Reprint **ISSN 2076-3972 (Web Version)**

Institutional Engineering and Technology (IET)

(*Inst. Engg. Tech.*)

Volume: 2	Issue: 1	April 2012

Inst. Engg. Tech. 2(1):32-38(April 2012)

A STUDY ON HYDRO ELECTRIC GENERATION IN BANGLADESH

M.M. AHMED, M.J. HOSSAIN AND M.A.RAHMAN

GGF
Nature is Power

An International Scientific Research Publisher

Green Global Foundation©

Publication and Bibliography Division
100 Leeward Glenway
Apartment # 1601
M3c2z1, Toronto, Canada
E-mails: publication@ggfagro.com, editor@ggfagro.com
http://ggfagro.com/ejournals/current issues

IET** issn 2076-3972, HQ:19-10 cantral place, saskatoon, saskatchewan, s7n 2s2, Canada

ISSN-2076-3972 (Online)
Inst. Engg. Tech. 2(1):32-38(April 2012)

A STUDY ON HYDRO ELECTRIC GENERATION IN BANGLADESH

M.M. AHMED, M.J. HOSSAIN AND M.A. RAHMAN

Department of Electrical & Electronic Engineering, World University of Bangladesh, Dhaka, Bangladesh.

Corresponding author & address: Md. Mostak Ahmed, E-mail: mostak321@yahoo.com
Accepted for publication on 2 April 2012

ABSTRACT

Ahmed MM, Hossain MJ, Rahman MA (2012) A study on hydro electric generation in Bangladesh. *Ins. Engg. Tech.* 2(1), 32-38.

At present about 52% of the total population of Bangladesh is served with the electricity and per capita electricity consumption is about 230 KWh. There are some remote areas where grid system has not reached yet and possibility is also bleak. The vast majority of populations have little access to electric commercial energy and thus being deprived of amenities associated with the use of electric energy .The loss of economic opportunities due to lack of access and non availability of electrical power is enormous. Clean energy services is essential for sustainable development and poverty eradication, provides major benefits in the areas of health, literacy and equity. Environmental concerns specially those related to carbon stabilization could hurt the economic attractiveness of other non-renewable, large scale generation technologies particularly coal. Those developments could be of particular significance in our country where small scale renewable generation may be most effective way to bring electricity to remote villages that are not near transmission system. Hydro power system is cost effective and environment friendly technique which can improve the energy situation. Hydro power generation is also eco-friendly and clean power generation method. The scope of Hydropower generation is very limited in Bangladesh because of its plain lands, except in some Hilly region in the northeast and southeast parts of the country.

Key words: *small hydro, electric generator, turbine, off-grid areas*

INTRODUCTION

Bangladesh is a riverine country with three main rivers (1) Padma (2) Brahmaputra and (3) Jamuna. About 1.4 trillion cubic meter (m^3) of water flows through the country in an average water year. Numerous rivers flow across the country which is mostly tributaries of these main rivers. Out of these, 57 rivers are transboundary which originate from India and Myanmar. Apart from the south-eastern region, other parts of the country are mostly flat in nature. Major rivers of the country have high flow rate for about 5 to 6 months during monsoon season, which is substantially reduced during winter. More than 90% of Bangladesh's rivers originate outside the country, due to which proper planning of water resource is difficult without neighboring countries' cooperation. Downstream water sharing with India is a highly contentious issue in Bangladesh.

At present only 230 MW of conventional hydro power is produced in the Karnafuli Hydro Station, which the only conventional hydro-electric power plant in the country operated by Bangladesh Power Development Board (BPDB). BPDB is considering extension of Karnafuli Hydro Station to augment another 100 MW capacity which will add energy marginally, but will be effective to operate it as a peaking power plant. The additional energy can be generated during the rainy season when most of the water is spilled. Several reconnaissance surveys and studies have been conducted in the past for installing small hydro power plants in the country. This paper covers detail study on present hydro power generation as well as future potentiality of producing additional power utilizing the following rivers: Faiz lake, Choto kumira Chara, Hinguli Chara, Sealock, Longi Chara, Budia Chara of Chittagong district.

MATERIALS AND METHODS

A hydro electric system consists of the following parts:

- Water diversion
- Pipeline
- Power house
- Shut-off valve
- Turbine
- Generator

Water Diversion (Intake)

The intake is typically the highest point of hydro system, where water is diverted from the stream into the pipeline that feeds the turbine. A diversion can be as simple as a screened pipe dropped into a pool of water, or as big and complex as a dam across an entire creek or river. A water diversion system serves two primary purposes. The first is to provide a deep enough pool of water to create a smooth, air-free inlet to the pipeline. The second is to remove dirt and debris. Trash racks and rough screens can help stop larger debris, such as leaves and limbs, while an area of quiet water will allow dirt and other sediment to settle to the bottom before entering the pipeline. This helps reduce abrasive wear on the turbine. Another approach is to use a fine, self-cleaning screen that filters both large debris and small particles.

Pipeline (Penstock)

The pipeline, or penstock, not only moves the water to the turbine, but also the enclosure that creates head pressure as the vertical drop increases. In effect, the pipeline focuses all the water power at the bottom of the pipe, where the turbine is rotate. In contrast, an open stream dissipates the energy as the water travels downhill. Pipeline diameter, length, material, and routing all affect efficiency.

Powerhouse

The powerhouse is simply a building or box that houses turbine, generator, and controls. Its main function is to provide a place for the system components to be mounted, and to protect them from the elements. Its design can affect system efficiency, especially with regard to how the water enters and exits the turbine. For example, too many elbows leading to the turbine can create turbulence and head loss. Likewise, any restrictions to water exiting the turbine may increase resistance against the turbine's moving parts.

Shut-off Valve

A shut-off valve is necessary, and should be directly in front of the turbine in case an immediate shutdown or the system required. This valve should be of high quality and very durable. It is recommended that one slightly close and then opens the valve on a regular basis to ensure they become seized in the open position and they don't function when mostly needed (Khurmi 2006).

Turbine

The turbine is the heart of the hydro system, where water power is converted into the rotational force that drives the generator. For maximum efficiency, the turbine should be designed to match the specific head and flow (Skrotzki 1999). There are many different types of turbines, and proper selection requires considerable expertise. Turbines can be divided into two major types. Reaction turbines use runners (the rotating portion that receives the water) that operate fully immersed in water, and another type used in low to moderate head systems with high flow.

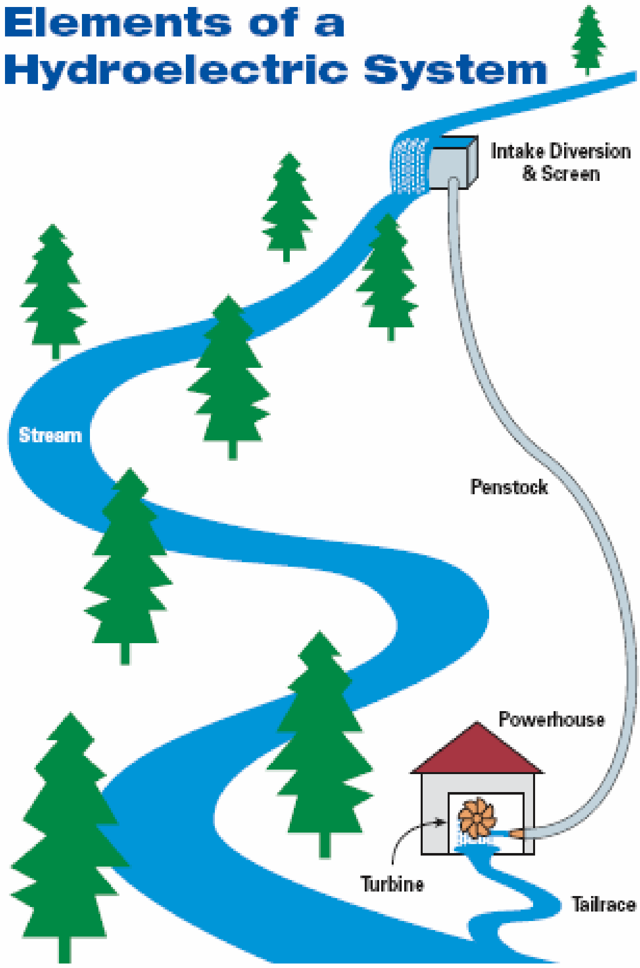

Fig. 1. A Hydro-Electric System

Generator

The generator converts the rotational energy from the turbine shaft into electricity. Efficiency is important factor at this stage too (Gupta 2007). Direct current (DC) generators, or alternators with rectifiers, are typically used with small household systems, and are usually augmented with batteries for reserve capacity, as well as inverters for converting the electricity into the AC required by most appliances. DC generators are available in a variety of voltages and power outputs. AC generators are typically used with systems producing about 3 KW or more. AC voltage is also easily changed using transformers, which can improve efficiency with long transmission lines. Depending on the requirements, one can choose either single-phase or three-phase AC generators in a variety of voltages (Chapman 2008).

HYDRO POWER BASICS

Hydro power basics denotes how much amount of power should be produced from a hydro electric system. In order to measure the total amount of power the following point could be considered.

Head and Flow

Hydraulic power can be captured whenever a flow of water falls from a higher level to a lower level. The vertical flow of water known as the ‘head’ is essential for hydro power generation. Which is denoted by ‘H’. Flow rate (Q). in the river is the volume of water passing per second measured in (m^3/sec) for small scale the flow rate can also be expressed in (litre^3/sec).

Output Power

Hydro-turbines convert water force into mechanical shaft power, which can be used to drive an electricity generator, or other machinery. The power available is proportional to the product of head and flow rate. The general formula for any hydro system’s power output is:

$P = \eta\rho GQH$

Where:
- P is the mechanical power produced at the turbine shaft (watts)
- η is the hydraulic efficiency of the turbine, ρ is the density of water (100kg/m^3)
- G is the acceleration due to gravity (9.81 m/s^2)
- Q is the volume flow rate passing through the turbine (m^3/s)
- H is the effective pressure head of water across the turbine (m)

The various prospects of Hydro power generation are:

Power would supply into the remote areas.
Low generating cost and better plant efficiency.
Reduce the maintenance cost.
Provides option for decentralization of rural electrification.
Provide much cleaner and sustainable energy that they would not pollute environment.
Relatively small investments are needed that are within the reach of low-income communities.

Classification of Hydro Power Schemes

Table 1. Hydro power schemes

Name	Capacity
Pico-Hydro	100w-1KW
Micro-Hydro	1KW-10KW
Mini-Hydro	10KW-1000KW
Small-Hydro	1000KW-10Mw
Medium-Hydro	10Mw-100Mw
Large-Hydro	Above 100Mw

OFF-GRID BATTERY BASED HYDRO-ELECTRIC SYSTEM

Most small off-grid hydro systems are battery-based as shown in Figure 2. Battery systems have great flexibility and can be comparing with other energy sources, such as wind generators and solar-electric arrays, if the stream is seasonal. Because stream flow is usually consistent, battery charging is as well, and it’s often possible to use a relatively small battery bank. Instantaneous demand (watts) will be limited not by the water potential or turbine, but by the size of the inverter.

Turbine (Waterwheel):

The turbine converts the energy in the water into electricity. Many types of turbines are available, so it is important to match the machine to the site’s conditions of head and flow. In impulse turbines, the water are routed through nozzles that direct the water at some type of runner or wheel. Reaction turbines are propeller machines and centrifugal pumps used as turbines, where the runner is submerged within a closed housing. With either turbine type, the energy of the falling water is converted into rotary motion in the runner's shaft. This shaft is coupled directly or belted to either a permanent magnet alternator, or a "synchronous" or induction AC Generator.

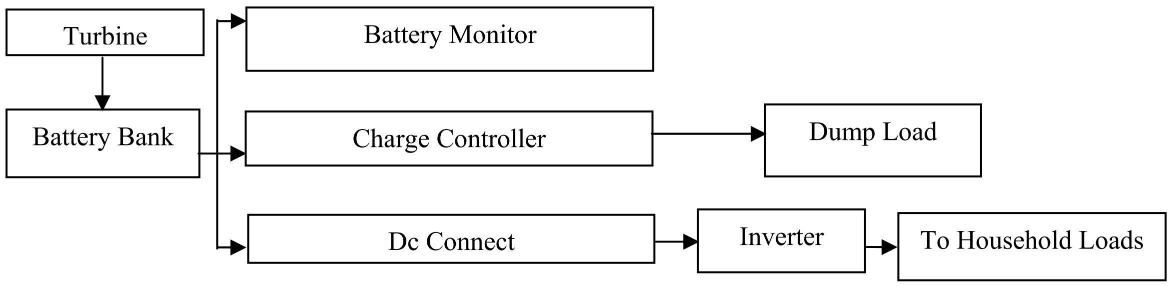

Fig. 2. Off-grid battery based hydro-electric system

Controls (Charge controller, regulator):

The function of a charge controller in a hydro system is equivalent to turning on a load to absorb excess energy. Battery based hydro systems require charge controllers to prevent overcharging the batteries. Controllers generally send excess energy to a secondary (dump) load, such as an air or water heater. Unlike a solar-electric controller, a micro hydro system controller does not disconnect the turbine from the batteries. This could create voltages that are higher than some components can withstand, or cause the turbine to over speed, which could result in dangerous and damaging over voltages. A load–control governor monitors the voltage or frequency of the system, and keeps the generator correctly loaded, turning dump-load capacity on and off as the load pattern changes, or mechanically deflects water away from the runner.

Dump Load (Diversion load, shunt load):

A dump load is an electrical resistance heater that must be sized to handle the full generating capacity of the micro hydro turbine. Dump loads can be air or water heaters, and are activated by the charge controller whenever the batteries or the grid cannot accept the energy being produced, to prevent damage to the system. Excess energy is "shunted" to the dump load when necessary.

Battery Bank (Storage battery):

By using reversible chemical reactions, a battery bank provides a way to store surplus energy when more is being produced than consumed. When demand increases beyond what is generated, the batteries can be called on to release energy to keep the household loads operating. A micro hydro system is typically the most gentle of the RE systems on the batteries, since they do not often remain in a discharged state. The bank can also be smaller than for a wind or PV system. One or two days of storage is usually sufficient. Deep-cycle lead-acid batteries are typically used in these systems. They are cost effective and do not usually account for a large percentage of the system cost.

OFF-GRID AREAS OF CHITTAGONG

The current off grid areas are as follows:

- Khagrachari
- Rangamati
- Bandarban
- Juldah
- Kutubdia
- Saintmartin
- Sandwip

Small Hydro Power Plant

There is a good potentiality of hydro power plant in Chittagong hill tracts as we have found from a source of BPDB Sealock river in CHT has a electrical potentiality of 81 KW, Lungichara and Budichara both has potentiality of 10 KW each. Several attempts has been made in the past to find out the potential of Small and Micro-Hydro power unit in Bangladesh which believed to be more environment or ecologically friendly in comparison to large hydro with dams. However the first Micro-hydro power unit at Monjoypara over Hanra Canal of Bandarban District is installed by Mr. Aung Thui Khain, a tribal of Marma community. The present output of this unit is 10 KW and supply electricity to 40 households in the locality. He has been used low cost indigenous appropriate technology.

Table 3. Mini hydro power generation in Chittagong & Bandarban districts

Name of River	Estimated avg monthly discharge	Approx duration of flow	Probable fall for hydro power generation	Electrical Energy in KW	Annual production in KWh	Types of generation
Faiz lake	15cfs	Constant all the year round	39.5ft	4KW	35,040	Micro
Choto kumiraChara	11cfs	-do-	20ft	15KW	131,400	Micro
Hinguli Chara	12cfs	-do-	15ft	12KW	1,05,120	Micro
Sealock	40cfs	-do-	30ft	81KW	7,09,560	Micro
Longi Chara	15cfs	-do-	10ft	10kKW	87,600	Micro
Budia Chara	6cfs	-do-	25ft	110KW	87,600	Mini
		TOTAL			11,56,320	

It has been understood that such Micro Hydro unit could be the most feasible and cost effective solution for electricity production in the off-grid Chittagong hill Tracts region. The whole CHT region are criss-crossed by numerous "Chara/Lake" that hold the potentials for harvesting hydro electricity for socio-economic development of local tribal community. It may be mentioned that LGED has already established GIS (Geographic Information System) setup in these hill Districts and this technology will be useful for identification of potential char. LGED has also came forward to provide assistance to Aung Thui Khayans initiatives. Moreover installation of 15KW Micro-Hydro unit at Bamerchara in Chittagong District is under consideration of Sustainable Rural Energy (SRE) Project.

Micro Hydro Potential

Several attempts have been made in the past to find out the potential of micro-hydro power generation which is believed to be more environment or ecology friendly in comparison to large hydro with dams. Map showing Micro Hydro Potential Sites in Bangladesh.

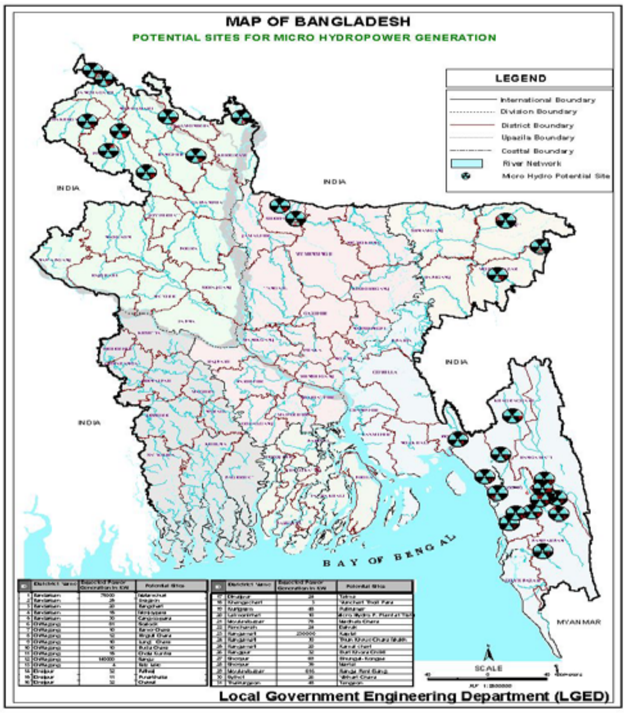

Figure. 3. District wise small hydro power system

RESULTS AND DISCUSSION

According to project on "Feasibility study of RD Renewable Energy" undertaken by Institute of Fuel Research Development (IFRD) of Bangladesh Council of Scientific and Industrial Research (BCSIR) the head and water flow measured. In 2008, from January to December IFRD had taken the reading of water flow (discharge data) and head in Mahamaya Chara. The monthly discharges data is shown in Table 4. We can say that when flow rate is high, head is low and vice versa.

Table 4. Average monthly flow and head at Mahamaya Chara

Month	Flow (meter)	Head (meter)
Jan.	5.8	11.4
Feb.	4.9	9.9
March	5.4	8.1
Apr.	5.1	5.3
May	2.2	4.3
June	2.0	7.8
July	2.0	10.8
Aug	2.0	13.3
Sep	2.0	14.0
Oct.	2.1	14.0
Nov.	2.6	13.7
Dec.	3.8	13.0

Initially the height of the water behind the proposed dam rises and then we measure the head of water that will result. To determine the difference in level between two points, we set a surveyor's level about midway between the points. Then one person stand with a surveyor's rod at one point, and see the level of water and recorded the height reading on the rod. Moving the rod to the second point and similar measurement are taken. The difference of the two readings gives the difference in elevation of the two points. Often it is impossible to see the two points from a single setting of the level so rods must be read at intermediate or turning points. The differences in readings between each pair of points can be added together to calculate the total depth of the dam or diversion and then calculate the average depth. After measuring the average depth, we measure the average velocity of water as shown in Table 5.

Table 5. Tidal current velocity ranges in different dates and times

Date	Day time 24hr	Velocity m/s	Day time 24hr	Velocity m/s	Total 24hr	Average Velocity range m/s
21.09.08	11.00-13.00	0.64-0.748	13.30-14.30	0.88-0.96	03	0.64-0.96
22.09.08	9.00-13.00	0.55-0.78	14.00-16.00	0.92-1.00	06	0.55-1.00
05.10.08	11.00-12.30	0.44-0.80	13.30-17.00	0.90-0.94	05	0.44-0.94
27.10.08	10.00-13.00	0.563-0.75	13.30-18.00	0.55-0.78	7.5	0.563-0.78
02.11.08	9.30-13.30	0.66-0.889	14.00-17.30	0.80-0.90	7.5	0.66-0.90

Hydrological Data:

Average Depth:
D1=0.45m, D2=0.50m, D3=0.6m, D4=0.7m, D5=0.6m, D6=0.55m, D7=0.65m
Average Depth: (D1+D2+D3+D4+D5+D6+D7) ÷ 7 = 0.578m
Average Cross-sectional Width of the river: W=30m
Lowest flow throughout the year = 12.9m^3/sec.
Av. Flood level (September-November) = 0.78m
Av. Flood level (June-August) = 7m
Highest flood level = 10.00m (Occasionally)
Measured head, H = 0.786m.
Average velocity, V = 0.7433m/s.
Area, A = 17.36m^2
Flow, Q = AV
= 17.36*0.7433m^3/s
= 12.90m^3/s.

Gravitational acceleration, G = 9.81m/s^2
Density of water, ρ = 1000kg/m^3
Turbine efficiency = 50%, (as a rule of thumb turbine efficiencies are 50%).

Turbine output power (KW)

P= Efficiency (%) x Flow (m^3/s) x Head (m) x Gravity (9.81m/s^2) x Density of water (ρ)
=0.5*12.9*0.786*9.81*1000 = 49.73 KW

From the above calculation we have seen that the output power is 49.73 KW which is under mini Hydro system in Chittagong. If we install a several number of mini and small Hydro in different location then a large output power generation is possible. To obtain the amount of energy (KWh) produced, we have to, multiply the practical power capacity by the time (hours). The plant will be operating at the particular output. Seasonal flow variations will have to be considered for more applications, as the maximum flow may only be available for short periods each year.

CONCLUSION

From our study we have found that the potential sites in Chittagong Hill Tracts (CHT) are suitable for mini and small Hydro generation. The expected power generation of mini hydro is below 100 KW. Small and mini hydro electric projects are renewable energy sources. This project will be useful for small irrigation scheme. These are eco-friendly. This system gives the power supply into the remote areas. It has low generating cost and better plant efficiency. It reduces the maintenance cost and the dependence on natural gas, coal, oil. Provide much cleaner and sustainable energy that they would not pollute environment. Relatively small investments are needed that are within the reach of low-income communities.

REFERENCES

Chapman J, Stephen (2008) Electric Machinery Fundamentals, 4^{th} ed, Mc Graw Hill 250-316.

Gupta JB (2007) Electrical Machines, 6^{th} ed. S.K. Kataria & Sons 59-96.

Khurmi RS (2006) Hydraulics, Fluid Mechanics and Hydraulic Machines,1^{st} ed. S. Chand 508-512.

Skrotzki GA, Vopat WA (1999) Power Station Engineering and Economy, 1^{st} ed. Mc Graw Hill 272-288.