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Article

A Case Study of the Notion and Model Of Micro Hydro Power Plant Using the Kinetic Energy of Flowing Water of Burinadi and Meghna Rivers of Bangladesh

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Abstract. Bangladesh is progressing through a stage of development where automation is the solution to its economy. At this stage for the progression of this country electricity is very vital to sustain the economic growth. These days it becomes extremely challenging to cope up with the required energy demand of the country. Continuous increase in price of fuel in the world market and also the unavailability of fuel are the reasons behind this. On the other hand fuel burning in energy generation is responsible for global climate change and Bangladesh residing in high risk of this. Renewable energy can be an immense hope under this circumstance. The country is blessed with a good number of rivers consisting adequate flow of water throughout the year. Harnessing this driving water of rivers can be a great source of kinetic energy and utilizing this kinetic energy of driving water Hydro Electricity can be produced. In this paper the real life practical data of Burinadi & Meghna Rivers were considered. A system is introduced that does not need the Dam or Reservoir to produce Electrical Power and is observed that 21.1MW-hr & 12.48MW-hr worth of energy can be produced annually from Burinadi & Meghna Rivers respectively. This extent of power can be very useful for these rivers nearby inhabitants in remote areas as they are still out of national grid range.

Keywords: Hydro, electricity, renewable energy, gas, Burinadi, Meghna, river.

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1. Introduction

Energy is the most fundamental sector for the progression of a nation. The production of energy is going on from many years for the need of energy in all around the world but the true scenario is that the whole world is currently facing dreadful energy crisis in spite of numerous energy sources. The current demand for energy exceeds the available resources and this gap is projected to widen significantly in the imminent future and Bangladesh is no exception [1]. The demand for electricity is on the rise in Bangladesh due to growing population and increasing economic activities. With the pace of economic development, the use of electricity increases in industrial, agricultural and other sectors. But the country cannot conform to the pace of energy demand thereby there is now a lack of adequate power generation capacity, and the existing national grid network is incapable to power the whole population. The per capita energy consumption in the country is 252 kWh which is very low compared to other developing countries [2]. As Electricity is a major element for country's most of the economic activities, in recent years, due to power supply shortage the pace of establishment of essential physical infrastructures, building up of new power plants and industrialization in the country has slowed down. It is, therefore, mandatory to promote our power sector in order to ensure the development of this country [3]. The percentage of population under the coverage of electricity supply is only around 49 percent and in the rural areas, where more than 70% of the population lives, only 25% have electricity. Bangladesh has the installed range of the power plants of around 8000 MW for meeting the demand of around 7000 MW. However due to failure in the proper fuel management, increase in energy demand and lack of infrastructures in the last few years the whole country is suffering from 1000-1800 MW of electricity. Around 1000 MW of power could not be generated from the public power plants due to shortage of gas as fuel and so on. [4]. It is also notable that energy demand is much higher during irrigation period than the other period. The energy production of Bangladesh is mainly dependence on fossil fuel but the resources of fossil fuel are limited and it's using results in global warming [5]. Thereupon, to encounter the growing energy demand, the government of Bangladesh has enhanced focus on renewable energy in the past decade. Bangladesh is endowed with vast renewable energy resources such as biomass and solar energy. Besides, hydro and wind power can be considered as potential renewable energy resources. Harnessing these resources appears to be a promising solution for improving the quality of life of rural villagers [6]. At present, Bangladesh is producing only 70 MW of electricity from its renewable energy sources. As potential renewable energy resources, Hydropower will have a significant important role in the approaching future. Bangladesh has one hydro power plant in Kaptai, Chittagong having generation capacity of 240 MW. That means this technology is not premature for Bangladesh. Hydroelectric plants are immune to increases in the cost of fossil fuels such as oil, natural gas or coal, and do not require fuel to be imported [7]. On the other hand, international research confirms that the emission of greenhouse gases is substantially lower in the case of hydropower compared to that generated by burning fossil fuels. From the economical point of view, the utilization of half of the feasible potential can reduce the emission of greenhouse gases by about 13%; also it can substantially reduce emissions of sulphur dioxide (main cause of acid rains) and nitrogen oxides [8]. If we can boost up the renewable energy sector with proper investment and ambitious policy, only then we could possibly get energy security and able to eradicate all the problems in a sustainable way [3]. Ensuring access to clean energy could provide multiple benefits for the world's poor, easing to meet basic needs and essential services, augmenting educational opportunities, decreasing pollution related health risks and soothing environmental hazards [9].

2. Location, Geography and GDP of Bangladesh

The People's Republic of Bangladesh, is located between 20^0 34' and 26^0 38' north latitude and between 88^0 01' and 92^0 41' east longitude [10]. Bangladesh has an area of 147,570 square kilometers and extends 820 kilometers north to south and 600 kilometers east to west. On the south is a highly irregular deltaic coastline of about 580 kilometers, fissured by many rivers and streams flowing into the Bay of Bengal. The country is divided into 7 divisions (regions): Dhaka, Chittagong, Rajshahi, Rangpur, Barisal, Sylhet and Khulna. The population of Bangladesh is reached at 152.51 million which made the country most densely populated [11].

There are almost 310 rivers and their tributaries crisscross the country of which the major rivers of the countries are Padma (Ganges), Jamuna, Meghna, Bramhaputra, Surma and Karnafuli. More than 90% of Bangladesh's rivers are originates outside the country. Three major types of landscapes are found in Bangladesh: floodplains (80%), terraces (8%), and hills (12%). Excepting the eastern hilly region, almost all of the country lies in the active delta of three of the world's major rivers: the Ganges, the Brahmaputra, and the Meghna (GBM Out of these, 57 rivers is Tran boundary, which originates from India and Myanmar. Apart from the south-eastern region, other parts of the country are mostly flat in nature [7]. During the annual monsoon period, the rivers of Bangladesh flow at about 140,000 cubic meters per second, but during the dry period they diminish to 7,000 cubic meters per second. The north western section of the country, drained by the Teesta River, is somewhat higher and less flat, but the only really hilly regions are in the east, notably in the Chittagong Hill Tracts to the southeast and the Sylhet District to the northeast. Near the Myanmar border in the extreme southeast is the Keokradong, which, at 1,230 m (4,034 ft), is the highest peak in Bangladesh [12]. Bangladesh has a tropical monsoon climate formed of wide seasonal variations in rainfall, high temperatures and high humidity. The climate in the country maintain a major three-season cycle: Summer (March-May), rainy season (June-September) and winter (December-February). The standard maximum and minimum temperatures are 26.5 and 13.9°C respectively in winter. On the other hand, the corresponding respective values in summer are 32.6°C and 22.4°C. The annual highest and lowest temperature is 30.4°C and 21.2°C respectively and while rainfall is 203 mm [13].

Bangladesh is a developing economy; since 1996 the economy has developed at a pace of 5-6% per year. More than half of the country's GDP is generated from the service sector. However, more than 40% of Bangladesh's population is engaged in agriculture. Presently, production and export of garment makes a significant contribution to the economy of the country [14]. At present, Bangladesh has a GDP of total $105.00 billion (at the rate of 2010-11), whereas GDP per capita is $775 and GDP growth rate is 6.32% [15]. GDP grew 6.7 percent in fiscal year 2011 compared to 6.1 percent in the previous year.

A pie chart showing the contribution of different sectors in the country economy is given in Fig. 1. Figure 2, is a pictorial representation of the Bangladesh map showing different rivers throughout the country is illustrated for a better comprehension about the potentiality of hydro energy in Bangladesh.

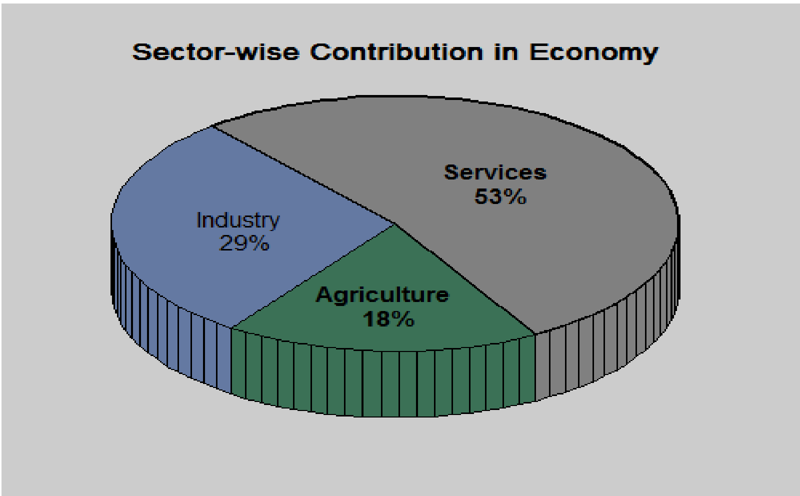

Fig.1. Contribution of different sectors in GDP of Bangladesh [16].

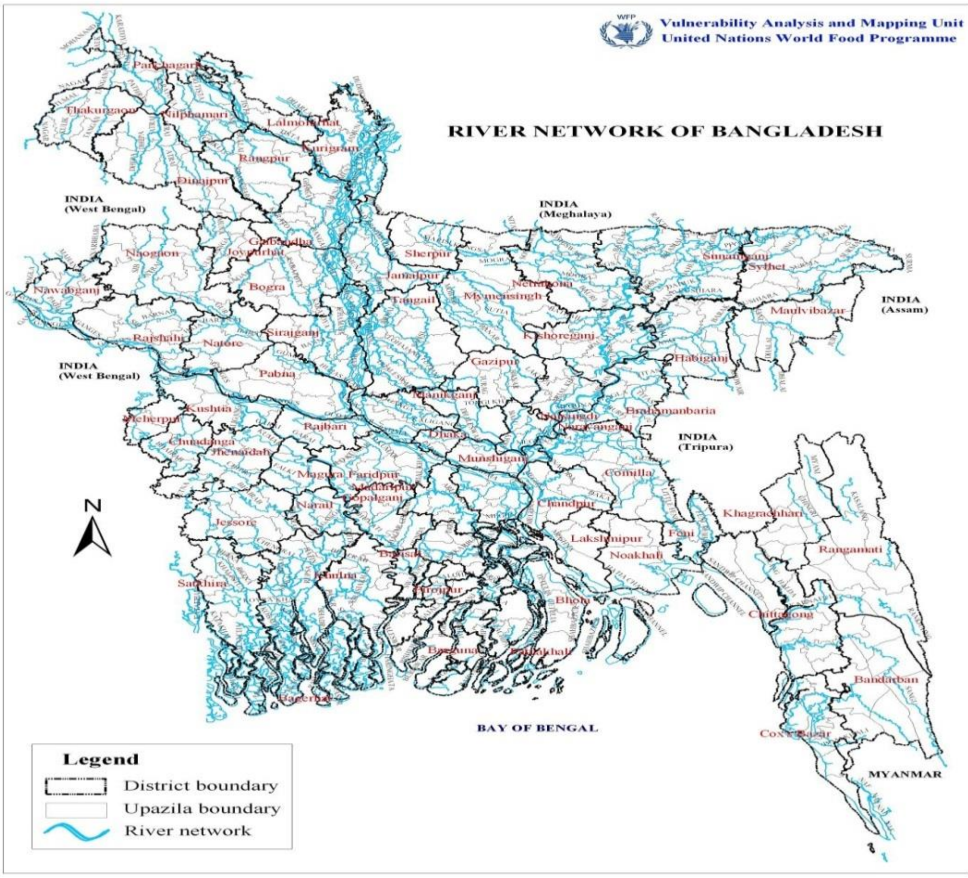

Fig. 2. Rivers of Bangladesh [17].

3. Contemporary Energy Scenario in Bangladesh

This segment of the paper demonstrates a concise overview of the status of power generation in Bangladesh. With the rapid growing energy demand it is being difficult for Bangladesh to meet required power generation. It is also observed that the demand for electricity has been increased with a rate of 5.43 percent per year whereas, the generation of electricity with a rate of 5.37 percent per year between 2007 and 2011. The lower increasing rate of generation (5.37 percent) than that of the demand (5.43 percent) has accelerated the rate of load shedding which has been increased at a rate of 6.72 percent per annum during the same period [18]. Due to the increasing demand for electricity, BPDB has taken steps to install new power plants and to meet up emergency demand the Government of the country is now trying to lessen the power crisis by taking several initiatives like small (10-20 MW) power plants, independent power producer (IPP), Quick Rental power plants [QRPP] etc. But these are not a permanent solution. Moreover, QRPP and IPP are mainly oil and gas based, which are very costly and these are also not very efficient. BPDB's per unit cost of purchasing electricity during 2009-10 was TK. 2.62, which increased to TK.4.05 in 2010-11 [17]. Consequently, the Government's subsidy in this sector is increasing as the Government has to provide subsidy as it purchases electricity from the private producers at a high price and distributes it at a low price among the people. In the meantime, though, a large number of different types of power plants synchronized them with the national grid along with public and private sector, Bangladesh still facing scarcity to conform to the energy demand. In FY 2012, Generation capacity (both public and private) has increased to about 8300 MW as shown in Table 1.

Table 1. Power Generation capacity (MW) as in July 2012.

Public Sector	**Generation Capacity (MW)**
BPDB	3600
APSCL	682
EGCB	210
RPCL	52
Subtotal	4544 (55%)
Private Sector	**Generation Capacity (MW)**
IPPs	1297
SIPPs(BPDB)	99
SIPPs(REB)	226
15 YEAR Rental	169
3/5 YEAR Rental	598
Quick Rental	1382
Subtotal	3771 (45%)
TOTAL	**8315**

According to new plan of the Government, targets for additional 12473 MW by 2015 and 15273 MW by 2016 have been set up. Under this plan, 500 MW imported electricity will be added to the national grid by 2013. The comparative scenario of the stated plan is presented in Table 2:

Table 2. A comparative picture of Electricity Production Plan [19].

	Plan Outlined in 2010			**Revised Plan**		
Year-wise plan	**Public Sector**	**Private Sector**	**Total (MW)**	**Public Sector**	**Private Sector**	**Total (MW)**
2010	360	432	792	255	520	775
2011	920	--	920	851	1343	2194
2012	505	1764	2269	838	1319	2157
2013	725	950	1675	1040	1134	2174+500 (Import)
2014	1170	--	1170	1270	1053	2323
2015	--	2600	2600	450	1900	2350
Total	**3680**	**5746**	**9426**	**4704**	**7260**	**12473**
2016				1500	1300	2800
Additional Aggregate				**6204**	**8569**	**15273**

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Based upon a preliminary study by Bangladesh Power Development Board (BPDB) the anticipated peak demand would be about 10,283 MW in FY2015, 17,304 MW in FY2020 and 25,199 MW in 2025. According to PSMP- 2010 Study year-wise peak demand forecast is given in Fig. 3.

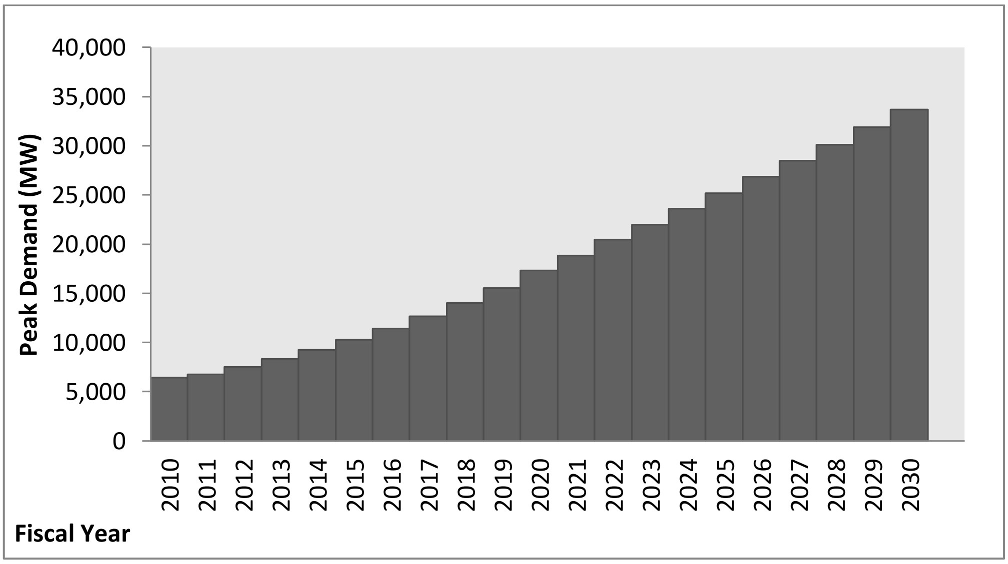

Fig. 3. Study year-wise peak demand forecast [20].

While the demand for electricity is increasing, the production capacity of existing power stations is falling. In spite of the existing gap between the demand for and the supply of electricity, it is projected that Bangladesh will be a power surplus country by 2012. The potential deficit/surplus of electricity during 2011 to 2016 is shown in Fig. 4.

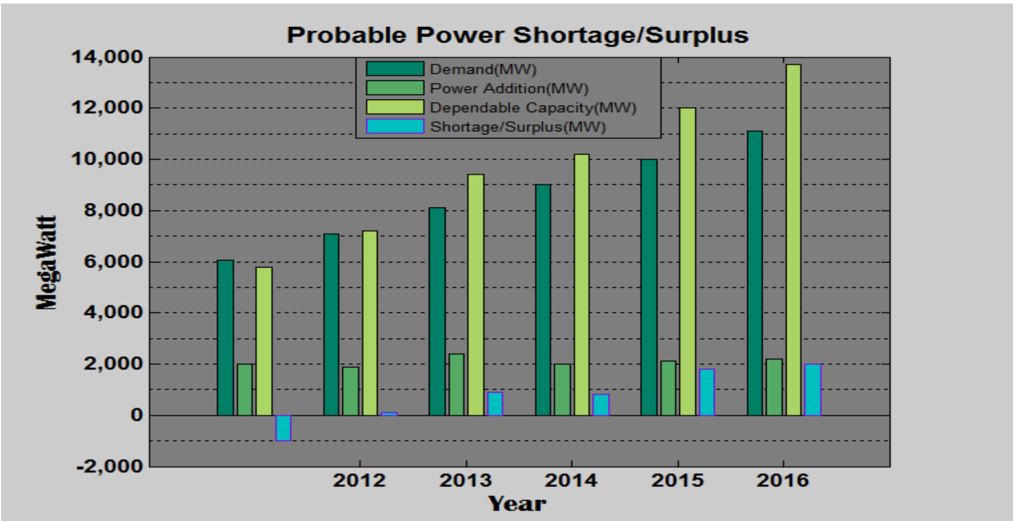

Fig. 4. Probable power shortage/surplus (2011-2016) [19].

But the literal scenario of progressing power generation is different than the projected generation by the BPDB due to crisis of fuel, ill management and corruption.

4. Fuel Shortage and Renewable Energy Resources in Bangladesh

This part of the paper explains ongoing fuel crisis in Bangladesh and its renewable energy sources. Electricity is produced from domestic gas and a little percentage through hydro power in the Eastern part of Bangladesh. Whereas in the Western part of the country, Coal and imported liquid fuel is used for generation of electricity. A pie chart showing the contribution of different fuels in the Total Generation Capacity of 8351 MW is shown in Fig. 5.

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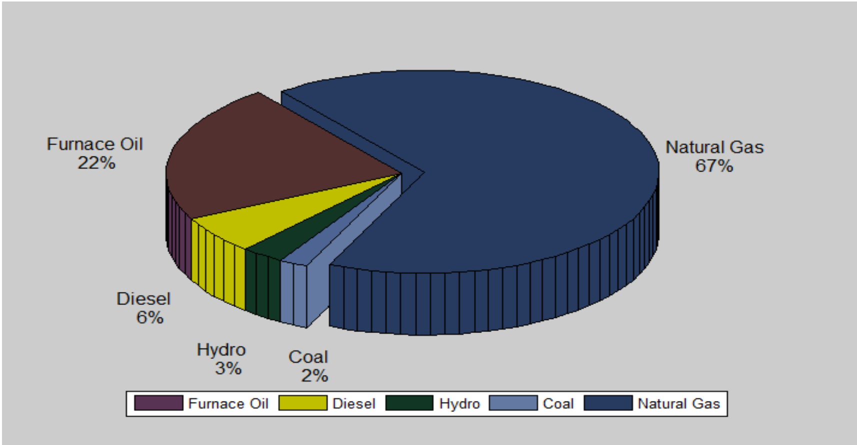


Fig. 5. Installed capacity by different resources as in July 2012 [21].

A good number of generation units have become very old and have been operating at a much-reduced capacity. As a result, their reliability and productivity are also poor. The major fuel source for power production is the natural gas in Bangladesh. Therefore, due to the shortage of gas supply, some power plants are unable to utilize their usual generation capacity and some are went out of order [22]. Also in the country, gas is not only being used in electricity generation but also used in different purposes. One of the key resources for dealing to deal with the existing and projected shortage of gas supply is to explore new gas fields and to re-evaluate the stock of existing gas fields in order to determine the actual reserve and to take initiatives to increase supply by excavating well in large number. This calls for huge investment and highly technological, technical and professional skills to implement this initiative. Exploration of gas and oil is a capital intensive venture and also a risky investment. According to a survey report, it requires around Tk. 700 crore to explore a gas field having a level of deposit that is commonly found. However, the success rate in this case could be only 20-25 percent. The developing countries cannot afford to make this kind of huge investment for exploration and extraction of gas even though there is a possibility of obtaining this energy resource [19]. As an alternative fuel to natural gas, coal can be extensively used. But being a densely populated country, it is very troublesome to rehabilitate the people in the mine areas of Bangladesh. Moreover, coal burning is the main point of CO_2 emission which now-a-days is a burning discussion. In addition, Furnace oil is accounted for slightly less than 22% energy generation. Although there is no Oil field in Bangladesh, the only way to fulfill the existing demand is to import from International market. As a result the Government needs to share a huge subsidy each year. The consistent rise of oil price in International market and to reduce the subsidy Government has impelled to increase the price of all types of oil including diesels for four times in the year 2011 [23]. Furthermore, Government is trying to build a Nuclear power station with the help of the Russians; however it is still a question about the massive financial cost for this sort of power plant. As an alternative of mainstream energy, the government of Bangladesh is now looking to explore the potential of low cost renewable energy sources. Out of various renewable sources solar, biomass, wind energy and hydro-power can be effectively used in Bangladesh. Targets of power generation from renewable energy sources as fixed by the Government are presented in Table 3.

Table 3. Targets of electricity generation by 2015 from Renewable Energy Sources and Achievements till date [24].

Classification	Production(MW)-2015	Achievement(MW)-2011
Solar PV	200	50
Wind Power	200	2
Biomass	45	<1
Biogas	45	<1
Others	15	<1
Total	500	55

5. Micro Hydro as a Source of Renewable Energy in Bangladesh

The government of Bangladesh has given top priority to the development of the power sector considering its importance in the overall development of the country. Current of river water and low head of water fall may be used for harnessing hydro-power. Hydropower is usually classified by size (generating capacity) and the type of scheme (run-of-river, reservoir, pumped storage). Although definition varies, the following bands are typical to describe the size of hydropower projects [25].

Table 4. Classification of hydropower by size.

Type of Hydro	Definition
Large-hydro	100 MW or more of capacity feeding into a large electricity grid
Medium-hydro	20 MW to 100 MW range almost always feeding a grid
Small-hydro	1 MW to 20 MW usually feeding into a grid
Mini-hydro	100 kW to 1 MW that can be either stand-alone, mini-grid or grid connected
Micro-hydro	5 kW to 100 kW that provide power for a small community or rural industry in remote areas away from the grid
Pico-hydro	From a few hundred watts up to 5 kW (often used in remote areas away from the grid)

BP, one of the world's largest oil and gas companies, published "Statistical Review of World Energy June 2012" on the consumption of hydroelectricity of different countries. The energy consumption (in million tonne of oil equivalent) in different countries of Asia is shown in Table 5.

Table 5. Hydroelectricity consumption (Million tonnes oil equivalent) in different countries of Asia [26].

	2007	2008	2009	2010	2011	Share of Total Energy Consumption
China	109.8	132.4	139.3	163.4	157.0	19.8%
Japan	17.5	17.5	16.4	20.6	19.2	2.4%
India	27.7	26.0	24.0	25.0	29.8	3.8%
Pakistan	7.1	6.1	6.4	6.7	6.9	0.9%
Philippines	1.9	2.2	2.2	1.8	2.1	0.3%
Thailand	1.8	1.6	1.6	1.3	1.8	0.2%
Bangladesh	0.3	0.3	0.4	0.3	0.3	<<0.05%

It is immediately apparent that among all these countries in Asia, pace of development of the Hydroelectricity sector in Bangladesh is extremely low, resulted less than 0.05% energy consumption from Hydro power of its total energy feeding. However, a good numbers of rivers of Bangladesh are flowing with consistent velocity through the year. Current of these river water could be used as a promising renewable energy source. In the country about 1.4 trillion cubic meters of water flows through the country in an average water year. Major rivers of the country have a high rate of water flow of about 5 to 6 months during monsoon season [27]. Currently, the three main rivers that flow through the flat plains of India and Bangladesh (the Ganges, Brahmaputra and Meghna) discharge an average of 2.5×10^4 m^3 s^{-1} to the Bay of Bengal. These rivers flow rate or moving water are source of kinetic energy. By utilizing this kinetic energy we can produce the Hydroelectricity. Therefore, run of rivers of the country could use as an effective renewable energy source. Harnessing a stream for hydroelectric power is a major undertaking. Careful planning is necessary for a successful and economic power plant [28]. When it refers to the economics of a hydro plant, several things must be kept in mind: development, operating, and maintenance costs, and electricity generation [29]. Though researchers confirmed it that this source of power production is economically viable compared to other renewable energy sources such as wind. Although sound in theory, practical implementation and performance analysis toward designing a cost-effective system and displaying its effectiveness is subject to in-depth investigation, research and entrepreneurial venture. In contrast to large or micro hydro turbines, river current energy could be used as distributed systems installed over a large river basin area. Therefore, environmental adversities attributed to the former group are expected to be minimal for the proposed case. However, a thorough investigation on turbine usage and its effect on natural flow of the river, impact on river course, ecosystem, and wildlife would only reveal the true extent of such assumption [30]. The most significant use of micro hydropower is the off-grid decentralization of its surrounding areas such as villages. Micro-hydropower meets smooth and stable power supply. Thus, the surrounding areas of individual generating stations can be easily powered and it is very economical. This will reduce consumer demand on the national grid network. Moreover, micro-hydropower stations can always be fed to the national grid. Micro-hydropower projects are generally considered to be more environmental friendly than both large hydro and fossil fuel-powered plants. With all these advantages, micro-hydropower can be implemented as principle renewable sources for sustainable development especially in developing countries like Bangladesh [31]. It is therefore high time, to explore the hydro power sector in depth and investing more money to support the infrastructure development and hydro power research to mitigate the ongoing power shortage, for the government of Bangladesh. Managing fund for Micro-hydropower project, on a practical level, could be critical issue for developing countries like Bangladesh. There are some donor agencies or global financial institutions which contribute for green technology and reduction of carbon emission. Green technology fund can be obtained from World Bank Climate Investment Funds, The Least Developed Countries Fund (LDCF), and The Adaptation Fund [32]. Besides these available funds, there are also some internationally recognized mechanisms, which create opportunity for developing nations to generate funds for implementing any green project in their country. Two of such mechanisms are CDM (Clean development mechanism) and Carbon finance. Regardless of the reason for wanting to develop a micro-hydro project, an appropriate location is required for the project. Choosing a site is one of the most important steps in development, as it will largely determine the amount of energy that can be developed and the complexity of site development [31]. In this paper, as a potential source of Hydro power using the kinetic energy of driving water various data of the Burinadi and Meghna rivers has been analyst and then calculated the attainable power. It is also suggested that this type of project could be built in the place, taking for instance, Daudkandi, Comilla, where Meghna is joined by the great river Gumti, created by the combination of many streams. This river reinforces Meghna a lot and increases the water flow considerably. However, before taking initiative to build this type of power plant a thorough investigation would be needed to confirm that the project is suitable economically as well as environmentally.

6. Estimation

The maximum power output from a turbine used in a run of river application is equal to the kinetic energy of the water impinging on the blades. Taking the efficiency η of the turbine and its installation into account, the maximum output power P_{max} is given by

$$P_{max} = \frac{1}{2} \eta\rho QV^2 \tag{1}$$

Here, v is the velocity of the water flow (m/s); Q is the volume of water flowing through the turbine per second (m^3/s); and ρ is the water density equal to 10^3 Kg/m^3. Q is given by: $Q=Av$. Here, A is the swept area of the turbine blades (m^2) equal to πr^2.

Thus, the maximum available power in the water flowing at mean velocity V through a water rotor blade with sweep area A at any given site[30] can be estimated as follows:

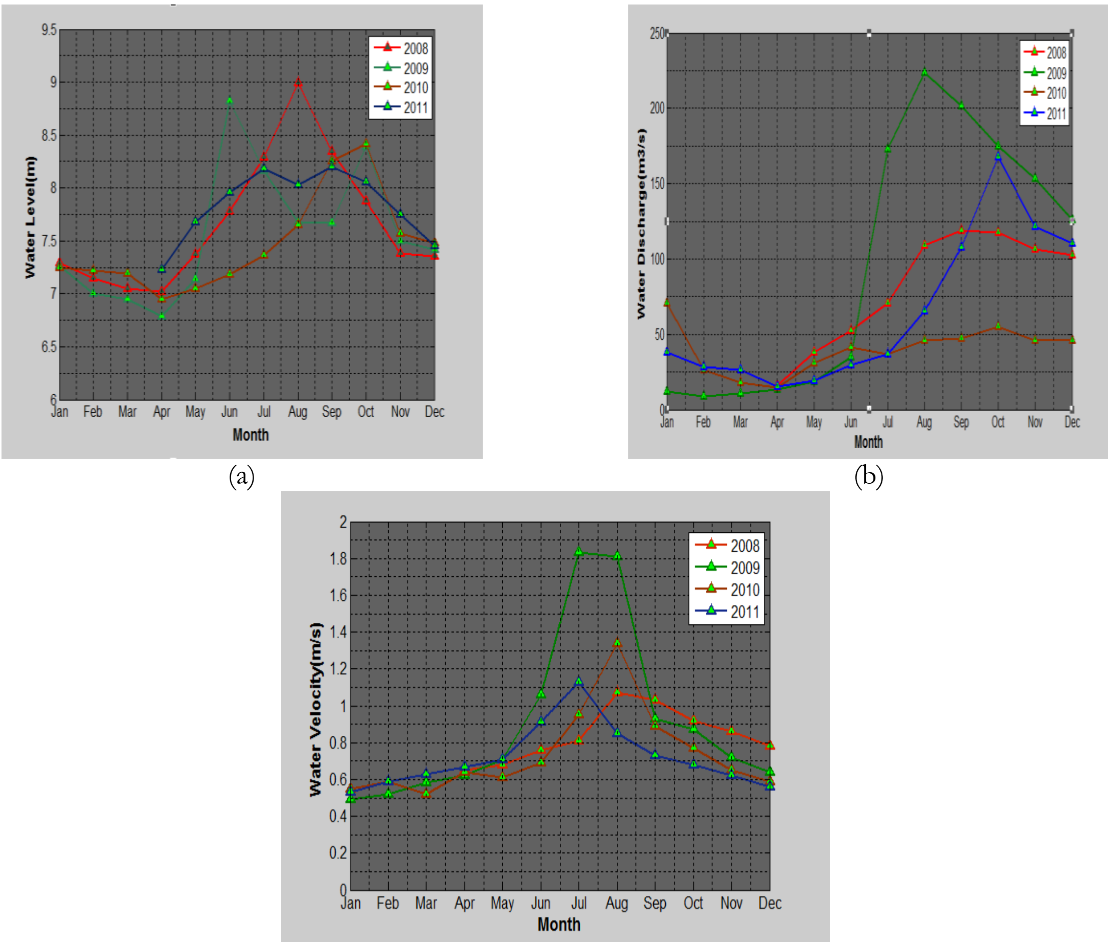
$$P_{max} = \frac{1}{2} \eta\rho AV^3 \tag{2}$$

This relationship is directly analogous to the equation for the theoretical power generated by wind turbines. Most of the principles of this type of turbine are based upon wind turbines, as they work out in a similar way. Taking into account the other factors e.g. the gearbox, bearings, and generator of water turbine only 10-30% of the power of the water is ever actually converted into usable electricity. Hence, the power coefficient needs to be factored in equation (1) and the extractable power from the run of river is given by:

$$P_m = \frac{1}{2} \eta\rho AV^3 C_p \tag{3}$$

Here, C_p is the power coefficient, a measure of the fluid-dynamic efficiency of the turbine and it is defined as the ratio between electricity produced in water turbine and total energy available in the water and the generalized value for C_p is in a range of 0.35 to 0.45. A German physicist Albert Betz concluded in 1919 that no wind turbine can convert more than 59.3% of the kinetic energy of the wind into mechanical energy turning a rotor. Once we incorporate various engineering requirements of a wind turbine - strength and durability in particular – the real world limit is well below the *Betz Limit* with values of 0.35-0.45 common even in the best designed wind turbines [33]. This case is analogous to water turbine. Extracted power from river current is directly proportional to the power coefficient of water turbine. However, power coefficient depends on the radius of the blade of turbine and water velocity. Considering the frictional losses, blade surface roughness and mechanical imperfections and own loss micro hydro turbine results reduce the power coefficient, thereby power available in the water is extractable under practical conditions is 40%, so the value of C_p has taken as 0.4 in our study.

7. Results and Calculation



(c)

Fig. 6. (a) Water level of the Burinadi River at different months of the years; (b) Water discharge of the Burinadi River at different months of the years; (c) Maximum water velocity of the Burinadi River at different months of the years.

Here, all the calculations have been done based on the real life data taken from the Water Development Board of Bangladesh (BWDB):

Total maximum velocity, $V = 36.24$ m/s

Average velocity, $V = 36.24 / 45$

$= 0.81$ m/s

The maximum velocity is divided by 45 because we dealt with 45 sets of data.

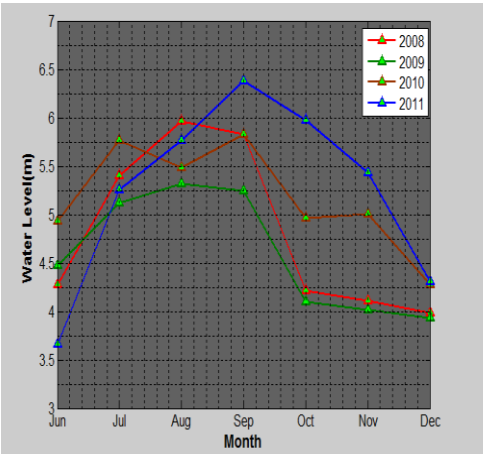
Assume that, the radius of the water turbine, r = 3 m

Input power:
$$\begin{aligned} P &= \frac{1}{2}\rho A V^3 \\ &= \frac{1}{2}\times 1000\times 3.1416\times 3^2\times 0.81^3 \\ &= 7513.09\ \text{W} \\ &= 7.51\ \text{kW} \end{aligned}$$

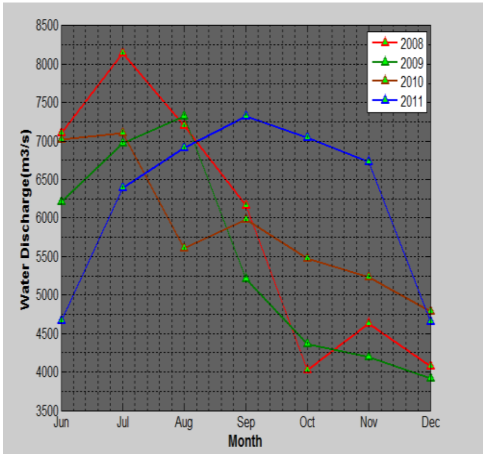
Operational calculation:
$$\begin{aligned} P_m &= \frac{1}{2}\rho A V^3 \times C_p \\ &= 7.51\times 0.40\ \text{W} \\ &= 3.01\ \text{kW} \end{aligned}$$

Output or electrical power:
$$\begin{aligned} P_e &= \frac{1}{2}\rho A V^3 \times C_p \times \eta \\ &= 3.01\times 0.80\ \text{[Efficiency taken as 80%]} \\ &= 2.41\ \text{kW} \end{aligned}$$

Energy:
$$\begin{aligned} E &= 2.41\times 24\ \text{kW}\cdot\text{hr (in a day)} \\ &= 57.792\times 365\ \text{kW}\cdot\text{hr (in a year)} \\ &= 21{,}094.08\ \text{kW}\cdot\text{hr} \\ &= 21.1\ \text{MW}\cdot\text{hr (per annum)} \end{aligned}$$



(a)



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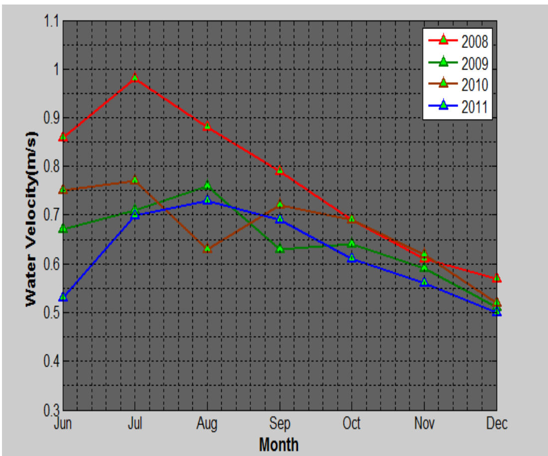

(c)

Fig. 7. (a) Water level of the Meghna River from June to December; (b) Water discharge of the Meghna River from June to December; (c) Maximum water velocity of the Meghna River from June to December.

Here, all the calculations have been done based on the real life data taken from the Water Development Board of Bangladesh (BWDB):

Total maximum velocity, $V = 18.96$ m/s

Average velocity, $V = 18.96/28$

$= 0.68$ m/s

The maximum velocity is divided by 28 because we dealt with 28 sets of data.

Input power:

$$P = \frac{1}{2}\rho A V^3$$
$$= \frac{1}{2} \times 1000 \times 3.1416 \times 3^2 \times 0.72^3$$
$$= 4445.19 \text{ W}$$
$$= 4.45 \text{ kW}$$

Operational calculation:

$$P_m = \frac{1}{2}\rho A V^3 \times C_p$$
$$= 7445 \times 0.40 \text{ W}$$
$$= 1.78 \text{ kW}$$

Output or electrical power:

$$P_e = \frac{1}{2}\rho A V^3 \times C_p \times \eta$$
$$= 1.78 \times 0.80 \text{ [Efficiency taken as 80\%]}$$
$$= 1.424 \text{ kW}$$

Energy:

$$E = 1.424 \times 24 \text{ kW} \cdot \text{hr (in a day)}$$
$$= 34.18 \text{ kW} \cdot \text{hr}$$
$$= 34.18 \times 365 \text{ kW} \cdot \text{hr (in a year)}$$
$$= 12,475.7 \text{ kW} \cdot \text{hr}$$
$$= 12.48 \text{ MW} \cdot \text{hr (per annum)}$$

8. Epilogue

As of now, 49 percent of the population is within the coverage of electricity, the demand for power will substantially rise in future if the rest of the population is brought under the electricity coverage and the agenda for high growth through industrialization and investment to realize the Vision is pursued in the country. It is impossible to implement any development strategy with the power. As the country continues to industrialize the importance of power generation and electricity supply has become a key Government priority. Consequently, a range of efforts need to be carried out in order to produce electricity from renewable energy by reducing the dependency on natural gas for power generation and to ensure diversification of the energy resources as well.

Bangladesh is still very much reliant on fossil fuel for power generation. But the country has restricted resources which are expected to be finished very shortly. On top of that, burning of fossil fuels involves negative environmental consequences. The preceding estimation suggests that, the calculated power from the run of river water can be used as a pressing renewable energy source of electricity generation as it promises sustainable energy, which may solve power crisis throughout the country to some extent. Also analysis of the given rivers indicates that Burinadi and Meghna have a good prospect of energy along the other rivers of Bangladesh.

Moreover, run of river projects are much less costly than dams because of the simpler civil works requirements. In addition, they have high predictability, water flow predicted years in advance, unlike wind. Other than these facts it is highly efficient as much as 90% in extremely low costs per kilowatt-hour whereas coal/oil efficiency is 30% and the technology has a potential life of more than 40 years. They are, however, susceptible to variations in the rainfall or water flow which reduce or even cut off potential power output during periods of drought. Energy and economic growth are affiliated with each other and the uttermost way to sustain the economic progression is to insure sufficient generation of power. A country born through sacrifice of so many freedom loving patriots does not deserve to be treated like that. Therefore, the Government should more facilitate the development of the renewable energy sector so that private entrepreneurs come forward to take the initiatives to invest in renewable energy technologies.

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