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POTENTIAL CANAL IRRIGATION FOR MICRO HYDRO POWER PLANT (MHPP) IN BATANG TONGAR IRRIGATION WEST PASAMAN DISTRICT

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ABSTRACT

MHPP establishment of the irrigation system can create an independent society for electricity provision. MHPP is environmentally friendly and continuous. Secondary canal irrigation has sufficient waterfall that potentially can be used as MHPP. The purpose of the research is to analyze the potential of the Batang Tongar irrigation canal in West Pasaman District to be a Micro Hidro Power Plants (MHPP). The waterfall partitial of irrigation canal for MHPP is set with more than 1 m and the power that can be produced is more than 5kW. The Batang Tongar irrigation canal that had been analyzed is BT 5, BT 7 and BT 8. The amount of potentially waterfall on BT 5, BT 7, and BT 8 is 35 waterfall with total power 526,673 Watt. With 526,652 Watt, Batang Tongar irrigation canal can suffice approximately 500 houses in a Pinagar Village in the West Pasaman District. Based on the power produced, shows that MHPP on irrigation canal, bring a solution to overcome the electricity scarcity and can guarantee electricity availability to create an independent society that does not just depend on the government.

Keyword: canal irrigation, MHPP, Batang Tongar.

1. INTRODUCTION

Irrigation canals located in the rural farming area have a potential to be utilized as a power plant. The flow of water in the irrigation channels has a more stable debit flow compared to the river stream. Discharge water in the irrigation flow relatively unaffected by changes of season or weather. These conditions are very suitable for the utilization of electricity generation that demands a continuous high water supply.

As small scale, exploiting the energy of water flow irrigation canals can be an alternative option to build the installation of Micro Hydro Power Plant (MHPP). Hydroelectricity is a form of hydroelectric power changes with altitude and a particular discharge into electricity, using water turbine and generator [1].

MHPP as one of the renewable energy sources can provide great benefits for the community to meet the needs of electrical energy without having to spend high cost for power transmission system or environment care in general, due to the implementation of the integrated system with its utility.

Irrigation service territory Stem Tongar is 6644 Ha. The primary channel of BatangTongar irrigation network trunk has the biggest area. BatangTongar Irrigation network have much decreased function. The decreasing function, i.e. diversion of paddy fields into plantation so that the use of irrigation water was very minimal. In addition, irrigation water is also used for laundry, cleaning and others. If we look into the irrigation network further, it can be utilized in other fields, as example, build the construction of Micro Hydro Power Plant (MHPP).

The utilization of irrigation water in the irrigation channels in the construction MHPP is useful for creating a self-contained community. The sense of community that this is a self-contained community that is not dependent on the need for electricity from the Government. Research needs to be done for that MHPP the right to the social and environmental conditions in the Pinagar village to get a simple and reliable MHPP design.

The purpose of this research is to examine the potential of irrigation canals with a high distinction for Micro Hydro Power Plant (MHPP) in BatangTongar Irrigation West Pasaman District.

2. RESEARCH METHOD

2.1 Place and time

The research was implemented on BatangTongar Irrigation channels in the Pinagar Village, Pasaman Subdistrict, West Pasaman District. This research was conducted from September to October 2013.

2.2 Tools and materials Research

The required data include: data on discharge, the cross-sectional flow area, the speed channel, height of channel irrigation water fall data, topographic maps and irrigation network schemes. Equipment used is buoy (paralon), stopwatch, bows; to measure the height of fall of water, the meter, the rope and other stationery.

2.3 Research procedure

This research uses data based on the data of discharge and the height of falling water obtained from measurements in the field. Discharge data and the height of falling water are going to be the reference for calculation of power generated at the irrigation channels. A resource that has been obtained from the calculations, will be analyzed in accordance with the provision of power for Micro Hydro Power Plant (MHPP); the power of 5 kW. The power more than 5 kW output data in form of MHPP irrigation channels potential will be used in meeting the electricity needs of the household communities in the environment.

This research requires BatangTongar irrigation networks schemes which are used to see the falls point on irrigation channels that will be plans for MHPP. Before the point out of falls plans that used in MHPP, field survey that aims to see the condition of the irrigation channels had been done to see how big the damage occurred in the BatangTongar irrigation channels. Potential irrigation canals data are:

A. Damages

In planning the preparation of potential MHPP for irrigation canals, the damage falls on irrigation channels should be avoided. The examples of the damage falls on irrigation channels that often happens is the degradation of irrigation channel walls and the destruction of the building falls. Such damage can reduce water flow so that the playback speed of the turbine is very weak. The maximum tolerance of damage percentage of the irrigation channel is 10% so the irrigation channels could be made from the potential for Micro Hydro Power Plant (MHPP).

B. Types of channels

The types of channels used in the BatangTongar irrigation network for Micro Hydro Power Plant (MHPP) is all secondary and tertiary channels that are potential as a MHPP in terms of discharge and the right water fall.

C. Debit

Actual discharge calculation, measurement performed is the input - output (Inflow-Outflow) for each channel with the observation segment measurement between two buildings. Debit calculation is done by measuring the flow velocity and cross-sectional area of flow and commonly used. Discharge at a cross-section of the channel for the flow of irregular expressed by the equation:

$$Q = V \times A \quad \text{......} (1)$$

Description:
Q = Discharge (m^3/s)
V = flow Velocity (m/s)
A = cross-sectional area of wet transverse (m^2)

The distribution of the velocity for each port on the channels are not the same, the speed of distribution depends on: channels, channel roughness shape and condition of the channel's straightness.

$$Q = C \times V \times A \quad \text{......} (2)$$

Description:
Q = Volumetric Flow (m^3/s)
C = coefficient of buoy
V = average speed (m/s)
A = cross-sectional area of wet (m^2)

a. Measurement of flow rate

The measured flow speed is the average speed of a transverse cross section of the channel. Tools used in the measurement of the speed of the flow are a float and a stopwatch.

The principle used in the buoy is the speed on the surface of the flow in a channel that is straight and one kind. Average speed of average flow can be measured by using the equation:

$$V_{average} = (V_1 + V_2 + V_3) \quad \text{......} (3)$$

Description:
V_1 = velocity of the flow of the first test (m/dt)
V_2 = Velocity of flow in the second replay (m/dt)
V3 = the flow rate on the third test (m/dt)

b. Wet Cross-sectional area channels measurement

Measurement of the cross-sectional area of wet channel is done by creating a profile cross section transverse by conducting measurements in the direction of the horizontal (width of flow) and vertical (depth of flow) in accordance of the form of the flow cross section which can be seen in Figure-1 and Figure-2. The measurement of a three-dimensional transverse cross section of the channels is to determine/calculating discharge of each channel that can be accommodated by the channel. A broad cross-section of the channel can be calculated using the equation:

- Wet cross-sectional width in square form

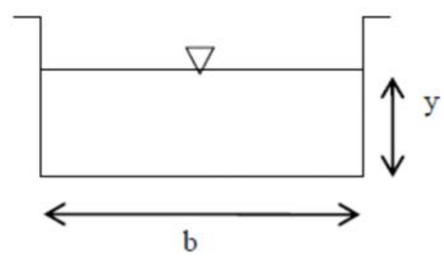

Figure-1. Transverse cross section of the square channel [2].

Formula:

$$A = b \times y \quad \text{......} (4)$$

Description:
A = cross-sectional area of wet (m^2)
b = width of the wet cross-section (m)
y = depth of water (m)

- Wet cross-section width of wet trapezoidal shape

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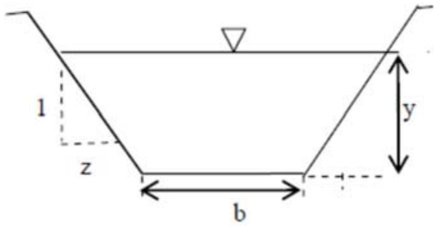


Figure-2. Horizontal Cross-section Trapezoid Channel [2].

$$A = (b+zy)\ y \quad (5)$$

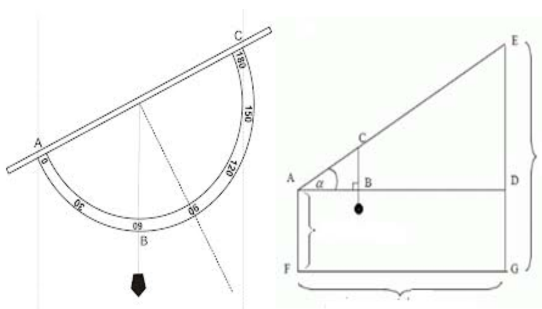
Description:
A = horizontal cross-sectional area (m^2)
b = basic channel Width (m)
h = depth of water (m)
m = slope of the wall (m/m)

D. Water fall height measurement (Head)

Water fall height measurement (head) was done in the beginning to the lastest fall of water irrigation channels. Water fall height measurement measured in accordance with the input power range just exceeds 5 kW. In this research, the provision of high water fall criteria stated in MHPP that plans is more than 1 m. Reference [3] show, with technical advances, height = of 1-1.5 m can be used and the capacity of the turbine can be made 4-5 kW. The measurement is done using a bow and the meter which can be seen in Figure-3, so high water fall (head) gained enough for the construction of MHPP. The equation is used, namely:

$$b = c \times \sin\theta \quad (6)$$

Description:
b = water fall Height (m)
θ = Angle that is formed from a plunge of irrigation (°)
c = side length of incline irrigation falls



Figuer-3. Water fall height measurement.

2.4 Data analysis

A. Power capacity analysis for MHPP

The analysis of power capacity for MHPP will be obtained from irrigation channel input power output, which has the potential to MHPP according to discharge and obtained high falling water. This resource calculation using a formula based on Reference [4].

$$P = \rho \times Q \times g \times h \quad (7)$$

Description:
P = power input (Watts)
ρ = density of the fluid (kg/m^3)
Q = water discharge (m^3/s)
h = effective height (m)
g = force of gravity (m/s^2)

After the calculation is performed, all input power will aggregate, so the total input power is the potential of BatangTongar irrigation channels.

B. Analysis of irrigation channels to potential MHPP

An analysis of the potential of irrigation canals to MHPP is done by looking at the power input and power output resulting from the irrigation potential. Limitation analysis of real power 5 kW > generated so that the irrigation channels could be made of the potential for development of the MHPP.

3. RESULTS AND DISCUSSIONS

3.1 Irrigation Koto Tuo description

Pasaman Barat district is a result of the expansion of Pasaman District - based on Indonesian Law No 38 Year 2003. West Pasaman District is located on the western coast of Sumatra Island, in the province of West Sumatra crossed by the Equator and lie between 0 ° 03' NL - 0 ° 11' SL and between 99 ° 10' WL - 100 ° 04' EL. West Pasaman District area covering an area of 375.422,67 Ha or 9, 29% of the land area of the province of West Sumatra areas. BatangTongar irrigation area is located in PasamanSubdistrict, West Pasaman District and West Sumatra Province sits at 0'3'30" – 0'9'30" NL and 9 '53'30" - 99'53'30" EL.

3.2 Description of the potential of BatangTongar irrigation channels

a) Damages

Based on observation and analysis on the field, there are three channels that have the potential to be a plan for the MHPP: on Channel BT 5, BT 7 and BT 8 in BatangTongar Irrigation network. BatangTongar Irrigation channel on channel No 5 BT there is no damage that occurs on the channel. BT channel 7 has no damage in excess of the specified tolerance or exceeds 10% on each fall for Micro Hydro Power Plant (MHPP). While at channel BT 8 there are several damages for every falls that has a lot of damage that exceed the specified tolerance. On the main channels BT 8 damage falls that occurred only on plunging 5. In the building of BT channel 8 part 1 there are 4 plunge waterfalls that is damaged; 2, 4, 5, and 6. The channels BT 8 part 2 has 4 plunge waterfalls that are damaged; 2, 3, 4 and 5. Damage of the plunge that

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occurred in the channel 8 BT is mostly because of the destruction of plunging buildings so cannot be used as planned for MHPP.

b) Types of channels

BatangTongar Irrigation network has 8 secondary channels consisting of BT 1 to BT BT 8. BT 1 to BT 4 has minimum height waterfalls while in BT 5 to 8 have a high enough waterfall which can be made of the potential for Micro Hydro Power Plant (MHPP). However, on the plunge BT 6 if made a potential MHPP, channeling electricity is too far from residential BatangTongar communities. This is because around the BT channel 6 area there are only fields and plantations. Secondary channels BatangTongar Irrigation network found potential of MHPP i.e. BT 5, 7 and BT BT 8. Irrigation channels in the channels BatangTongar 5 BT have % building parts, channel 7 BT has 8 buildings parts for BT and channel 8 BT has 13 buildings parts.

c) Debit

On the results of the measurements in the field, the discharge channel of BT 5, 7 and 8, and this is obtained through calculation of the speed of the flow by using a float, and a broad cross-section of the BatangTongar irrigation wet channel. The value of the buoy coefficient is 0.9 because the channel walls made of concrete. This discharge measurement carried out by as much as 6 times the looping. This is so that the data obtained more accurate discharge and discharge values obtained from 6 times the looping averages. This discharge calculation results obtained from researchers who have done this will illustrate the calculation of power resulting from BatangTongar Irrigation channels. Calculation of discharge of BatangTongar Irrigation channels can be seen in Table-1.

Based on Table-1, it can be seen that the discharge value obtained from the measurements in the field is large enough. Channel 8 BT has the biggest median value: 0, 914 m3/s and on channel 7 had smallest median value of discharge that amount 0,394 m3/s. This is due to the wet cross-section channel BT 8 has a bigger area of cross section instead of the wet channel 5 and channel 7.

Table-1. Discharge in Batang Tongarirrigation canals in secondary channels BT 5, 7, and 8.

Channels name	**Days**	**Flow velocity** (m/s)	**Wet cross section width** (m^2)	**Discharge** (m^3/s)
BT 5 Channel	24-9-2013	0.307	0.920	0.254
	26-9-2013	0.519	1.173	0.548
	1-10-2013	0.537	1.150	0.556
	2-10-2013	0.511	1.265	0.582
	3-10-2013	0.432	1.150	0.447
	4-10-2013	0.482	1.105	0.479
	Discharge Average			0.478
BT 7 Channel	24-9-2013	0.230	1.922	0.398
	26-9-2013	0.254	1.994	0.456
	1-10-2013	0.216	2.136	0.415
	2-10-2013	0.228	2.029	0.416
	3-10-2013	0.148	1.887	0.251
	4-10-2013	0.235	2.029	0.429
	Discharge Average			0.394
BT 8 Channel	24-9-2013	1.846	0.484	0.804
	26-9-2013	1.702	0.528	0.809
	1-10-2013	1.775	0.616	0.984
	2-10-2013	1.764	0.528	0.838
	3-10-2013	2.178	0.572	1.121
	4-10-2013	1.796	0.572	0.925
	Discharge Average			0.914

d) High falling water

Observation and analysis in the field, on the channels BT 5 there are 16 plunge that has high down enough water for irrigation potential of the made MHPP in 1 building part. On Channel BT 5 there are 11 plunging, quite as potential irrigation canals to MHPP, but to plunge to-3 and to-7 MHPP has been built to meet the electricity needs of some in the environmental community households. In the building there are 6 plunge that is located in the building, but only 5 plunge that has a high enough to be made into the plan for MHPP and the rest do not have a high enough with the suitability of the criteria that have been set that high waterfall must be higher than 1 m.

Channel BT 7 has 6 plunge that could be used to plan the MHPP falls on 2, 4, 5, 6, 7 and 8. The height of plunge 1 is not suitable for MHPP plans due to the height if waterfall does not reached 1 m. Thus plunge 1 is not feasible as plans for MHPP. The height of plunge 3 is high enough to plan the MHPP and MHPP have been built to

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meet the needs of electricity to some homes in the neighborhood.

There are 15 plunge of BT 8 channel that has potential as a MHPP plan. BT 8 channel has 6 buildings which are waterfalls has the potential, but building 4 due to the waterfalls is too low. Channel BT 8 there are 6 high waterfall that has the potential, the BT channel 8 building 1 has 2 plunge that has the potential, BT 8 building 2 has 1 waterfall high enough to MHPP, BT 8 channel building 3 there are 2 plunge that has the potential and the other 2 waterfall did not reach 1 m, BT 8-channel there is 2 of 4 waterfall that can be made into the plan for MHPP and 2 other high falls did not reach 1 m, and at the channels BT 8 building 6 there is only 2 of 5 waterfall that has the potential and the rest of the other waterfalls has no sufficient height or not reached 1 m. High Measurement falls can be seen in Table-2.

Table-2. High falls on the channel BT 5, 7 and 8.

Watefall	**High falls angle** (^{0})	**High falls slope** (m)	**High of falls** (m)	**Power** (Watt)
Channels: BT 5				
1	33	3.70	2.01	9,416
2	38	4.04	2.49	11,664
4	45	3.32	2.35	11,008
5	46	3.32	2.39	11,196
6	50	3.38	2.59	12,133
8	51	3.80	2.95	13,819
9	50	3.38	2.59	12,133
10	50	3.37	2.58	12,086
11	46	2.82	2.03	9,509
Chanells: BT 5 Building For 1				
1	53	5.60	4.47	20,939
2	40	2.90	1.86	8,713
3	46	3.26	2.35	11,008
4	49	3.44	2.60	12,161
5	40	3.48	2.24	10,493
Chanells: BT 7				
2	45	3.42	2.42	9,344
4	45	3.16	2.23	8,610
5	38	3.80	2.34	9,035
6	44	3.60	2.50	9,653
7	39	3.57	2.25	8,688
8	48	3.36	2.50	9,653
Chanells: BT 8				
1	50	2.20	1.68	15,048
2	39	4.04	2.54	22,751
3	40	4.06	2.61	23,378
4	37	4.14	2.49	22,303
6	45	3.84	2.71	24,274
7	39	4.34	2.73	24,453
Chanells: BT 8 Building For 1				
1	40	4.02	2.58	22,477
3	25	5.22	2.20	19,167
Chanells: BT 8 Building For 2				
1	39	4.36	2.74	23,871
Chanells: BT 8 Building For 3				
2	34	4.58	2.56	22,303
3	37	4.44	2.20	19,167
Chanells: BT 8 Building For 5				
1	42	3.52	2.35	19,460
3	31	4.02	2.07	17,142
Chanells: BT 8 Building For 6				
1	42	2.75	1.84	14,155
2	44	2.90	2.01	15,463

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From Table-2, the height of waterfalls on Channel BT 5, 6 and 7 in each waterfall's height have values higher than 1 m. Waterfall on channel BT5, 7 and 8 could be made plans for MHPP in accordance with the measurements that have been carried out in the field. High Data falls this will be helpful in doing the calculations generated power at every plunge on Channel BT 5, 7 and 8.

e) Power calculation for MHPP

Power is an important potential data to determine on each foray on the channel can be made into the plan for MHPP. Analysis of the power capacity of the BatangTongar Irrigation canal in the Tongar Village of West Pasaman District to plan Micro Hydro Power Plant (MHPP) has been obtained through calculation of the gravitational acceleration, the density of the fluid, high-falling water and the discharge. Calculation of BatangTongar Irrigation channel's power in Tongar Village in West Pasaman District to Micro Hydro Power Plant (MHPP) at Channel BT 5, 8 and 7 in each waterfall can be seen in Table-3.

Table-3. The power of batangTongar irrigation channels in secondary channels bt 5, 7 and 8.

No.	Channels name	Total Power (Watt)
1	Channel BT 5	166,278
2	Channel BT 7	54,983
3	Channel BT 8	305,412
	Total	526,673

Based on Table-3, can be seen the overall total power generated in the BT channel 5 which is as big as 166.278 kW, channel 7 of 54.983 kW BT and channel BT 8 of 305.412 kW. Reference [5], stated that for the medium-scale household installation of electrical power on a single household of 1300 W/220 v. Power generated on such channel BT 5 can supply electricity to households as many as 150 homes, on channel 7 BT can supply 40 households and channel BT 8 can supply more or less 300 households. High falls water relations with power produced is presented in Figure-4.

From Figure-4, the relationships of power with high water fall on Channel BT 5, 7 and 8 in the form of a linear line. Reference [6], stating that the amount of electrical power that can be raised on a central water power plant depends on the height (h) the waterfalls and water flow rate. This can be mean that the smaller high falling water obtained in the measurements makes the power generated would be smaller and higher falls water obtained in the measurements then the power produced will also be getting bigger.

3.3 An analysis of the potential of BatangTongar irrigation channels for MHPP

On the calculation of power on each plunge on Channel BT 5, 7 and 8, a BatangTongar Irrigation channels to Micro Hydro Power Plant (MHPP) that every waterfall has a power output in excess of 5 kW. The total of all output power generated by BatangTongar irrigation canal in Tongar Village, PasamanSubdistrict, WestPasaman District is 526.652 kW. So, the MHPP plan can run electricity to households in Pinagar Village community about 500 homes. It can cope with the crisis of electricity shortages and creating communities that are independent or not rely on the Government.

4. CONCLUSIONS

From the results of research that has been done on the BatangTongar Irrigation can be concluded that the amount of the total power generated from a 35-point plunge channel on BT 5,7 and 8 for MHPP plans on BatangTonagar Irrigation channels is 526,652 Watts. With power 526,652 Watts, a BatangTongar Irrigation channels able to full fill more or less 500 houses in Pinagar Village, Pasaman Subdistrict, West Pasaman District.

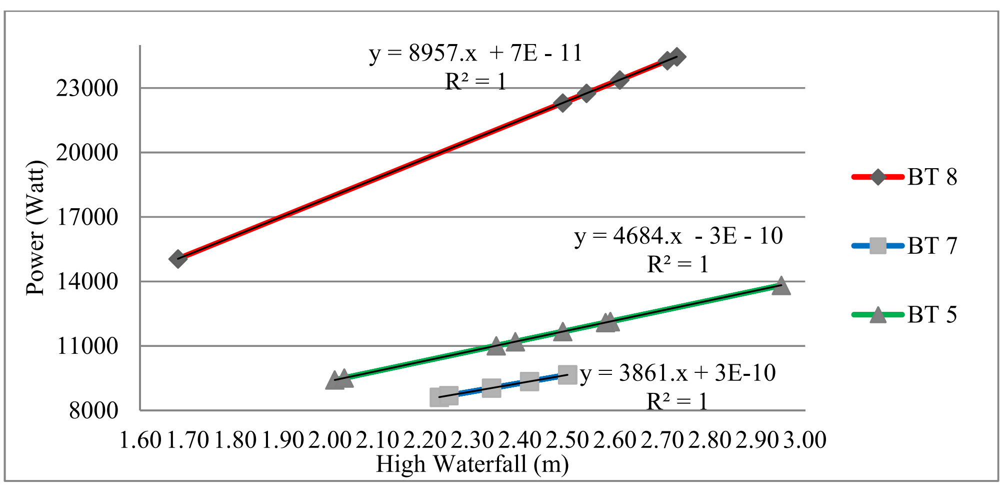

Figure-4. The relationship of power with high water fall on Channel BT 5, 7 and 8with the assumption debit and style gravity constant.

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