Renewable Energy Scenario of Bangladesh: Physical Perspective

Md. Zunaid Baten[1], Emran Md. Amin[1], Anika Sharin[1], Raisul Islam[1] and Shahriar A. Chowdhury[*2]

[1]Department of EEE, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh.
[2]Department of EEE, United International University, Dhaka, Bangladesh.
[*]E-mail of corresponding author: shahriar@eee.uiu.ac.bd

Abstract: The looming energy crisis, heightened by the continuing depletion of fossil fuels, accentuates the need for deployment of renewable energy resources in Bangladesh, now more than ever before. Though hydrocarbon resources in the country are limited, the substantial availability of renewable energy sources in the form of solar, biomass, hydropower and wind energy offers opportunities of sustainable energy based development. Motivated by this auspice, the government of Bangladesh and different non-government organizations have been working towards the dissemination of renewable energy based technologies throughout the country. Though this diffusion of renewable energy sources is yet to assume extensive commercial dimensions and widespread implementations, the advancement has been significant in recent years. With the objective of reviewing this progress, this paper presents a comprehensive study of the contemporary renewable energy scenario in Bangladesh in terms of distribution, research and infrastructural development in the country. In addition to this, installed capacity has been calculated to assess the relative contributions of the five renewable energy sectors of Bangladesh.

1. Introduction

Low-income developing countries like Bangladesh are very much susceptible to the setbacks arising from the ongoing energy crisis. Natural gas lies at the heart of the country's energy usage, accounting for around 72% of the total commercial energy consumption and 81.72% of the total electricity generated [1]-[2]. However, the waning gas resources suggest that the country will face deficit of 142 million cubic feet per day (mmcfd) in 2011 and it will rise to 1714 mmcfd by 2019-20. Even if Bangladesh's GDP growth remains as low as 5.5 percent till 2025, the country will need to add 19,000 MW of additional power, causing the gas demand to spiral up to 4,567 mmcfd by 2019-20 [3]. Such an overwhelming dependence on bio fuel has brought into focus the substantial amount of renewable energy resources available in the country. The potential non-exhaustive sources of energies, available in the form solar, biomass, biogas, hydropower and wind, can be harnessed to provide an environmentally sustainable energy security, as well as affordable power supply to the off-grid rural areas of the country. To this end, effective utilization of renewable energy resources has been adopted as a policy of the Government of Bangladesh (GOB) [4]. Different government, semi-government and non-government organizations (NGOs) have been working separately or jointly to disseminate renewable energy technologies (RET) throughout the country over a significant period, as has been reported in the recent literature [5]-[8]. However, prospective planning and comprehensive understanding of this dynamic field requires continuous assessment. Moreover, the progression, as well as regressions, in this sector should be continually scrutinized. Motivated by these objectives, we present in this paper a contemporary scenario of the renewable energy related activities in Bangladesh. Based on fieldwork, covering discussions with key figures of the public and private sector, and exhaustive literature review, we demonstrate here the advancement in this field with respect to physical progress, research activities and infrastructural development. Also a comparison of the five forms of renewable energy resources in Bangladesh has been drawn on the basis of the output power calculation of each sector.

2. Physical Implementations in the Renewable Energy Sector

A. Solar Energy Based Installations

The profusion of solar radiation (daily 4.0- 4.5 kWh/m^2) [9] has facilitated the growth of solar energy based technologies in Bangladesh. These technologies can be classified into two broad categories: solar photovoltaic (PV) systems and Solar Thermal Power/Concentrating Solar Power (CSP) systems. Though solar PV systems have received widespread implementation throughout the country, the CSP technology is yet to be disseminated on large scale [4]. The major existing applications under the category of solar PV systems are solar home systems (SHS), solar street light systems (SSLS), solar PV submersible water pump and centralized solar electrification system. These RETs are promoted by different government and non-government organizations, which operate independently, and/or on a partnership basis. A synopsis of the contributions of these organizations in the development of solar energy based technologies in Bangladesh is presented in the subsequent sections. Although all the major contribution in the development of solar energy in Bangladesh is explored, some are not included here because of their permanent unavailability. The examples include solar system used for

power line signalling and equipments in the light house situated in the coastal belt.

(i) Infrastructure Development Company Limited or IDCOL's Renewable Energy Development Project (REREDP):

IDCOL, a public limited company created by the GOB, has been promoting SHSs in Bangladesh under the Rural Electrification and Renewable Energy Development Project (REREDP), which is jointly funded by the International Development Association (IDA), Global Environment Facility (GEF), German government-owned development bank KfW and German Technical Cooperation or GTZ [10]. IDCOL's solar energy program is one of the fastest growing renewable energy programs in the world [6]. Till 26 July 2009, IDCOL has installed 334,091 SHSs (rating ranging from 21Wp to 130Wp) in collaboration with its 15 non-government Partner Organizations (POs) in all the 6 divisions of the country. This amounts to a total installed capacity of more than 11 MW [11].

(ii) Grameen Shakti (GS) and the Solar PV Program:

Besides operating as a PO of IDCOL's REREDP program, GS carries out its own programs relating to the distribution of solar energy based technologies in the country. With an installation rate of 8000 SHs/month, this NGO has installed 209,928 SHSs in partnership with IDCOL and 43,297 SHSs without IDCOL's affiliation. The capacity of GS's solar home systems range from 30-128Wp [10]-[11]. So excluding the SHSs installed in partnership with IDCOL and considering an average rating of 50Wp per SHS, the estimated capacity of GS's 43,297 SHSs is around 2.17MW. GS has been globally acclaimed for its remarkable approach of ''micro-credit'' for distributing SHSs in rural areas. The flourishing of SHSs in Bangladesh has often been attributed to the initial initiatives of GS and the recent activities of IDCOL [6].

(iii) Rural Electrification Board (REB) Solar Electrification Program:

REB has been providing electricity to rural consumers through rural electric co-operative societies called Palli Bidyut Samities (PBSs) which run on the basis of ownership and direct participation of the consumer members. REB started its solar electrification program back in 1993 with a solar PV pilot project funded by the government of France. The aggregated capacity of the SHSs installed by REB is 233.095 kWp [11]-[12].

(iv) Bangladesh Power Development Board or BPDB's Solar Energy Program:

With support from the Ministry of Chittagong Hill Tracts Affairs, BPDB has implemented two solar PV electrification project in Juraichari, Borkol and Thanchi Upazilla of Chittagong hill tracts. The installations involve 1200 Solar Home Systems (each of 120 Wp), 30 Solar Street Lamp Systems (each of 75 Wp), 3 solar PV submersible water pumps (each of 1800 Wp), 3 solar PV vaccine refrigerators (each of 360 Wp) and 2 centralized Solar electrification systems (each of 10 kWp), resulting a total installation capacity of 173.81 kWp [19].

(v) Local Government Engineering Department (LGED) and Sustainable Environment Management Program (SEMP):

In line with the Sustainable Environment Management Program (SEMP) of the Ministry of Environment and Forest, LGED has demonstrated diversified applications of solar PV technologies in a number of off-grid areas of the country. The installations involve solar PV pumping, centralized solar alternating current (AC) system, SHS, solar battery charging station, solar-wind hybrid system, solar lantern system and solar PV application for pisciculture. These establishments result a total installed capacity of 40.5 kWp [11].

(vi) Grameen Phone

Grameen Phone, the largest mobile phone operator in Bangladesh has recently taken the initiative to provide power to their off grid BTS (Base Transceiver Station) by Solar/Diesel hybrid systems. In this respect they have installed two PV systems in their BTSs as a pilot project in Hobigang district. The telecommunication equipment will run primarily on solar power, with the diesel generator installed as a backup solution. The capacity of each PV system is 8.05 kWp to provide power to BTS whose power consumption is 1.5 to 2 kW. The systems are designed for 3days autonomy with a storage system of 2400 AH (Battery). GP has already planned to install 12 more solar systems to power their off grid BTSs.

(vii) Bangladesh Council of Scientific and Industrial Research (BCSIR) Solar Energy Program

BCSIR's activities in this field have been basically research oriented, though some off grid rural areas of the country have benefited from these works. The installations involve SHSs, solar PV water pumping and rotating shadow band pyranometers for solar data logging. The total installed capacity equals 3.12 kWp [11].

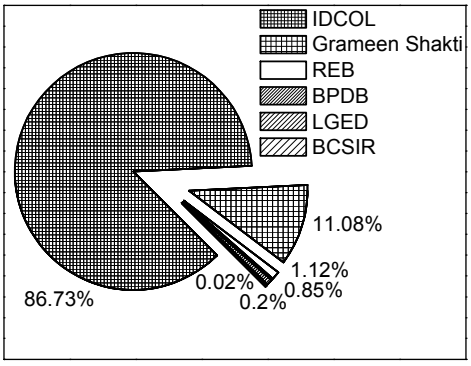

Figure 1: Relative contribution to the solar energy sector by different organizations in terms of installed capacity [up to July 2009. having a total installed capacity of 20.75MWp]

(viii) Other Organizations:

Other organizations, which are involved with the dissemination of solar energy based technologies in the country, are mostly NGOs. Total capacity of the SHSs installed by different organizations are mostly calculated under IDCOL SHS project as these organizations opearte as POs of IDCOL. The relative contributions to the solar energy sector by different organizations are shown in Figure 1, indicating that IDCOL has been the key role

player in the solar energy sector in Bangladesh. Besides these some other organization like BIWTA and some other NGOs installed some PV installation, due to their insignificant number and also lack of information those can not be included.

According to IDCOL, total installed capacity of its 334091 SHSs is around 18MWp which gives an average capacity of 53Wp per SHS. Hence, based on this average value, total capacity of the solar energy based installations in Bangladesh appears to be 20.75MWp. Though it is a small percentage of the overall installed electricity capacity of 5,202 MW [1], the amount is significant considering the upward trend of the number of SHS installations in the country.

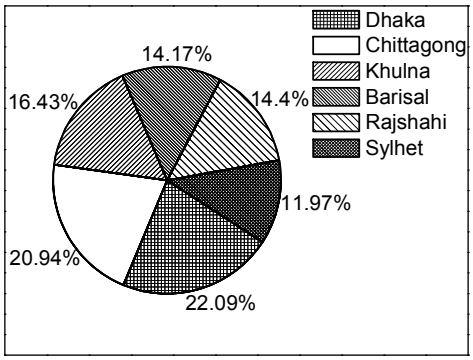

Figure 2: Distribution of the SHSs in six divisions

Besides, Figure 2 indicates that the installations are very much distributed throughout the country as far as the six divisions are concerned.

B. Biogas Based Installations

Bangladesh being an agricultural country, raw materials for biogas are easily and cheaply available everywhere. The materials include various natural and derived materials mainly categorized as agricultural residues and other solid wastes. The major sources of raw materials are rice straw (37%), rice husks (32%) and cow dung (9%) [14].

In Bangladesh, a number of organizations have taken various attempts to promote biogas technology from time to time. The first floating-drum biogas plant was constructed in 1972 at the premises of Bangladesh Agriculture University (BAU). Starting from that time different government institutions like LGED, Department of Environment (DOE), Bangladesh Agricultural Development Corporation (BADC), BAU and NGOs like BCSIR, BRAC, Thengamara Mohila Sabuj Sangha (TMSS) etc. have taken initiatives and successfully constructed about 29,789 biogas plants in different parts of this country till 2004 [11]. Of these different organizations, BCSIR was the most dynamic and it alone constructed about 22,100 biogas plants under "Biogas Pilot Plant Project" in two phases. The biogas plants constructed were mainly of fixed dome structure and most of these used human excreta as feeding materials.

Since 2006, IDCOL has been promoting the new fixed-dome design of biogas plants in partnership with its POs and Micro Finance Institutes (MFI) under the National Domestic Biogas and Manure Programme (NDBMP), which has already resulted in the installation of 8,458 domestic biogas plants [10]. Besides working in partnership with IDCOL, some organizations have constructed domestic biogas plants with their own funds. These are Grameen shakti (about 3,664 plants of their own), BRAC (about 300 plants of their own) and some other private organizations which promote biogas plants independently [11],[14]. Therefore, the total number of domestic biogas plants constructed in different parts of Bangladesh so far starting from 1972 is about 42,211.

Beyond these fixed dome plants, some biogas based power generation units have been set up in Bangladesh. There are two more biogas power units based in poultry farms: one 7.5 kW power unit in Bogra and another 4kW rated unit in Faridpur district. Recently BRAC has installed two cow dung based biogas power plants in Shaturia Upazila, Manikganj and in Shafipur Upazila, Tangail. Both these plants have a capacity of 800Wp [11].

C. Biomass Based Installations

As an agricultural country, Bangladesh possesses the potential for power generation from biomass sources. To tap the unharnessed potential of biomass energy sources, IDCOL financed the first and only biomass gasification based commercial power plant at Kapasia of Gazipur district. The project, which has an installed capacity of 250kW, was initiated in 2005 by Dreams Power Private Limited (DPPL) and gained commercial go-ahead in December 2007. Constructed in an off-grid area, this plant utilizes locally available agricultural residue like rice husk as a raw material and is capable of serving 395 households. Though the plant has successfully served the customers since its commencement, meagre electricity demand during evening hours results in a per capita consumption of 130W only, a value much lower than projected [10]-[11].

D. Wind Energy Based Installations

The large coastal belt with adequate wind speed in some regions offers the prospect of utilizing wind energy as a possible renewable energy source in Bangladesh [9]. As of date, wind energy based physical implementations have been carried out mainly by BPDB. As part of the first Grid Connected Wind Energy (GCWE) project of the country, BPDB installed 4 units of GCWE turbines, each having a rating of 225kW. The second wind energy based project by BPDB, initiated in March 2008, consists of 50 stand-alone type wind turbines each having a capacity of 20kW in the island of Kutubdia.

Besides BPDB, LGED has implemented two projects on wind energy, which involve a 10kW wind-solar hybrid system at Saint Martin's island and a 400W system at the LGED guesthouse cum cyclone shelter in Kuakata sea beach of Patuakhali district. LGED has also implemented a windmill in Sherpur district, which is mainly used for water pumping and irrigation. Among the NGOs, GS has also played a role in the wind energy sector by installing three 1.5 kW and one-10kW wind-diesel hybrid power stations in 4 cyclone shelters of Grameen Bank. Two other NGOs, Bangladesh Centre for Advanced Studies (BCAS) and Bangladesh Rural Advancement Committee (BRAC),

installed wind turbines in some coastal areas of Bangladesh mainly for irrigation and water pumping purpose [11].

E. Hydropower Based Installations

Although hydropower is an eco-friendly clean power generation method, the scope of hydropower generation is very limited in Bangladesh because of its plain terrains, with the exception of some hilly region in the northeast and southeast parts of the country. At present only 230MW of conventional hydropower is being utilized in the Karnaphuli Hydro Station located at Kaptai of Rangamati district operated by BPDB. Utilizing a natural waterfall, one 50kW stand-alone type micro hydro power pilot project has been implemented by BPDB at Barkal Upazilla Sadar in Rangamati. LGED, under its Sustainable Rural Energy (SRE) project has successfully demonstrated the first 10kW micro-hydro power unit at Bamerchara in Chittagong district [11].

3. Research and Developments

Different organizations are carrying out research activities to find an appropriate technology and feasibility of different aspects of renewable energy suitable for the socio-economic and geographical nature of Bangladesh. Major research organizations are Renewable Energy Research Centre (RERC) of Dhaka University, IFRD of BCSIR, Centre for Energy Studies (CES) of Bangladesh University of Engineering and Technology (BUET), Khulna University of Engineering and Technology (KUET) and Bangladesh Agricultural University (BAU).

IFRD has been working on improved stove and solar cookers to save energy during cooking [17]. CES, BAU and IFRD have been supervising numerous projects on bio-fuel production from non-edible plants like *Jatropha circus* (Verenda). RERC supervised the largest wind and solar energy assessment project in Bangladesh namely, 'Solar and Wind Energy Resource Assessment Project' (SWERA) [9]. RERC is also running a project on 'roof top grid connected PV power system' [11], [17]. KUET has been doing research and development activities on improved briquetting for biogas generation [7].

4. A Comparative Scenario of the RETs in Bangladesh

Based on the information obtained, a comparative scenario of the five aforementioned renewable energy sectors of Bangladesh is illustrated in Fig. 3 in terms of the installed capacity. Though capacity of solar, biomass, wind energy and hydropower based installations have been obtained in wattage, only the number of installed biogas domes are available as far as the biogas energy sector is concerned. So to obtain a comparative picture, equivalent wattage of the generated biogas in Bangladesh has been calculated.

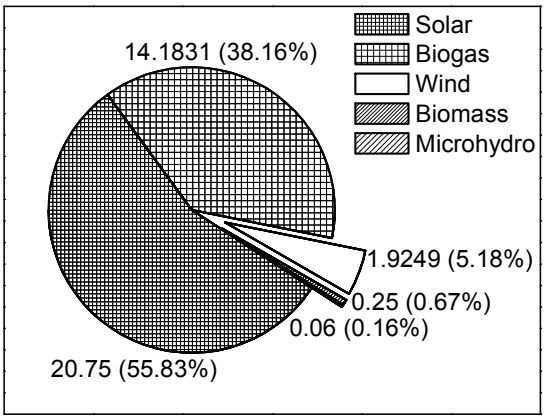

Figure 3: Contribution of Different Implemented Renewable Energy Technologies in Bangladesh [in terms of installed capacity in MWp, up to July, 2009]

Unfortunately, it has been found that out of the total 42,211 biogas plants installed till July 2009, about 47 percent has been functioning well, while another 32 percent are partially functioning because of lack of proper maintenance and knowledge on appropriate use of bio-slurry and non-compliance with the suitable quality standards [16]. These plants have various gas generation capacities but the average plant capacity is taken to be $2.5m^3$ of biogas per day. Hence, it can be assumed that the fully active 47% biogas plants generate $2.5m^3$ of biogas per day whereas the partially active 32% of the installed plants generate half the rated value, i.e. $1.25m^3$ of biogas per day. Calculation based on these assumptions show that the net maximum biogas production per day throughout the country is $61209.95m^3$. Since biogas contains 60%-70% methane, its heating value is about $20MJ/m^3$ [18]. So in 24 hours duration, the equivalent heat energy from the produced biogas throughout the country is equal to 1224199MJ, which is equivalent to 14.17MW of power. Taking into account the installed capacities of the one 50kWp, one 7.5kWp, one 10kWp and two 800Wp biogas based power generation units, the net wattage equivalent of biogas energy amounts to 14.1831MWp.

Based on the estimation that the average installed capacity per SHS is 53Wp, the total solar energy related wattage is 20.75MWp. As mentioned before, the power corresponding to biomass gasification, wind energy based installations and micro-hydropower has been found to be 250kW, 1.9249MW and 60kW respectively. Based on the calculations and data available, relative contributions of the five renewable energy sectors is shown in Fig. 3 in the form of a pie chart. From the figure, it is obvious that solar and biogas energy sectors are the most dominant sources of renewable energy in Bangladesh. However, biomass gasification and wind energy also appear to have potential but their ultimate feasibility is still questionable and is subject to further study.

5. Conclusions

A contemporary scenario of Bangladesh's renewable energy sector has been presented using data and illustrations, on the basis of careful literature review and fieldworks. The relative contribution of the five renewable energy sectors in Bangladesh has been demonstrated with

respect to installed capacity. The results show that solar and biogas based installations are holding a dominant position in terms of feasibility and resource availability. However, the collection of available reliable information regarding the actual progress of renewable energy technology in Bangladesh is difficult and thus any prediction about the future of this technology needs more meticulous research. More organized studies are also needed to assess the effective potential of energies other than solar or biogas.

References

[1] International Energy Agency, *World Energy Outlook, Executive Summary*, 2008.

[2] Christopher Flavin and Molly Hull Aeck, "The potential role of renewable energy in meeting the millennium development goals", in *REN21 Network*, The Worldwatch Institute.

[3] Shahrier Khan, "The search for alternatives," in *Star Weekend Magazine*, vol. 8, no. 65, Apr. 2009.

[4] Ministry of Power, Energy and Mineral Resources, Govt. of the Peoples Republic of Bangladesh, *Renewable energy policy of Bangladesh*, Dhaka, Bangladesh, Nov. 2008.

[5] A.K.M. Sadrul Islam, Mazharul Islam and Tazmilur Rahman, "Effective renewable energy activities in Bangladesh," *Renewable Energy*, vol. 31, no. 5, pp. 677-688, Apr. 2006.

[6] Sk. Noim Uddin and Ros Taplin, "A Sustainable Energy Future in Bangladesh: Current Situation and Need for Effective Strategies," in *The 2nd Joint International Conference on "Sustainable Energy and Environment (SEE 2006)"*, Bangkok, Thailand, Nov. 2006.

[7] M. Rofiqul Islam, M. Rabiul Islam and M. Rafiqul Alam Beg, "Renewable energy resources and technologies practice in Bangladesh," *Renewable and Sustainable Energy Reviews*, vol. 12, no. 2, pp. 299-343, Feb. 2008.

[8] M.A.R. Sarkar, M. Ehsan and M.A. Islam, "Issues relating to energy conservation and renewable energy in Bangladesh," *Energy for Sustainable Development,* vol. 7, no. 2, pp. 77-87, Jun. 2003.

[9] Renewable Energy Research Center (RERC), University of Dhaka, *Final report of Solar and Wind Energy Resource Assessment (SWERA) - Bangladesh project*, Dhaka, Bangladesh, Feb. 2007.

[10] Official Website of Infrastructure Development Company Limited (IDCOL): http://www.idcol.org/

[11] Official Website of Renewable Energy and Environmental Information Network (REEIN): http://www.reein.org/

[12] Official Website of Rural Electrification Board (REB), Bangladesh: http://www.reb.gov.bd/

[13] Rahimafrooz Limited Website: http://www.rahimafrooz.com/

[14] Grameen Shakti Website: http://www.gshakti.org/ics.html

[15] Infrastructure Development Company Limited (IDCOL), *List of approved SHS equipment*, Bangladesh, Jun. 2009.

[16] Infrastructure Development Company Limited (IDCOL), *Implementation plan National Domestic Biogas and Manure Programme in Bangladesh*, Jan. 2006.

[17] Institute of Fuel Research and Development (IFRD). *Annual report 2002–2003*. Bangladesh Science and Industrial Research (BCSIR), Dhaka, Bangladesh.

[18] Tulasi Sharan Sigdel, "Development of biogas energy and its impact on users in rural Nepal," *Socio-Economic Development Panaroma*, vol.1, no. 2, pp. 47-62, 2007.

[19] Annual Development Programme: Bangladesh Power Development Board, July, 2008.