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Prospects of Pico Hydro Energy in Bandarban

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ABSTRACT
The complete energy scenario can be facilitated if the exploitable source of energy could be harvested using sustainable technology. This paper describes the prospects of renewable energy in Bandarban by utilizing natural resources. As Bandarban is a hilly area so it has numerous waterfalls, canals which can be used through the construction of a small hydro plant for small energy generation which will be a promising solution to suppress the problem of electricity crisis in Ruma. In several areas of Bandarban, electricity is a name only. To suppress this problem, it will be the auspicious solution to make a step of installing the hydro plant. This paper also includes some information about waterfalls & canals in Ruma, Bandarban that are a vast source of hydropower generation. To do so, a reconnaissance survey has been taken place with the assistance of Chief Executive Engineer of Bandarban Hill District Council in several spots of Ruma. Data of some sites were taken using the conventional method of measuring head & flow rate. Also, an observation includes the utilization of forebay is required or not. Using the data's a mathematical procedure also followed for the approximation of total power generation & also the turbine selection method was carried out which was done by RETscreen. From the survey, it was seen that some of the flow remains dead at the time of summer & winter so this should be in concern before designing a small hydro plant. Also, the risk factor is high due to the severe slippery condition of some sites.

Keywords: Renewable Energy, Pico hydro, Micro-hydro, Rural electrification.

1. Introduction

Renewable energy is the energy that is obtained from renewable resources, which are naturally restocked on a human timescale, such as sunlight, wind, rain, tides, waves and geothermal heat[9]. The present renewable energy mostly comes from biogas and solar. Bangladesh is a developing country which have several options and opportunities to explot renewable energy sources for green energy generation. In Bangladesh, there are numerous natural resources, such as coal, gas, and petroleum. The main source of energy in Bangladesh is natural gas (24%) which is likely to be depleted by the year 2020. The government issued its prospect and policy assertion in February 2000, with the plan to provide electricity service to the entire country by the year 2020[9]. At present, the total electricity generation capacity is 15,351 MW as of February 2017 (ES in Bangladesh). The electrification rate in the country was 41 per cent in 2009, and the population without electricity was about 95.7 million[2]. Modern times are calling for a clean, efficient renewable energy source. A possible solution for several instances is the implementation of pico or micro hydropower systems. This paper will provide us with a basic understanding and design process of pico hydroelectric power generation. The pico hydro power plant is below than 5kw power generation plant. Pico hydro plnats are basically used in rural areas and off grid power generation. The Kaptai hydropower plant on Karnafuli River, has a generating capacity of 230 MW and is the only hydropower plant which is operated by Bangladesh Power Development Board (BPDB).

2. POTENTIAL OF MICRO-HYDRO POWER IN BANGLADESH

Some previous investigation was done for finding resource potential of small hydropower by the joint operation of BPDB/ BWDB & Flood Action Plan & also individually by SRE.

Table 1 Location and Resource Potential (KW)

LOCATION	RESOURCE POTENTIAL(KW)	REFERENCE
Chittagong Fiaz lake	4	[6]
Chota Kumira	15	[6]
Hinguli Chara	12	[6]
Lungi Chara	10	[6]
Budia Chara	10	[6]
Nunchari Tholi Khal in Khagrachari	11	[7]
Hnara Khal in Rangamati	20	[7]
Monjaipara micro-hydropower unit	15	[7]
Punarbhaba	11	[7]
Kamalchar, Rangamati	20	[8]
Bangchari, Bandarban	25	[8]
Liragaon, Bandarban	20	[8]
Chang-o-par, Bandarban	30	[8]

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Table 2 Classification based on plant capacity [5]

Type	Capacity
Pico Hydro	<5 KW
Micro Hydro	<100 KW
Mini Hydro	100kW to 1MW
Small Hydro	1 MW to 25MW
Medium Hydro	25 MW to 1000 MW
Big Hydro	More than 1000 MW

Table 3 Classification based on the head [5]

Type	Head
Low head power plants	< 15 m
Medium head power plants	15 – 70 m
High head power plants	70 – 250 m
Very high head power plants	More than 250 m

Table 4 Factors affecting the selection of the Turbine for MHS [4]

Head Classification	Type of Turbine	
	Impulse	Reaction
High (>50m)	Pelton, Turgo	
Medium (10-50m)	Crossflow, Turgo, Multijet Pelton	Francis (spiral case)
Low (<10m)	Crossflow	Propeller, Kaplan, Francis

3. Project Concern

As Bangladesh has numerous hilly areas where several numbers of waterfalls exist. These natural waterfalls originated from natural river flow can be utilized by converting the potential energy stored in the flow of vertical stream into mechanical energy using turbine & then into electrical energy by using the alternator. In another way, it is also possible to harness energy from this flowing stream. When the stream touches the ground from an elevation it continues to flow through a horizontal surface which is as similar as streamline flow defined in fluid mechanics. In that way, the potential energy is converted into kinetic energy that is from E= mgh to E= 1/2mv2 where velocity plays a vital role for harvesting energy as well as the flow rate of flowing stream since velocity is proportional to flow rate(Q=AV). The concern of our project is utilizing the flow stream on the horizontal surface, i.e. converting the kinetic energy into mechanical energy then into electrical energy. In general, we are considering the Run-of-River type of hydropower generation. The natural resources have no diminish & if these resources are utilized without forming any obstruction to the natural flow, the output will be much beneficial. As a result, this project includes power generation from natural channel water flow where no block will be provided to the natural flow also negligible carbon emission. Another issue is that no forebay & penstock will be used, just simply the natural energy stored in natural flow will be harnessed through a zero head turbine.

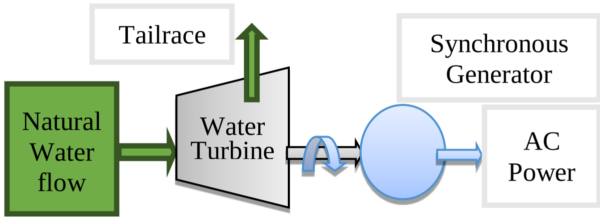

Fig.1 Block diagram of the Proposed Concept.

4. Reconnaissance Survey

We are a group of three students from Ahsanullah University of Science & Technology have visited Bandarban for site inspection in Ruma to set up a hydro plant using natural channel flow that comes from the river. With the help of Bandarban Hill District Council, we have inspected several waterfalls & canals in Ruma which all are a prosperous source of developing hydro energy through the utilization of natural flow of water if appropriately utilized. This paper will include scopes of energy generation on our inspection fields, with other factors that are inextricably related to energy generation. Some prospective sites are given below:

Fig.2a Shailapropat Waterfall (Upper section).

Fig.2b Shailapropat Waterfall (Down section).

Fig.2c A narrow waterfall which is used by locals.

Fig.2d A hilly channel that generated from the Sangu River.

As per the inspection the last pictured site is chosen for developing hydro plant considering the nearest localization, easy transport, safety measurement as well as site-specific parameters to design the plant. The site-specific parameters are:

Flow Rate = 0.4572 m^3/s

Average Depth = 2 ft

Width = 4.5 ft

Average Velocity = 0.762 m/s (measured by surveying the site at Ruma, Bandarban through conventional float technique discharge method)

Area = 6.36 ft^2 = 0.60 m^2

Site Condition = Run-of-River.

5. Mechanical Modeling

Power Available in The Natural Stream

$$P_{natural} = \rho g Q S$$

Where,

S = Slope of the stream(the streamflow is not perpendicular to the ground but it creates an angle of cosine which is cos 53^o) = 0.6096 m

ρ = the density of the water = 10^3 kg/m^3

Q= hydraulic discharge (measured by surveying the site at Ruma, Bandarban through conventional float technique discharge method) = 0.4572 m^3/s

g = acceleration due to the gravity = 9.81 m/s^2

So, $P_{natural}$ = 2734 W = 2.734 KW

Power Developed in Turbine

$$P = \frac{1}{2}\rho A V^3 C_p \eta$$

where:

η = the efficiency of the turbine, assuming 0.65
ρ = the density of the water (10^3 kg/m^3),
Q = the volume of water flowing per second (the flow rate in m^3/s) is around
= 0.4572 m^3/s
V = the velocity of the water flow, 0.762 m/sec

C_p = Power co-efficient = 0.592

A = the swept area of the turbine blades = $\frac{\pi d^2}{4}$ where, d = 0.762 meter that is the diameter of the turbine

= 0.456 m^2

Thus

$$P = \frac{1}{2}\rho A V^3 C_p \eta$$

= 0.5x1000x0.456x0.762^3x0.592x0.65

= 38 W

If the turbine runs for 24 hours, then P = 912 W-hr

As seen from the above equation, there is no use of head since the power calculation is done in terms of run of river type hydropower generation. In case of a run of river ICMIEE20-130-4 type hydropower generation, the head is near to zero, and the only influencing factor is the flow rate or velocity of the flowing water. The higher the flow rate or velocity, the higher the power generation is possible.

Rotational Speed of Turbine

To calculate the rotational speed of your turbine two parameter required.

1. the radius of your turbine blades (R in meter)
2. the speed that the water is flowing (V in m/s)

The rotational speed of your turbine = $\frac{V}{R}$ (rps)

$= \frac{V}{R} * 60\ (rpm)$

6. Assessment of The Selected Sites

The most important criteria for installing a hydro plant is selecting the location of powerhouse & measure head, flow rate, load demand. The selection of components is also required. What type of turbine is required will be determined from the data of the head available on that site. A penstock pipe can be used to make passage of water flow & due to the penstock pipe flow rate will increase. When the flow of water is in a passage, all that water coming from the penstock outlet will impinge at the turbine blade. As a result, the rotational speed of the turbine will increase & as the generator will be coupled with the turbine shaft better power generation can be achieved. A forebay tank will be better suited when the volume of water coming from the waterfalls is low. In that case, water will be stored in the forebay tank & from the forebay tank water will go to the turbine through penstock pipe & a nozzle can be used at the discharge section of the penstock pipe to increase the flow pressure. A settling basin is required for removing the hard particles so that the turbine blades & penstock pipe materials will have a longer life. Some inspection site has a flow rate of 0.280-0.35 m^3/sec with 2 – 4 meter head which will result in 3- 5 KW electricity production. A dam can be built in some places but should be concerned about the rainy season. In run-of-river type, dam sometimes required but can be constructed in different ways as for example not blocking the whole volume of the water flow, but a portion of the flow can be diverted to the dam

7. Design of Cross-flow Turbine

Considering the condition of the proposed site, the cross-flow turbine is a good option to manufacture. Cross-flow turbine is suitable under low head condition. In our case, we constructed the cross-flow turbine considering the design parameter of the wind turbine since wind turbines also operate in zero head condition.

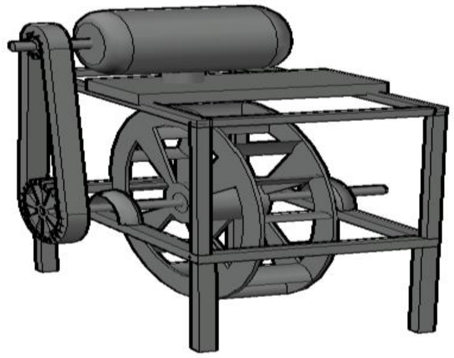

Fig.3 Design of the constructed cross-flow turbine using AutoCAD 2016 (with chain).

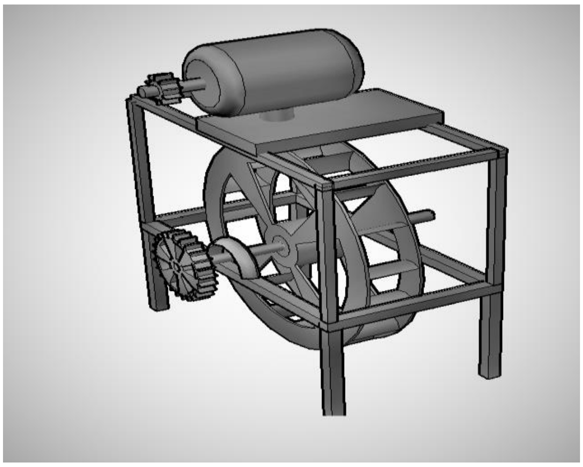

Fig.4 Design of the constructed cross-flow turbine using AutoCAD 2016 (without chain)

The gear mechanism is used to increase the rpm, which is required to generate electricity from the alternator. 1:15 gear ratio is used, and the gear is designed as per the ratio. Aluminium is used to construct the turbine body, which ensures lightweight. If the weight increases, then the inertia will also increase, which can affect the smooth rotation of the turbine.

8. Conclusion

Pico hydro is better suited for development in Bandarban, specifically in the inspection sites. The cost will not be high enough & overall durability will be increased if maintenance properly though it requires little maintenance. As the load demand is not high due to fewer or little communities having no heavy electricity consumption devices, so energy efficiency can be achieved. If Govt. or private organizations make necessary steps to utilize these natural resources not only rural communities will be benefited, but also it will be useful for urban localization by storing extra produced energy in a system & supply it when needed. Another vital scenario is, it requires no fuel, environmental degradation & other harmful effects will not occur.

9. Nomenclature

P=electrical or mechanical power production, watt
ρ=density of water, kg/m^3
g=acceleration due to gravity, m/s^2
H=Elevation head of water, m
Q=Flow rate of water, m^3/s
η=Overall Efficiency of MH_s (Micro Hydropower System)
H_g=The gross head which is the vertical distance between the water surface level at the intake to the turbine, m
H_f=Total head losses due to the channel those approximately equal to 6% of gross head, m
A= Area of channel, m^2
f=Friction factor for pipe material, dimensionless
V=Velocity of steam, m/s
L=Length of pipe, m
d_{pipe}= The inside pipe diameter, m
KS=Coefficients for pipe shape geometry, dimensionless
Ψ=Blade roughness coefficient (0.98)
C=Nozzle roughness coefficient (0.98)
H_n=Net head, m

10. Acknowledgement

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