

Solar PV Energy Achievements and Prospects in Development of Rural Bangladesh

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Abstract: Bangladesh is a developing country with full courage to be developed by 2021 and celebrate its Golden Jubilee of liberation as a Digital Bangladesh. But the main factor of development, electricity has not met with the daily demand yet. Nearly 72% of the population lives in rural areas and still many areas have not covered by national grid. Alternative source of electricity must be developed to meet the vision 2021. This paper focuses on how much the country achieved to establish Solar Photovoltaic Energy as alternative clean energy which can help reduce poverty, energy shortage and environmental degradation at remote settlements of Bangladesh. The future plans to mitigate the rising demand of electricity especially in remote areas considering the environment has also presented here. The basic applied forms of solar PV in rural Bangladesh are solar home system (SHS) and micro utility (electrification of rural markets, small and cottage industries). Feedback from the users of these systems indicates that solar energy based electricity has been providing very satisfactory service.

Keywords: Rural Development, Clean energy, Micro utility, Solar Energy, Renewable Energy.

1. Introduction

Bangladesh has major problems with energy crisis, persisting poverty and environmental degradation. With only 60% of Bangladeshis having access to electricity, the per capita energy consumption is only 292 kWh per annum [11]. Even people who are connected with the national grid are experiencing frequent load shedding. So electricity source with ownership getting popular day by day without dependency on the national grid supply. As average solar radiation varies here from 4 kWh/m² day in winter to 6.5 kWh/m² day in summer, Solar Home System (SHS) has become one of the most popular sources of electricity in rural areas of Bangladesh. And now in some places Solar PV panels have installed commercially. There is no resource constraint for application of SHS as solar energy is abundant throughout the country.

There are more than 87,319 villages in Bangladesh with overall population 152.51 million. In view of the dispersion of localities, the low demand, the cost of production, transmission and especially distribution of electricity would be prohibitively expensive for these regions. Decentralized and standalone systems could effectively become a viable option in these areas [3]. In the perspective of Bangladesh several NGOs like IDCOL (Infrastructure Development Company Limited), GS (Grameen Shakti), Rahim Afroz, BRAC (Bangladesh Rural Advancement Committee), CCDR (Center for Community Development & Research) foundations are working to develop our electricity sector with renewable energy sources.

The government also has set a target of generating 500 megawatts (MW) of green energy almost ten times the

current amount by 2015, in an attempt to narrow the gap between current supplies of grid electricity and the needs of the people [4]. Fossil fuels account for almost all the current capacity of 5,500 MW, with renewable sources mostly solar power contributing just 55 MW.

2. Present power scenario in Bangladesh

Bangladesh relies greatly on fossil fuels for its energy. Here coal is still the major fuel for power generation. Bangladesh has adequate high quality coal resources. But the coal mining has not been started effectively. The exploration of coal continues to remain uncertain. 5 coal fields are identified in Bangladesh. Known reserves and resources are around 2,700 million tons. The country still awaits the adoption of a national coal policy before any coal extraction will take place. Major political debate takes place over extraction methods etc. One coal-fired power plant exists, but it is only running at half of its installed capacity (250MW).

As of 2011, 79 natural gas wells are present in the 23 operational gas fields which produce over 2000 millions of cubic feet of gas per day (MMCFD). It is well short of over 2500 MMCFD that is demanded, a number which is growing by around 7% each year. About 89% of generated power comes from natural gas and the rest is from liquid fuel, coal and hydropower. The present share of renewable energy is only 0.5%. Following pie chart refers:

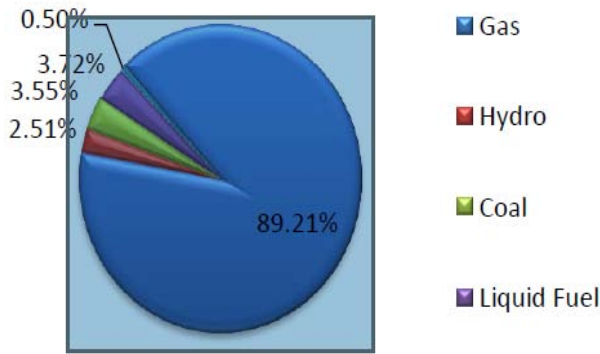


Figure 1. Fuel Consumption for Power Generation in Bangladesh.

99 power plants exist in Bangladesh. Their average age is around 20 years and very little updating has taken place. A study has shown that 7,090 MMCFD was used to generate 480 Gwh at two local plants. A modern plant would produce almost twice as much output (around 880 Gwh) using the same input! System loss is estimated at 7%, while distribution losses are estimated at 14.5% (excl. bulk). On top of this come theft and bypassing of meter limited focus and resources have been given to energy efficiency solutions – mostly because technologies are not in place. Industries – like the textile industry, which only gets 60% of the needed power – are increasingly turning their attention to energy saving initiatives to be able to sustain their business.

3. Overview of Current Renewable Energy Status in Bangladesh

In our country renewable energy such as biomass, solar power and wind power are being used since time immemorial. Especially in areas which are outside gas coverage, usage of biomass for cooking and solar power and wind for drying of different grains as well as clothes are known to all. At present, the different categories of renewable energy that are being used in our country are as follows:

Solar power generation using solar rays, Wind-mill power generation using wind power, Hydro-electricity, Production of bio-gas using waste, Electricity produced by Biomass Gasification Method using wood, rice husk, etc.

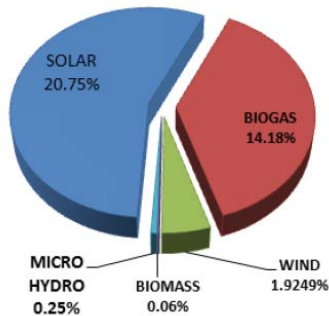


Figure 2. Contribution of different implemented renewable sources in Bangladesh

4. Solar Energy in Bangladesh

Solar Energy is a great source for solving power crisis in Bangladesh. Bangladesh is situated between 20.30 and 26.38 degrees north latitude and 88.04 and 92.44 degrees east which is an ideal location for solar energy utilization [2]. At this position the amount of hours of sunlight each day throughout a year is shown in the following graph in the Figure-3. The highest and the lowest intensity of direct radiation in W/m² (Watts per square meter) are also shown in the following figures.

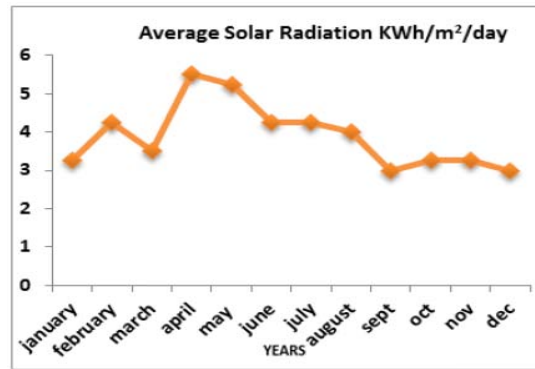


Figure 3. Monthly average solar radiation profile in Bangladesh

Electricity generated from sunlight is called solar electricity and the process of converting solar light into electricity is known as the photovoltaic process. In this process direct current (DC) electricity is produced. The major components of solar PV systems are (a) solar panels, (b) batteries, (c) charge controllers, and (d) DC electric appliances (e.g., lamps, small fans, or televisions).

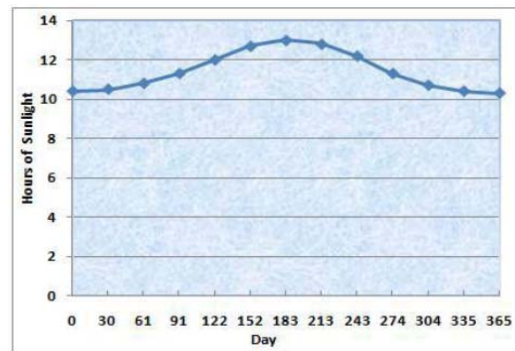


Figure 4. The Amount of Hours of Sunlight in Bangladesh.

5. Solar Electricity and the Applications of Solar PV

A solar panel consists of many cells produced from silicon. Each silicon solar cell can yield 0.5 volt DC. The sunlight impinging on panels, i.e. irradiance or insolation (incoming solar radiation), is measured in units of watts per square meter (W/m²). We can use only 25% of sunlight radiation for PV module. The PV system power output (DC) has approximately a linear relationship to the insolation. Using the solar radiation available on the tilted surface the hourly

energy output of the PV generator can be calculated according to following equation:

$$P = A \cdot x^2 + B \cdot x + C \text{ (in Watts)}$$

Where, x = solar radiation, P =power generation, and A, B, C are constants, which can be derived from measured data. By using above formula, we can predict solar power generation at any solar radiation

Solar panels are installed at a 23° alignment with the ground in Bangladesh, though this alignment depends upon the installation’s geographic location. In Bangladesh the sunlight falls directly in summer and transversely in winter. So, it is most efficient to slant the panel at 45° in summer and between 15° and 20° in winter [12]. Since it is troublesome to adjust the panels at different angles with the change of seasons, the technical experts decided to place the panels at 23° to optimize the light received to avoid moving the panels to track the sun.

Solar PV systems have already made significant headway in Bangladesh. Recent pioneering attempts in this field have generated enthusiasm, but they have also exposed some barriers. Table 1 indicates the existing and potential applications of solar PV in rural Bangladesh.

Table.1. Existing and Potential Applications of Solar PV in Rural Bangladesh

Type of application	Description of application
Rural electrification	Power supply to remote villages. Battery-charging stations.
Water pumping and treatment system	Pumping for drinking water. Pumping for irrigation. Water purification.
Health-care system	Lighting in rural clinics. Vaccine refrigeration. Blood storage refrigeration.
Communication	Remote TV and radio receivers. Remote weather measuring. Mobile radios.
Agriculture	Agriculture Livestock watering. Irrigation pumping.
Income generation	Battery-charging stations. Radio, TV, and video pay stations. Village industry power. Refrigeration services. Electrification of rural markets.

6. The Major Advantages of Solar PV Systems

For using solar PV systems are (a) the customer is the owner of his or her own power-generating system, (b) no billing for charges occurs, (c) electricity is generated for more than 20 years without any traditional fuels, (d) no fuel cost is involved, (d) solar PV systems are durable, (e) the systems are suitable for any part of the country (e.g., underserved areas), (f) no noise pollution is generated and (g) the production of power is environmentally friendly.

7. Achievements with Solar Home System

The only type of modern renewable energy technology that has had some success in Bangladesh is solar PV. With the help of soft loans and grant facilities of donors, more

than 100,000 SHSs have been installed in different parts of Bangladesh. The first solar PV-based rural electrification project in Bangladesh was initiated with the financial support of France, with a total installed capacity of 62 kilowatts peak (KWp), of which 29,414 Wp came from battery charge stations and the rest from SHS. Infrastructure Development Company Limited (IDCOL) has supported NGOs in installation of solar home systems (SHSs).

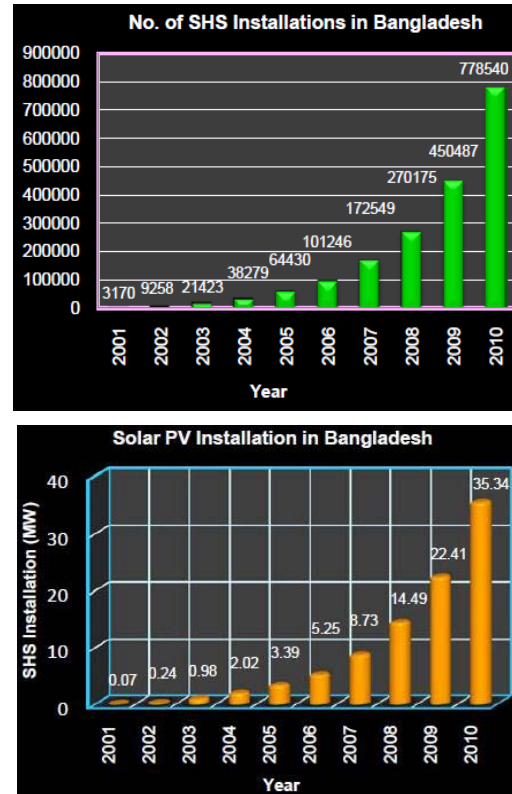


Figure 6. SHS Installation in Bangladesh [10]

Till now, national capacity of renewable energy based power is approx. 50 MW as shown below:

Category	Achievement
SHS	45 MW
Other solar PV applications including solar irrigation	1 MW
Wind Energy	2 MW
Biomass based electricity	<1 MW
Biogas based electricity	1 MW
Total	50 MW

8. Achievements with Solar PV DC Water Pumping System

As an alternative to the conventional water pumping system solar photovoltaic (PV) pumping system has great potential for large, medium, and small scale applications. Out of 11 million hectares of land under rice production, modern Boro rice alone covers about 4.70 million hectares and nearly 98% of this area requires irrigation. However, power shortage and low voltage affecting irrigation from the electricity operated

pumps causing lower production of crops. On the other hand, there are about 1.2 Million irrigation pumps exists of which 85% are diesel driven requiring 800 Million liters imported per year and remaining 15% are electrical requiring 1200 Mw of power [16].

Bangladesh government and NGOs are taking initiatives to remove this problem and they proposed a total of 10,000 solar irrigation pumps to be installed all over the country to replace diesel based pumps. Under the program, solar irrigation pumps with an average capacity of 8 kW will be installed which will operate at total head of 12-15 meter. The pump of this size is capable to lift 500,000 liters of water per day in local solar irradiation condition i.e. 4.5 kWh/m²/day.

9. Initiatives Taken By Government in Renewable Energy

In order to fulfill the electrification target, the government has taken initiatives for utilization of renewable energy sources for electricity generation. Under 1st, 2nd and 3rd Phases, 1200 sets solar home systems capacity of 120 Wp each, 30 sets solar PV street light systems of 75 Wp each, 3 sets solar PV submersible water PV vaccine refrigerators for the health care centers of 360 Wp (3X120Wp) each and 2 sets of 10 KWp each solar system for market electrification are installed by the BPDP (Bangladesh Power Development Board). Moreover the BPDB has planned to install solar home systems in all offices of BPDB for lighting purposes and grid connected solar power plant of capacity 7 MWp [14].

Some more initiatives are listed below [15]:

- a. Solar PV with capacity of 21.2 KW has been installed at the Hon'ble Prime Minister's office as a demonstration program.
- b. Nearly 10MW solar plant will be installed by PDB in Sarihabari (2-4 MW), Regional Training Office, Rajshahi (1 MW), Rajabarihat, Godagari (2-4 MW) in IPP model. Preparation of tender documents is underway.
- c. Power plant in combination with 1MW solar hybrid system along with 5MW by diesel, will be set up in Hatia island. 5MW Solar PV plant will be installed in Kaptai. Some roads of six City Corporation areas will be replaced by Solar Street lights. Asian Development Bank (ADB) is supporting these projects.
- d. REB has taken project for Solar Irrigation System. 40 irrigation pumps will be brought under solar power under this project.
- e. PDB has undertaken a project in a remote area Sullah to provide 600kW solar power under Climate mitigation program.
- f. Ministry of Industry primarily targeted 400 Industries. Estimated solar power capacity addition from this project shall be 20 MW.
- g. Bangladesh Railway has so far 450 Rail stations. So Railway Division, Ministry of Communication proposed 25 MW Solar Power systems to be installed at the remote railway stations and 5 MW Solar Power systems would be installed at the roof-top of unutilized large railway stations.

- h. According to ADB's preliminary study, 40 W, 30 W and 15 W LED Lighting System could be used. Corresponding Solar Panel size would be 100 Wp, 75 Wp and 40 Wp respectively. 33 LED units might be required to electrify 1 km street. The project is aimed to add 10 MW solar power through Solar LED.
- i. Ministry of Education aims to provide 7000 solar power systems to selected government and non-governmental institutions.

Number of Funds for Energy Projects

Government has number of large scale funds especially for renewable energy projects [6]:

- USD 100 million declared as climate fund by the government for climate related initiatives
- USD 40 million set aside by Bangladesh Bank in soft loans for all kinds of renewable energy projects.
- USD 135 million IDCOL fund for solar installation projects (funded by World Bank and others)
- USD 23 million IDCOL fund for biogas/biomass related projects
- USD 29 million IDCOL fund for other renewable energy projects
- USD 245 million IDCOL fund for large infrastructure, conventional energy and renewable energy projects.

10. Conclusion

Power is one of the significant raw materials for all sorts of industries starting from agricultural industries. Electrification is also necessary for increasing socio-economic activities in rural areas. Bangladesh is lacking continuous supply of power from national grid connection especially in rural and remote areas. The current scenario of country's renewable energy sector with PV System has been presented with necessary data and graphs. This solution will definitely help solving current power crisis and at the same time will have a positive impact over social and economic status of rural society using green energy technology. If we go ahead as planned, it will be possible for all citizens to have access to power within 2021. In addition, a six year plan up to 2016 has been adopted to improve power scarcity and provide excess power for future. Vision of increasing economic growth to 8 percent by 2014 and 10 percent by 2017 through industrialization will be a reality with the implementation of this plan. Other countries with similar socio-economic status can utilize the same policy to develop their electricity sector.

11. Acknowledgment

This survey has been accomplished by the information available at the present time and more detailed statistics on energy use in Bangladesh. Finally a model has been developed in which it is shown that Solar Energy using appropriately may improve the quality of life of rural people and provide income-generating opportunities with redressing social inequities and environmental impacts in Bangladesh.

References

- [1] Website of Wikipedia on Electricity sector in Bangladesh. http://en.wikipedia.org/wiki/Electricity_sector_in_Bangladesh
- [2] Statistical Pocket Book Bangladesh-2010, <http://www.bbs.gov.bd/>
- [3] M. A. Wazed, Shamsuddin Ahmed, "Micro Hydro Energy Resources in Bangladesh: A Review", Australian Journal of Basic and Applied Sciences, 2(4): 1209-1222, 2008.
- [4] Website of Renewable energy information network, Bangladesh. Available at: www.renewableenergybd.com
- [5] "Bangladesh Energy Crisis: Soul Searching," Energy Bangladesh, (2011, March). URL:
- [6] <http://www.energybangla.com/index.php?mod=article&cat=SomethingtoSay&article=2051>
- [7] Ministry of Foreign Affairs of Denmark
- [8] Kazy Fayeem Shariar, Enaiyat Ghani Ovy, Kazi Tabassum Aziz Hossainy, "Closed Environment Design of Solar Collector Trough using lens and reflectors," World Renewable Energy Congress 2011, Sweden.
- [9] M. S. Kaiser, M. A. Rahman, M. M. Rahman, and S. A. Sharna, "Wind energy assessment for the coastal part of Bangladesh," Journal of Engineering and Applied Sciences, vol. 1, no. 2, pp. 87-92.
- [10] S. Islam, IDCOL, "An off grid lighting solution in Bangladesh," International Renewable Energy Conference, Delhi, Oct. 2010.
- [11] Ministry of Power Energy and Mineral Resources. Website: www.powerdivision.gov.bd
- [12] Rajib Baran Roy, "Design And Performance Analysis of Solar PV DC Water Pumping System" Canadian Journal on Electrical and Electronics Engineering Vol. 3, No. 7, September 2012
- [13] Official Site of Grameen Shakti <http://www.gshakti.org/>
- [14] Bidut Barta, 12th Edition, Bangladesh Power Development Board.
- [15] <http://www.powerdivision.gov.bd/user/brec/49/90>
- [16] Power Supply Activities, Irrigation Scenario 2010, Power Division, Ministry of Power, Energy and Mineral resources, Bangladesh