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# Renewable Energy: An Ideal Solution of Energy Crisis and Economic Development in Bangladesh

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# Renewable Energy: An Ideal Solution of Energy Crisis and Economic Development in Bangladesh

Abu Md. Abdul Wadud <sup>α</sup>, Md. Tousif Zaman <sup>σ</sup>, Fazlay Rabbee <sup>ρ</sup> & Md. Rajibur Rahman <sup>ω</sup>

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## I. INTRODUCTION

Bangladesh is situated between 20°34' and 26°38' North Latitude and 88°01' and 92°41' East Longitude with a total landmass of 1,47,570 square kilometers (56,977 Sq. miles). India on the West, North and Northeast, Myanmar on the Southeast and the Bay of Bengal on the South surround Bangladesh. Bangladesh has a tropical monsoon climate with heavy summer rain and high summer temperatures. Main seasons prevail in Bangladesh are summer (March-May), Rainy Season (June-September) and winter (December-February). 95% of the total rainfall, which averages about 1733 millimeters, occurs during these

periods [1]. The temperatures range from an average of about 68°F(18°C) in January to about 86°F (30°C) in April [1]. Bangladesh is an agro-based country. Her economy depends on agriculture. Production needs sufficient electricity. But failure of power creates a bad impression on production. About 70% people of the rural area are deprived from electricity [2]. They depend on conventional energy sources-near 70% energy comes from these sources [3]. Electricity generation rate is less than the huge demand. To meet the demand Government of Bangladesh is using natural sources like gas, oil, coal etc. Bangladesh has huge reserve of gas, limited reserve of oil and coal. According to the Gas Initially in Place (GIIP) data, Bangladesh has 21.3 tcf of proven gas (P1; proved or with probably of 90 percent of greater or equal volume). Out of which 15.4 tcf is recoverable and 7.7 tcf of gas has already been produced [4]. The total coal reserve is estimated to be 2.9 billion metric tons [4]. Bangladesh imports 1.2 million tons of crude and 2.5 million tons of refined oil each year. The source of gas (24%) may be depleted nearby 2020 [5]. Huge amount of imported oil costs a lot of foreign money. To take coal through digging from soil is very much expensive and this process may be harmful for climate. Therefore, energy crisis becomes a major concern now. About 53% of total electricity comes from public sector and 47% of the rest electricity comes from private sector [6]. Due to the geophysical location Bangladesh has potentiality of renewable energy. Several government organizations such as Bangladesh Power Development Board (BPDB), Dhaka Electric Supply Authority (DESA), Rural Electrification Board (REB), Local Government Engineering Department (LGED), non government organizations and private companies such as Grameen Shakti (GS), Bangladesh Center for Advanced Studies (BRAC), Centre for Mass Education in Science (CMES) etc are involved in the renewable sector of the country. Renewable energy can be a good solution of energy crisis, which has less impact on climate. Different forms of renewable energy source can provide sufficient power to urban and remote areas. It can also reduce the pressure on natural sources and can help to save foreign currency. Previous works have done to recognize the

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renewable energy sources of Bangladesh and some difficulties to establish project in rural areas. This paper reviews present condition of energy crisis and possible application of renewable sources in Bangladesh. This paper also indicates the beneficial aspects of renewable energy for the people of Bangladesh.

## II. PRESENT POWER SCENERIO IN BANGLADESH

Demand of power is increasing day by day. Due to high demand maximum generation of 4130 MW in 2007, 4036.7 MW in 2008, 4296 MW in 2009, 4698.5 MW in 2010, 5174 MW in 2011, 6350 MW in 2012, 6675 MW in 2013 could not remove the power crisis [6]. Vast rural areas are being affected by load shedding. Due to power failure irrigation, production of products, water supply and daily activities are being disturbed. To solve the crisis government has planned to install power plants with capacity of 14720 MW by the year 2016 [6]. But there is a huge gap between generation and demand. Huge amount of power loss is occurred through transmission. Most of the power plants are old. Generation rate of these power plants is lower than newer plants. Most of the power plants are gas and oil based. Rental power plants are set up to meet short-term and emergency requirements of the country, which seems to be costly. Here figure-1 [4]. shows energy sector of Bangladesh and in table-1 [4] shows electricity generation through various sources. The given table-2 [7] presents power generation capacity. According to the Master Plan 2010, the forecasted demand would be 19,000 MW in 2021 and 34,000 MW in 2030 [7]. This plan insisted to use domestic coal 30%, imported coal 20 %, natural gas (including LNG) 25%, liquid fuel 5%, nuclear, renewable energy and power import 20% [7].

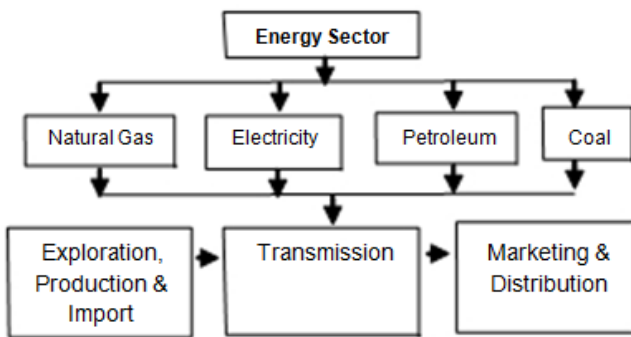


Figure 1 : Energy sector of Bangladesh

Table 1 : Source of energy of electricity generation

Source of Energy	Installed Capacity (MW)	% of Total Installed capacity	Present Capacity	% of Present Capacity	Shutdown Capacity (MW)	Running Capacity (MW)	% of Total Running Capacity
Gas	4847	74.38	4412	74.21	792	3620	74.23
Coal	250	3.84	220	3.70	100	120	2.46
HFO	275	4.22	271	4.56	0	271	5.56
HSD	594.5	9.12	567	9.54	16	551	11.30
FO	170	2.61	95	1.60	60	35	0.72
GT	150	2.30	150	2.52	0	150	3.08
Hydro	230	3.53	230	3.87	100	130	2.67

Table 2 : Present Generation Capacity (Oct, 2011)

Public Sector		Generation Capacity (MW)
SL.		
1	BPDB	2868
2	APSCL	659
3	EGCB	255
	Subtotal	3782 (53%)
Private Sector		
1	IPPs	1231
2	SIPPs (BPDB)	99
3	SIPPs	226
4	15 YR. Rental	168
5	3/5 YR. Rental	1613
	Subtotal	3337 (47%)
	Total	7119

## III. BIOMASS & BIOGAS

Bangladesh has strong potential for biomass gasification based electricity. More common biomass resources available in the country are rice husk, crop, residue, wood, jute stick, animal waste, municipal waste etc. Exploration of these resources for electricity generation is still at preliminary stage. Biogas is composed of CH<sub>4</sub>, CO<sub>2</sub> and other gases, which can be produced by cattle dung, poultry droppings, human excreta and agricultural residues. The digested slurry obtained as a byproduct which acts as a nutrient-rich fertilizer [8]. Bangladesh is in a suitable position for availability of raw materials and the climate conditions for biogas production. About 29.7 billion m<sup>3</sup> of biogas and 10 billion m<sup>3</sup> can be produced from cow dung and human excreta [8]. Different institutions and organizations such as Institute of Fuel Research and Development (IFRD) of Bangladesh Council of Scientific and Industrial Research (BCSIR), universities (BUET, DU, RUET, KUET, JU, BAU etc), LGED, GS etc are working on biogas projects. In 1972, Bangladesh entered the area of biogas technology through Bangladesh Agricultural University (BAU). In 1976, BCSIR first constructed a family-size biogas plant following the design of Khadi and Village Industries Commission, India. In 1986, LGED constructed its first biogas plant at kurigram. In 1992, a biogas plant of 85

cubic meter digester volume was built at dholpur, Dhaka to produce 200 cft biogas from garbage [9]. About 17194 biogas plants were established under a project of IFRD in 2004 [10]. In 2004, Sustainable Rural Energy (SRE) project under LGED has installed 10KW power generation unit, which was based on poultry litter. Excess gas from this unit is being used for cooking purpose at Faridpur Muslim Mission. SRE has also installed two biogas units, one at Kutubdia and the other at Kishoregonj which were based on human excreta. This type of inventions created better health and sanitation facilities as well as energy requirement for cooking and lighting. Demonstration of 3.5KW cow dung based power generation unit at Netrokona district created enthusiasm among the small-scale farmers. Beginning from June 2006, over 10000 biogas plants were constructed under National Domestic Biogas and Manure program (NDBMP) [9]. According to the renewable energy policy, govt. has planned to develop biogas plants to produce at least 500MW power by 2015. Fig-2 shows installation of biogas plants.

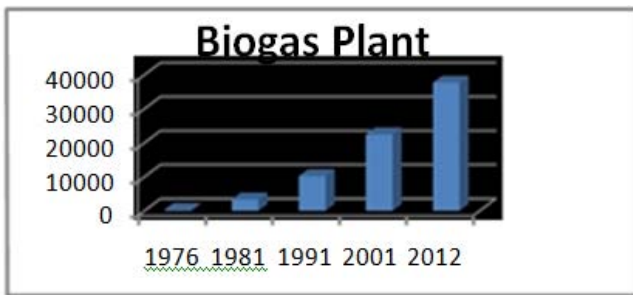


Figure 2 : Biogas plant chart from 1976 to 2012

a) Utilization of Biogas

Significant amount of power can be produced from biomass energy. It can be used in some applications as well as in small household works, cooking, harvesting, lighting, irrigation etc. A fig-2 [11] shows the utilization of biogas in a house.

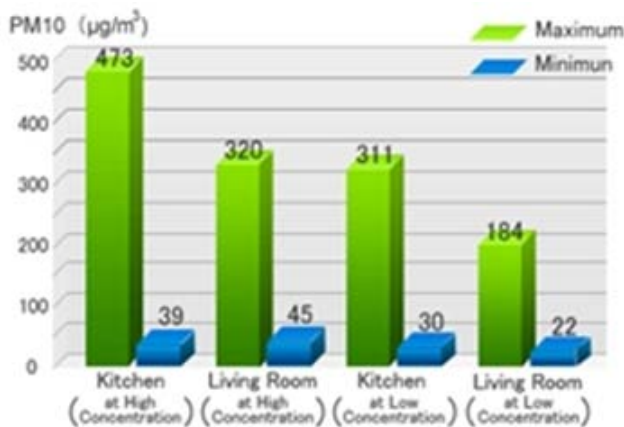


Figure 3 : Utilization of biogas in Bangladesh Houses (24Hr mean)

b) Benefits of biogas energy

People can be benefitted through biomass energy. These benefits are given below:

i. Financial Benefits

- revenues from the sales of electricity and heat
- independence from network providers
- use of exhaust heat as thermal and process heat
- sale of high quality fertilizer

ii. Emission issues

- methane reduction through elimination of digestible organic mass
- odor nuisance reduction through digesting substrates

iii. Energy Economic Benefits

- continuous power generation with basic and peak load capability
- biogas can compensate for fluctuations in wind and solar energy
- reduction of dependence on fossil fuels

iii. Environmental Aspects

- production of clean energy from waste
- easier way to spread the fermented residues through improved flow ability
- reduced CO2 emissions of biogas in contrast to fossil fuels
- recycling of previously unused energy resources
- active environmental protection through energy-related recycling
- waste recycling
- production of high-quality, natural fertilizer

iv. Market Aspects

- use of overproduction of energy crops relieves food markets
- biogas production opens new production and sales markets

## IV. WIND ENERGY

Recently Bangladesh gets experiences on wind energy. Several locations have already been assessed to evaluate the wind energy potential of the coastal region of the country. Strong wind potential flows during the months of April to September, and a very weak potential during rest of the year. Table-1 shows wind speed [12] in Kuakata. Wind Resource Assessment Station (WRAS) established by BPDB at Moghnama Ghat, Cox Bazar district in December 2003. For the first time in Bangladesh, BPDB implemented a pilot project of 0.90 MW capacity of the

Table 3 : Wind speed in Kuakata

Month	Wind Speed (m/s)
January	5.80
February	5.50
March	7.70
April	8.30
May	7.90
June	6.90
July	7.70
August	7.50
September	6.90
October	6.30
November	5.50
December	4.80

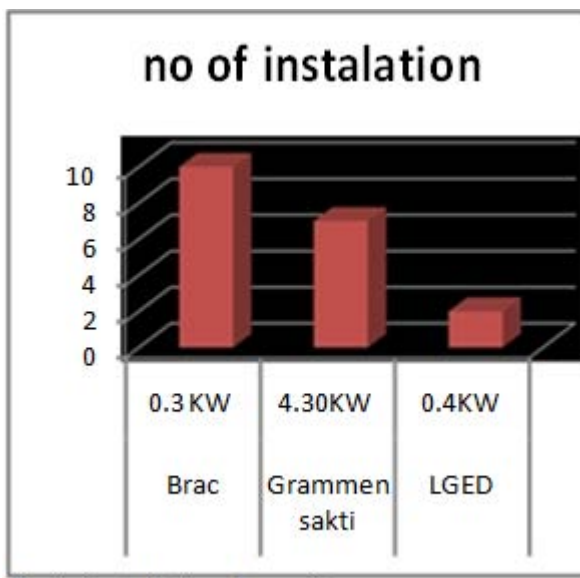


Figure 4 : Installation Capacity

Grid Connected Wind Energy (GCWE) in the Muhuri Dam areas, which is suitable for 100MW wind electricity [13]. BPDB has planned to implement 50-200 MW Wind Power Project at Parky Beach area, Anawara, Chittagong. BPDB has also planned to install 1MW off Grid Solar- Diesel based Hybrid Power Plant in Kutubdia Island. 10KWp capacity based Wind-Solar Hybrid System installed by LGED in Saint Martin Island at Bay of Bengal. GS has installed seven numbers of wind-diesel systems of 4.32KW capacity at coastal areas. BRAC has also installed .3KW capacity based wind turbine. Here fig-4 shows installation of wind hybrid systems. A pilot project has taken to set up 250KW capacity based diesel power stations at Kutubdia and Kuakata. The estimated annual energy outputs for Kutubdia and Kuakata are about 200MWh and 230MWh respectively from a 250KW station at these places [14].

#### a) Utilization of wind energy

Wind speed is not sufficient in Bangladesh to produce wind electricity. But this electricity can be

utilized in different ways such as wind water pumping and power generation through Wind-Diesel-hybrid systems, small battery charging, shrimp production, fish/poultry firming, salt/ice production, fish-mill industries, hatcheries, domestic applications and vegetable irrigation.

#### b) Benefits of wind energy

Wind energy has not utilized properly in Bangladesh due to the lack of wind speed and huge cost. However, it has some benefits. Those are given below:

- The wind is free and with modern technology, it can be captured efficiently.
- Once the wind turbine is established, the produces energy does not cause green house gases or other pollutants.
- Although wind turbines may rich in height, each have only a small piece of land. This means that the unused land can be utilized for other purposes, especially for agricultural or farming purposes.
- Remote areas where electricity has not supplied yet can use wind turbines to produce their own supply.
- Wind turbines have a role to play in both the developed and third world.
- Wind turbines are available in a range of sizes, which means a vast range of people, and businesses can use them.
- Single households to small towns and villages can make good use of range of wind turbines available today.
- Wind energy is a clean renewable energy source cheaper to maintain, saves fuel and can give decentralized energy [14].

## V. SOLAR ENERGY

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic converts light into electric current using the photoelectric effect. Average daily solar radiation is 4-6.5 kWh/m in Bangladesh. The first significant program of solar system was Norshingdi project. Under this project, solar home systems (SHS) with a total capacity of 32.586KWp were installed [15]. Under Renewable Energy Technologies (RET) 40.5KWp capacity based solar systems have installed through LGED from 1998 to 2006. BPDB has installed several types of solar systems such as Solar Home System (SHS), Solar Vaccination, Solar water pump, Solar Street light, Centralized Solar PV Power Plant of 123.55kWp (233.095KW or 0.233MW) [16]. From 1993 to 2007 REB established SHS of 233.095KW (0.233MW)

capacity. Private organizations such as BRAC and GS also installed valuable solar systems in the rural areas. Recently BPDB has taken a project to implement 1000 Solar Home Systems of 120Wp each in Chittagong hill tracts. Government of Bangladesh (GOB) has taken a solar program under which about 400 no's of solar panels has been installed in Juraichhri area of Rangamati district. Fig-5 shows installation through various organizations. A fig [6] of solar panel is shown below [17]. Cost of solar power has decreased about 60% from 1991 to 2003 and decrease about 47% from 2006 to 2010 [18]. Now 30% household works can be done through SHS system [19].

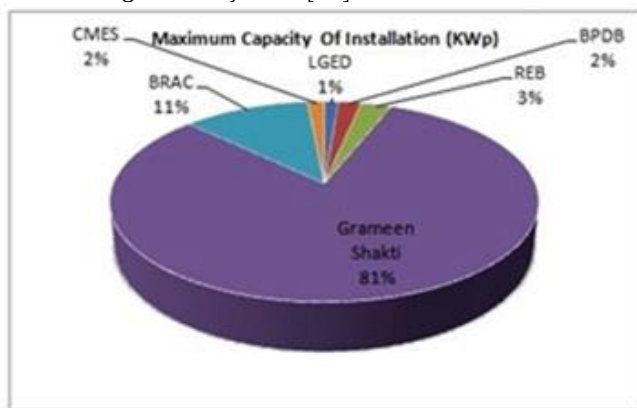


Figure 5 : Installation capacity of Solar panels

a) Utilization of Solar energy

Due to graphical location, Bangladesh has huge opportunities to use solar energy. Instead of having some bad impact on climate as well as CO<sub>2</sub> impact however the blessing of solar energy is untold [32]. So far this energy can be utilized in many activities of daily life as solar lighting, pumping, irrigation, solar park, poultry-firms, small dc applications etc.

b) Benefits of Solar energy

Most of the rural areas where people are suffering from energy crisis, solar energy can bring them solution through its some benefits as:

- Solar energy is free although there is a cost in the building of "collectors" and other equipment required to convert solar energy into electricity or hot water.
- Solar energy does not cause pollution. However, solar collectors and other associated equipment/machines are manufactured in factories that in turn cause some pollution.
- Solar energy can be used in remote areas where it is too expensive to extend the electricity power grid.
- Low cost and easy installation.
- Could be an effective alternative source of energy.
- Energy can be stored in the battery.



Figure 6 : Solar panels at Rangamati

## VI. GEOTHERMAL ENERGY

Geothermal energy is very much cost effective and environmentally friendly thermal energy generated and stored inside the earth surface. To generate electricity, the steam and hot water produced inside the earth surface is used in this technology. Geothermal energy is a reliable source of power that can reduce the need for imported fuels for power generation and emits almost no greenhouse gases. As renewable, it based on a practically limitless resource of natural heat within the earth. Geothermal energy is generated about 4,000 miles below the surface, in the earth's core. The process takes place due to the slow decay of radioactive particles, the high temperature produced inside the earth and it happens in all rocks. About 10,715 megawatts (MW) of geothermal energy is generated in 25 countries worldwide [21]. The first geothermal power plant for electricity generation in Bangladesh is under construction, which will thus become the twenty-sixth country in the world to use this source of renewable energy [22]. The northern districts of Bangladesh show the prospect to explore the geothermal resources. Also there is a hot salt water spring known as Labanakhya at Sitakunda (40 kilometer from Chittagong) which has the possibility to

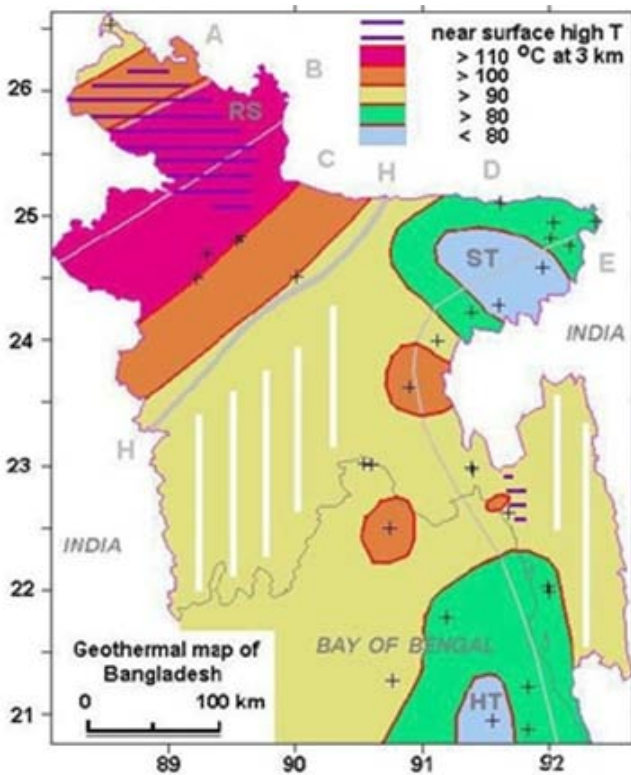


Figure 7 : Geothermal map of Bangladesh

be an excellent location for the extraction of geothermal energy, and so further investigation is required to fully evaluate its potential. Recently, the Ministry of Power, Energy and Mineral Resources has approved the establishment of the first ever-geothermal power plant in the country [23]. The demand of electricity in urban as well as in the rural areas are increasing, but our production of electricity is not increasing. The rural demand for electricity can be covered by the production of electricity through geothermal energy. A private company named Anglo MGH Energy has planned to setup Bangladesh's first geothermal power plant with a capacity to produce 200 MW. Plants for 200 MW are in the pipeline at Salandar village in the northern district of Thakurgain [22]. The company has done primary feasibility studies on the plan and will conduct a final one shortly on a span of 3500 hectares of land to select the spot for the plant. The Company has secured favorable opinions from the Geological Survey of Bangladesh, the Ministry of Water Resources and the Ministry of Environment and Forest [22]. According to the plan, 28 deep tube wells will be dug to lift hot steam to run a turbine connect to the generator to generate electricity, whose temperature will be at least 12 degree Celsius. These geothermal resources can therefore play a significant role as regards energy supply for populated areas, where there is a severe shortage of energy in general and specifically of electricity. Fig-7 shows geothermal energy prospects of Bangladesh (Guha et al., 2010)

[24]. The establishment cost of geothermal power plant is high due to the high cost of drilling wells, it can be reduced by using the abandoned on shore dry wells which have sufficient high temperature gradient (like over 30K/km) [23]. Geothermal energy can provide a suitable energy solution for Bangladesh as it is green, indigenous, abundant, continuously available and independent of climate changes [23]. With the population of over 156 million inhabitants, it must be noted that 200MW are not sufficient to consider the solution of energy crisis where the total installed power capacity is currently about 6000 MW [22].

## VII. HYDRO POWER

Flowing water creates energy that can be captured and turned into electricity. This is called hydroelectric power or hydropower. It is an eco- friendly clean power generation method. As a riverine country, Bangladesh is a great delta formed by the alluvial deposits of the three mighty Himalayan Rivers: the Ganges, the Brahmaputra and the Meghna [25]. Also there are lots of canals, tributaries of main river Karnafuli, Shangu, Matamuhuri as well as tiny waterfalls having good potentials for setting up mini/ micro hydropower unit in Chittagong Hill Tracts (CHT) region [26]. At present only 230 MW of conventional hydro power is utilized 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 will be generated during the rainy season when most of the water is spilled [8]. Classifications of hydro power based on generated power are as follows:

- Pico-Hydro < 5KW
- micro-hydro > 5 < 300KW
- Mini-hydro > 300KW < 3MW
- Small hydro > 3MW < 10MW

Bangladesh Water Development Board (BWDB) and Power Development Board (BPDB) carried out a joint study on Micro-Hydro power potential in the country. In Table-4, it is given in detail [23].

Table 4 : Potential Small Hydro Sites identified by BPDB and BWDB

District	Name River/Chara /stream	Potential of Electrical energy in KW
Chittagong	1. Foy's lake	4
Chittagong	2. Choto Kumira	15
Chittagong	3. Hinguli Chara	12
Chittagong Hill Tracts	4. Sealock	81

Chittagong	5. Lungichara	10
Chittagong	6. Budiachara	10
Sylhet	7. Nikhari Chara	26
Sylhet	8. Ranga Pani Gung	616
Jamalpur	9. Bhugai-Kongsa at 2 miles U/S. Of Nalitabari P.S	69KW for 10 months 48 KW for 2 months
Jamalpur	10. Marisi at Dukabad near Jhinaigati Thana Head Quarter	35KW for 10 months 20 KW for 2 months
Dinajpur	11. Dahuk at Burabari	24
	12. Chawai at U/S. of Chawai L.L.P	32
	13. Talam at U/S. of Talam L.L.P	24
	14. Pathraj at Fulbari	32
	15. Tangon at D/S of Nargun L.L.P	48
	16. Punarbhaba at Singrabani	11
Rangpur	17. Buri Khora Chikli at Nizbari	32
	18. Fulkumar at Raiganj Bazar	48

SRE under LGED has successfully demonstrated first micro-hydro power unit at Bamerchara Lake, Banshkhali, and Chittagong district in Bangladesh. Its installed capacity was 10kW but due to inadequate water head about 4kW power was generated. Estimated capacity of the system was 10kW. Salient feature of the unit has been illustrated below [26]:

- Turbine type : Corssflow
- Penstock : 52m
- Design flow : 150 litter/sec.
- Net head available : 6m-10m
- Preferred gove : Flowcontrol (Manual)
- Electrical Output : 4-6 KW, 50Hz, 3 phase voltage, 220 V / 440 V

SRE has carried out a study on prospective micro-hydro sites in the Chittagong Hill Tract region and eight potential sites were identified with an estimated capacity of 135kW. It also provided technical support to promote indigenous technology (wooden water wheel which is driving locally procured generator) of micro-hydro power generation unit which was developed by member of local indigenous community named Mr. Aung Thui Khoyan [27]. A recent study on Sustainable Rural Energy shows that micro hydro power plants are able to provide necessary power supply for rural areas. According to socio- economic development strategy, the study was conducted on the micro hydro power plants of generation capacity starting from 3KW up to 30KW [27] [28].Table-5 shows socio- economic development & Fig-8 represents power generation capacity of these plants:

Table 5 : Micro hydro plants of Bangladesh

Site	Expected Power Generation (KW)	Socio- economic Infrastructure within 1 km		
		House hold	School/ Mosque / Bazar/ Clinic	Small Industry
Nunchari Tholipara, Khagrachari	3	100	3	1
Chang-oo-Para, Bandarban	30	200	5	2
Bangchhari, Bandarban	25	600	12	5
Liragaon, Bandarban	20	500	8	3
Kamalchar, Rangamati	20	150	8	9
Thang Khru, Rangamati	30	300	6	3
Monjaipara, Bandarban	7.5	50	9	-

a) Ongoing Projects of Hydro Power in Bangladesh

- BPDB has taken steps to install 50-70 kW Mohamaya Irrigation-cum-Hydro Power Project at Mirersorai, Chittagong [28].
- Rehabilitation of 50 kW Micro-Hydro Power Plant at Barkal Upazila of Rangamati district [28].

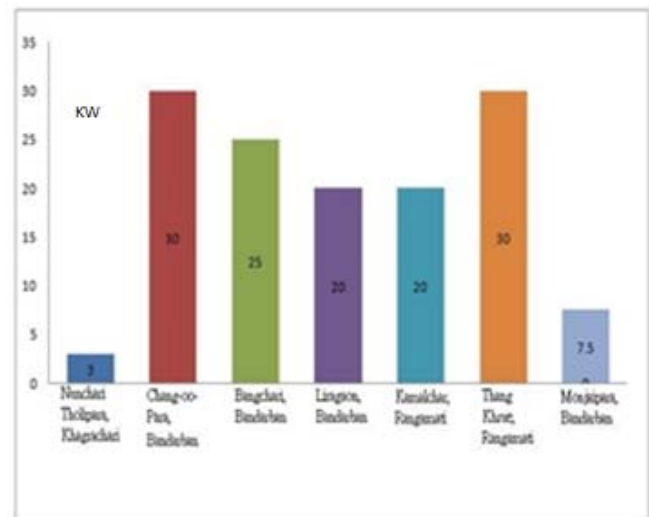


Figure 8 : Power generation capacity of Micro- Hydro plants



There are many rivers with high flow rate in monsoon but low in winter. It would be a good idea to create a diversion structure across the river channel, diversion channel along the bridge and the powerhouse at a suitable location that offers a suitable head. The Teesta Barrage, the largest irrigation project of the country has several sites with sufficient head. BPDB has submitted a proposal to the government to install a 25kW power plant at the Teesta barrage. Further investigation can open the door to more success in this regard. To improve development outcomes, Bangladesh has good potential of hydro power through micro/ mini hydro power and its proper utilization can bring effective changes to energy sector in upcoming days.

### VIII. ECONOMIC DEVELOPMENT

Now Bangladesh has started to have advantages of renewable energy. Day by day, it becomes cheaper. Rather than high power equipments, long transmission and distribution line and other installations, it becomes easier to set up. Due to fall in price, people become interested in biomass and solar energy. This motivation saves money and makes our life easier. This also influences our social and economical activities. Renewable energy reduces dependency of natural fuel. Employment opportunities are increasing for rural people. Especially green jobs where people can produce harmless chemical pesticides and fertilizer, Compact Fluorescent Light (CFL) to reduce 80% of electricity cost [30]. Here fig-9 illustrates employment estimation through renewable energy.

**Employment**

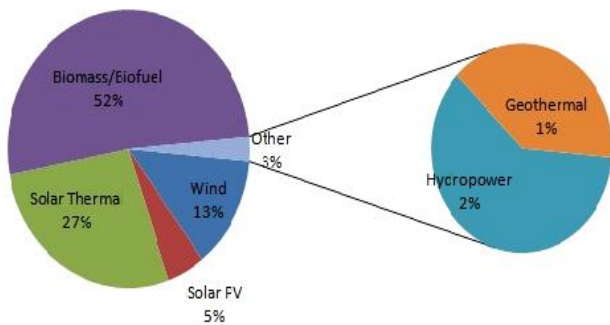


Figure 9 : Employment estimation around the world

### IX. CONCLUSION

Bangladesh, the land of natural resources, rich in gas, limited amount of coal, oil as diesel and kerosene. These natural resources are stored in deep soil and sea blocks. As if, carry out these resources through open access digging from soil is very much

expensive and harmful for environment. For this Proper utilization and installation of biogas plants, solar panels and wind turbines could be cost effective for our economy. Bangladesh is mainly dependent on natural gas and imported oil. Excessive use of natural energies may cause bad impact on GDP (Gross Domestic Product). A prediction estimates that maximum reserve of natural energy sources will deplete within few decades. So dependency on natural sources should be reduced. If we create diversity to renewable energy then it will be our achievable energy sources in near future. However, Economic development through renewable energy can play a vital role to reduce unemployment and poverty, which is helpful for Bangladesh to continue her journey with global world.

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