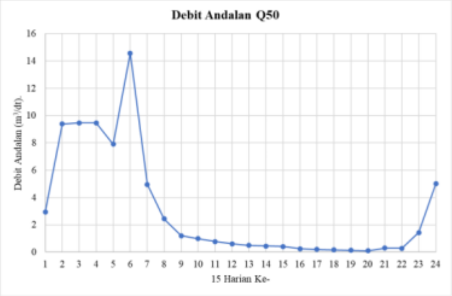


Fig.6 Grafik debit andalan Q50 – tahun 2015

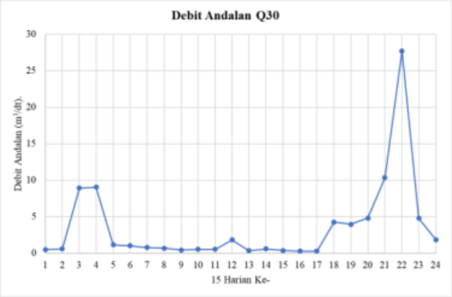


Fig.7 Grafik debit andalan Q30 – tahun 2016

3.5 Energy potential analysis

1. Power calculation

The resulting electrical power can be calculated Values range from 0.8 – 0.95. Because η_t*the existing* turbine is an old turbine and has been used, the value is determined to be = 0.8. An example of calculating electrical power using the maximum discharge through a pipe, is as follows:η_t

$$P = \eta_t \times g \times Q_{andalan} \times H_{eff}$$

$$P = 0{,}8 \times 9{,}81 \times 0{,}179 \times 50{,}45$$

$$P = 70{,}95415\ kW$$

2. Calculation of Electrical Energy Potential

Electrical energy obtained by generating electrical power calculations with the operating time of PLTMH in a period of 15 days. As an example taken the duration of operation 15 days (360 hours), which is as follows:

$$E = P \times T$$

$$E = 70{,}95415 \times 360$$

$$E = 25.543{,}49\ kWh$$

3. Calculation of Electrical Energy Load

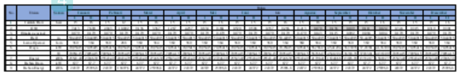
The electrical energy load is obtained from the electrical power load of production activities and also from employee housing in the PT Tea Factory area. Loka Jamus Temple (amounting to 67.7 kW) which is multiplied by the operational time of PLTMH.

$$E_{beban} = P \times T$$

$$E_{beban} = 67{,}7 \times 360$$

$$E_{beban} = 24.372 \text{ kWh}$$

Table 9. Rekapitulasi perhitungan potensi energi listrik untuk Q80



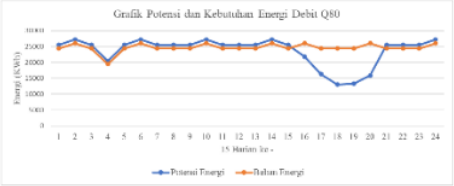


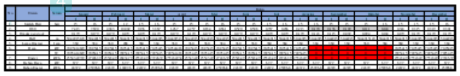
Fig.8 Grafik potensi dan kebutuhan energi debit Q80

3.6 Time simulation

Time Simulation used as the basis for calculations here is of two types, namely:

1. Time simulation based on the operational time of the Micro Hydro Power Plant, which is determined based on whether or not the Micro Hydro Power Plant meets the power needs of production activities and housing of PT Candi Loka Jamus employees. When the Micro Hydro Power Plant is unable to meet power needs, the PLTMH will be deactivated for maintenance purposes. After that, the difference in annual energy potential will be calculated if the Micro Hydro Power Plant is activated at any time, with the conditions mentioned above.

Table 10. Rekapitulasi perhitungan energi listrik (Q80) dengan simulasi waktu operasional



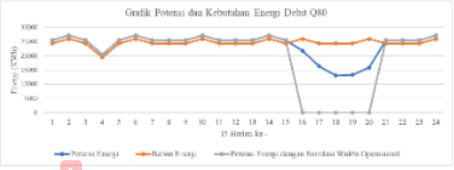


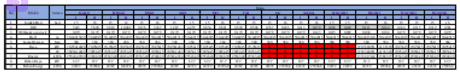
Fig.9 Grafik potensi dan kebutuhan energi debit probabilitas 80% (Q80) dengan simulasi waktu operasional

Table 11. Perbandingan potensi energi listrik sebelum dan sesudah simulasi waktu operasional

Debit Andalan	Sebelum Simulasi (KWh)	Sesudah Simulasi (KWh)	Selisih (KWh)
Q80	569.173,91	488.732,74	80.441,17
Q70	614.737,01	534.311,95	80.425,06
Q50	589.641,81	541.522,06	48.119,75
Q30	619.855,44	619.855,44	-

1. Time simulation based on the time of season. The basis for determining the season is determined based on rainfall at an interval of 3 months. Where the highest rainfall during the 3-month period will be determined as the rainy season, then continued with the interval of the next season. Then later on each time interval of the season will be calculated the energy potential. Then in the dry season the Micro Hydro Power Plant will be decommissioned

Table 11. Rekapitulasi perhitungan energi listrik (Q80) dengan simulasi waktu musim



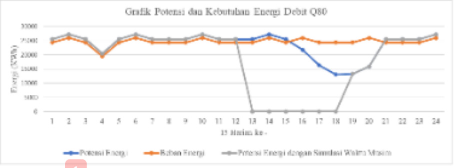


Fig.10 Grafik potensi dan kebutuhan energi debit probabilitas 80% (Q80) dengan simulasi waktu musim

Table 12. Perbandingan potensi energi listrik sebelum dan sesudah simulasi waktu musim

Debit Andalan	Sebelum Simulasi (KWh)	Sesudah Simulasi (KWh)	Selisih (KWh)
Q80	569.173,91	439.614,74	129.559,17
Q70	614.737,01	463.188,68	151.548,33
Q50	589.641,81	439.135,66	150.506,15
Q30	619.855,44	463.155,68	156.699,76

3.7 Determination of efficient PLTMH operational time

Based on the results of a graph comparison of energy potential and needs, it can be concluded that the uptime of PLTMH based on operational time simulation (PLTMH is disabled when unable to meet electricity needs) is more efficient because without sideways the time for maintenance, the uptime of PLTMH based on the simulation of operational time is longer than the active time of PLTMH based on a simulation of season time (PLTMH is disabled throughout the dry season) this active time directly proportional to the electrical energy produced. It is established that the operational time based on the calculation of the potential with the mainstay discharge of the probability of 80% (Q80), namely:

- The first active period of PLTMH Jamus starts from January 1 (15th daily 1st) to August 15th (15th daily).
- PLTMH Jamus was deactivated from August 16 (15 to the 16th daily) to October 31 (15th daily 20th) because the river discharge was unable to produce enough energy to meet the electricity needs of production activities and houses of PT factory employees. Loka Jamus Temple, so it will be deactivated for PLTMH maintenance needs.
- PLTMH was reactivated on November 1 (21st daily 15) to December 31 (24th daily 15), then continued into the following year.
- PLTMH has a total active period of 287 days with an energy potential of 488,732.17 KWh in one year.

4. Conclusion

Based on the results of the research that has been carried out, the following conclusions are obtained:

1. The amount of the river's flagship discharge based on the probability mainstay discharge is as follows:
    - Debit andalan probabilitas 80% (Q80) = 2,1393 m^3/dt
    - Debit andalan probabilitas 70% (Q70) = 2,8721 m^3/dt
    - Debit andalan probabilitas 50% (Q50) = 3,0837 m^3/dt
    - Debit andalan probabilitas 30% (Q30) = 3,5553 m^3/dt
2. The amount of energy potential that can be produced by PLTMH Jamus based on the mainstay discharge of probability is as follows:
    - Potensi energi debit andalan probabilitas 80% (Q80) = 569.173,91 KWh
    - Potensi energi debit andalan probabilitas 70% (Q70) = 614.737,01 KWh
    - Potensi energi debit andalan probabilitas 50% (Q50) = 589.640,81 KWh
    - Potensi energi debit andalan probabilitas 30% (Q30) = 619.855,44 KWh
3. The amount of energy potential produced by PLTMH Jamus based on time simulation is as follows:

Table 13. Perbandingan potensi energi listrik sebelum dan sesudah simulasi waktu operasional

Debit Andalan	Sebelum Simulasi (KWh)	Sesudah Simulasi (KWh)	Selisih (KWh)
Q80	569.173,91	488.732,74	80.441,17
Q70	614.737,01	534.311,95	80.425,06
Q50	589.641,81	541.522,06	48.119,75
Q30	619.855,44	619.855,44	-

Table 14. Perbandingan potensi energi listrik sebelum dan sesudah simulasi waktu musim

Debit Andalan	Sebelum Simulasi (KWh)	Sesudah Simulasi (KWh)	Selisih (KWh)
Q80	569.173,91	439.614,74	129.559,17
Q70	614.737,01	463.188,68	151.548,33
Q50	589.641,81	439.135,66	150.506,15
Q30	619.855,44	463.155,68	156.699,76

4. The efficient operating time of the Jamus Micro Hydro Power Plant (PLTMH) system is viewed in terms of maximum ability to meet electrical energy needs based on the analysis of energy potential that has been carried out based on the availability of water for river discharge, operational time calculations are used with a mainstay discharge of 80% probability (Q80), as follows:
    - The first active period of PLTMH Jamus starts from January 1 (15th daily 1st) to August 15th (15th daily).
    - PLTMH Jamus was deactivated from August 16 (15 to the 16th daily) to October 31 (15th daily 20th) because the river discharge was unable to produce enough energy to meet the electricity needs of production activities and houses of PT factory employees. Loka Jamus Temple, so it will be deactivated for PLTMH maintenance needs.
    - PLTMH was reactivated on November 1 (21st daily 15) to December 31 (24th daily 15), then continued into the following year.
    - PLTMH has a total active period of 287 days with an energy potential of 488,732.17 KWh in one year

5. Acknowledgment

Subsequent research can increase the number of samples of research commodities. Subsequent studies can use even newer methods to add to the selling point of research. Further studies can be developed with a qualitative approach to find out even more complex problems in each region.

6. Authors' Note (Font 10 pt)

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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