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Solar Energy Resources and Related Technologies Practice in Bangladesh

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Abstract

Bangladesh, a middle income south Asian country currently facing several problems, including its overpopulation, energy crisis, global warming, etc. that eventually hinders her industrial as well as socioeconomic development. The frequent load shedding and power outages due to insufficient fuel supply of conventional resources makes this condition worse. Only the 80% of its total population have connected with the national grid. Besides, in the rural areas where more than 65% people reside only 51.4% gets the benefits of electricity. The Bangladesh government has indicated 1027 locations where there is no plan to extend the national grid in the near future. It is not possible to become economically developed by keeping aside this huge population. It is necessary to promote renewable energy sources to meet current energy demand and ensure energy security for the future. Due to the favorable geographical location, Bangladesh has received an enormous amount of solar energy. It would be a potential approach to electrify off grid community and supplying electricity to remote households, markets, health clinics, food industry, agricultural irrigation, etc. This paper presents the opportunity, challenges and technologies related to the use of solar energy and also discuss various projects undertaken by the government and non-government organizations, plans and strategies to promote solar energy technologies in Bangladesh.

Keywords: Sustainable development, Renewable Energy, Solar Home System, Solar Pumping, Solar mini grid

1. Introduction

Bangladesh is an agricultural country in South Asia with 162.9 million people, where sustainable development, energy crisis and food security is of great concern. Nearly 65% of the population live in rural areas. About 51.4 % rural people have access to electricity, where about 90.7% urban people have access to electricity [1]. The statistics indicate a probability of load shedding of around 2500 MW [2]. According to the rural electrification board, Peak electricity demand is 6200 MW but maximum supply is about 4800 MW. Most people in the rural areas depend on kerosene lamps for light [3], 90% of all Bangladeshis cook with biomass, such as rice straw, dried leaves, jute sticks, cow dung, or wood. If it was possible to supply the demand it would ensure the modern lining of rural people, freedom from poverty, 100 % literacy, social security, better work habits, improvement of industrial and agricultural sectors, ultimately the global growth of Bangladesh. The present government is committed to elevating the country to the status of a middle income country by 2021, to be a middle income country by 2021 and a developed economy by 2041 the national demand of electricity will be 24,000 MW by 2021 and 60,000 MW by 2041 [4] which concludes that the electricity demand is increasing day by day. Bangladesh's power sector is mostly dependent on the supply of natural gas. Almost 86% power plants use natural gas as their fuel. As a result, almost 40% of gas produced is used in this sector. Moreover, it has been estimated that at the current rate of natural gas employment and provided no new natural gas fields are discovered any time soon, the country is likely to run out of its natural gas reserves by 2031 [5]. Therefore, the country will be failed to match its energy demand due to the electricity demand growth by 2031. As a result Bangladesh has to import electricity from outside the country or to look forward for some renewable energy solution. However, once electricity demand is assured Bangladesh can surely achieve much of its other development goals.

Use of non-renewable energy resources has multi-faceted environmental and health hazards as well. Burning of fossil fuels like coal and oil for power generation emits greenhouse gases like carbon dioxide, which are primarily responsible for ozone layer depletion, global warming, and respiratory diseases. Acid rain created by the emission of chemicals like sulfur into the atmosphere, often as a result of conversion of fossil fuels into electricity, corrodes machinery and sometimes severely harms local ecosystems. News of oil spills in rivers and oceans, a very relevant example of which is the 2014 Sundarbans oil spill, have been on the rise. The recent sinking of a coal-laden vessel in Shela River is another tragic example. These accidents have devastating

impacts on aquatic life. Therefore, for sustainable development it is high time to eradicate this problem by using some alternative energy source. Alternative solutions to the electricity crisis in Bangladesh include nuclear power plant, wind energy, biomass energy, solar energy project, etc. Among the alternative solutions, solar energy is a viable option, though the startup costs are on the higher side, but due to the very lower contribution to the environmental degradation solar energy is believed to be the most efficient and sustainable source of energy.

The amount of solar energy reaching the surface of the Earth is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable energy resources of coal, oil, natural gas, and uranium combined. Deserts with little cloud supplies nearly 50% more energy per square meter and also equatorial areas have a higher sunshine hour. As a result, depending upon geographical location of areas solar energy can be harnessed at different levels [6]. Solar energy has experienced phenomenal growth in recent years due to both technological improvements and organizational policies as supportive of renewable energy development and utilization. The policies initial works for flexible and easy flow of cash have a major role to play in the proliferation of PV technology in the market, especially when the market development is in the initial stage and is dominated by the rural population.The current study represents the potential of solar energy and electricity generation scenario from different solar energy technologies, energy sustainability and relative factors and overall impacts solar power on electrifying off grid rural areas in Bangladesh.

2. Energy Status of Bangladesh

The present electricity situation is shown in the figure 1, which shows the statistics of last six fiscal years in Bangladesh about the installed capacity, installed capacity (derated), demand forecast, maximum peak generation, and maximum load shedding. In most of the case, load shedding increases due to insufficient electricity supply or generation. In 2015-16, the maximum generation was recorded was 9036 MW where the derated capacity and installed capacity was 11770 MW and 12365 MW respectively.

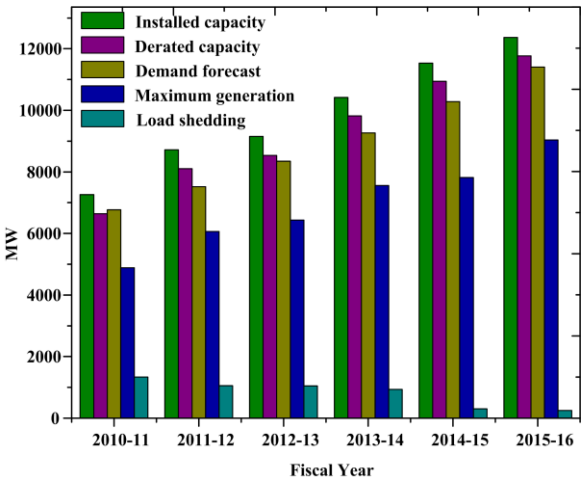

Fig. 1. Present energy scenario of Bangladesh

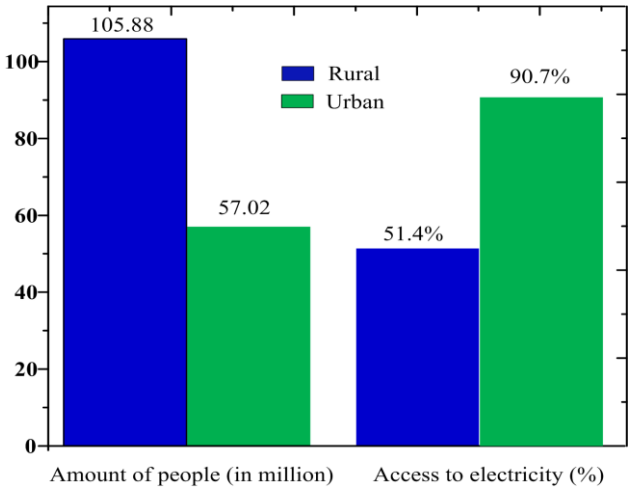

Fig. 2. Electricity access of Bangladeshi people corresponding to total population.

Though the power generation is increasing, but it is insufficient to mitigate the current electricity demand which causes serious load shedding. The load shedding was 250 MW, which increases up to 2000 MW during peak irrigation season. Figure 2 shows that about 50 % of total rural people have access to electricity where total rural people is about 10.6 million and 90.7 % urban people have access to electricity where the total urban people is about 35 % of total 162.9 million people of Bangladesh. The rural people have higher access to solar power than the urban [1] and this rate is increasing day by day. In other prospect rural people have very lower access to the national power grid of Bangladesh.

Table 1. Year wise demand forecast and allocation of gas consumption by population

Year	Population in Million	Demand forecast in GW	Allocation of Gas in bcf
2009-2010	145.1	6454	783.1
2010-2011	149.7	6765	872.8
2011-2012	151.6	7518	962
2012-2013	153.7	8349	1061.5

2013-2014	155.8	9268	1222.4
2014-2015	157.9	10283	1335

Natural gas is the main sources of fossil energy in Bangladesh. Only 3% of the total people have the access of natural gas coming to their households through national grid pipe lines and most of them live in the cities. Majority portion of natural gas is used in power generation. Table 1 indicates that with increasing people electricity demand increases [2] significantly as well causes rapid depletion of reserved gas supply, since majority power power plants of Bangladesh depend on the natural gas. It is now evident that total number of extractable gas is about 20.5 TCF (Trillion cubic feet) including all 27 gas fields among which there are 23 gas fields currently in production. Total consumption up to April 2017 is about 8.5 TCF and hence about 12 TCF is remaining [7]. Therefore it is high time to think about some alternative renewable energy sources to utilize the natural gas consumption.

3. Renewable energy policy in Bangladesh

To utilize renewable energy most conveniently, plan and programs sre needed. 'National Energy Policy for Bangladesh' was taken in 1996. That was not effective plan for using enormous renewable energy source. To accelerate the development of RE program, Government of Bangladesh prepared a roadmap, known as 'Renewable Energy Policy of Bangladesh in 2008 [8]. This policy includes-

1. Goal of renewable energy constituting 5% of total generation by 2015 and 10% by 2020
2. GoB committed to facilitating public and private sector RE investments
3. Scale up RE contributions to electricity and heat energy, and substitute RE for indigenous non-renewable energy supplies.
4. Facilitate RE use at every level of energy usage
5. Develop a legal environment that promotes RE use
6. Encourage efficient and environmentally-friendly use of renewable energy, and promote clean energy

The GoB has two sets of directives for renewable energy investment. The GoB has set renewable energy development targets for several technologies for each year from 2015 to 2021. It is targeted to add 3,100 MW of RE capacity to be installed by 2021. Most of the new capacity will be provided by solar (1,676 MW, or 54%) and wind (1,370 MW, or 44 percent). There are also targets for biomass (47 MW), biogas (7 MW) and hydroelectricity (4 MW). The second directive is the 500 MW solar Program, developed in 2012. The objective of the program is to add 500 MW of solar generation capacity by 2016 through financing and implementing solar-powered projects in both the public and private sectors.

4. Solar energy potential in Bangladesh

Bangladesh is a developing country. It is positioned between 241 0' 0″ N latitude and 901 0' 0″ E longitude, which is an ideal geographic location for receiving abundant solar energy. Bangladesh receives an enormous amount of energy from the sun.

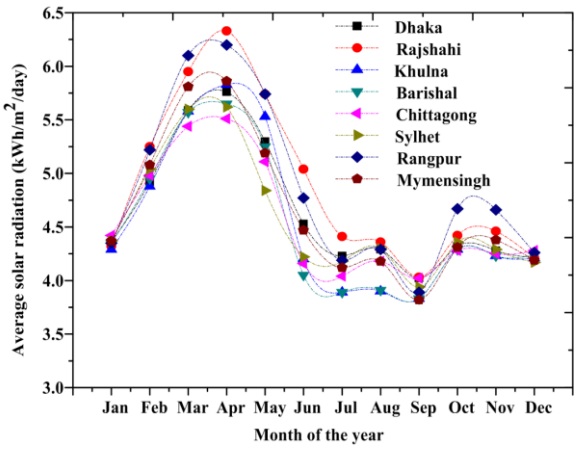

Fig. 3. Average solar radiation in eight divisions.

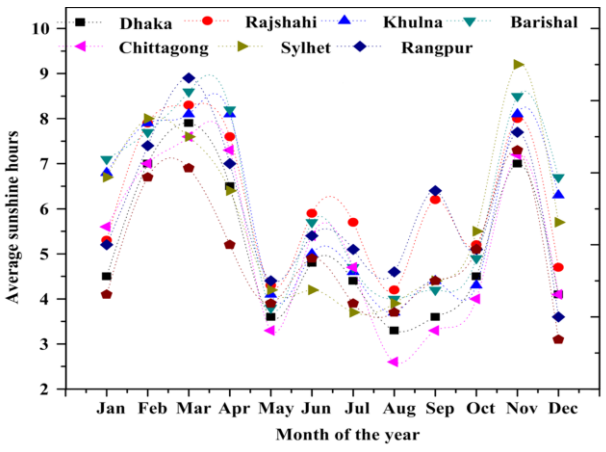

Fig. 4. Average sunlight hour in eight divisions.

Every day at the outer atmosphere of the Earth receive about 1300 W worth of power per hour per square meter.

Around 30% of this power is reflected back which results in a staggering 4.2 kWh/m^2/day. Therefore, it can be safely said that each square meter area collects the approximate energy equivalent of almost a barrel of oil each year [4]. An average of 4 to 4.65 kWh/m^2/day solar radiation falls on this land over 300 days per annum. The daily sunlight hours in Bangladesh ranges from 10 to 7 hours; they further reduced by 54% (to 4.6 hours) to account for rainfall, cloud, and fog [9]. So, solar energy has a large potential to be used in various sector in Bangladesh and will reduce the traditional fuel based power consumption and ensuring a green environment for the future generation [10]. The solar irradiation in eight divisions of Bangladesh are shown in Fig. 3. The daily average variation of solar radiation fluctuates following the pattern of dry and wet seasons in Bangladesh from 4 to 6.5 kWh/m^2. The higher amount of radiation is available during the month of March-April and minimum on December-January Rajshahi region receives higher amount of radiation with a average value of 4.85 kWh/m^2/day where average sola radiation is lowest in Khulna with aveage value of 4.5 kWh/m^2/day. The average sunlight hours vary between 6.69/7.6 h, 6.16 h and 4.81 h respectively in winter, summer and monsoon seasons. The average sun shine in eight divisions has been presented in Fig.4. The maximum sunlight hours recorded in Rajshahi differ from 4.3 to 8.3 h whereas in Chittagong it varies from 3.6 to 8.9 hours.
In Bangladesh, the cloud coverage is maximum during moonsoon season from May to September which is shown in the Figure 5. The lowest cloud coverage is in Rajshahi and highest is in Sylhet, with readings varying from 0.4 to 6.6 okta in Rajshahi and 0.8 to 7.3 okta in Sylhet. During the monsoon season the average cloud coverage across the country is about 5.42 okta.

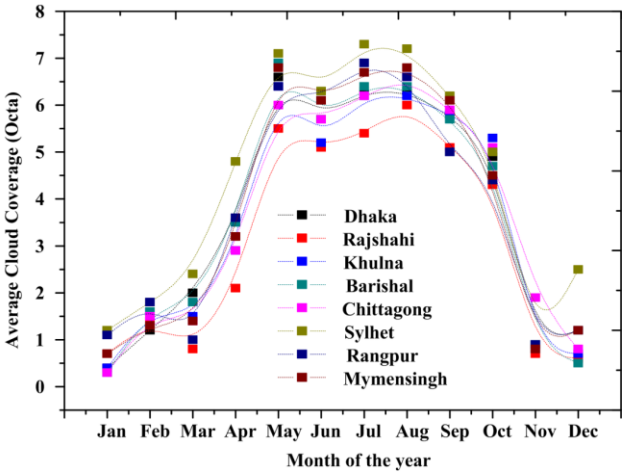

Fig. 5. Average Cloud Coverage in eight divisions.

Rajshahi, Rangpur, Khulna region is more suitable for solar installation since they receive a higher than average amount of solar radiation when compared to the rest of the country. The unit price of PV, maintenance and installation cost have been decreasing over the years, and that is the advantage for investment as an economic scale for a developing country like Bangladesh. From these graphical analysis, it is seen that solar energy in Bangladesh has a huge potential that can be used in rural electrification.

5. Technology practices in Bangladesh

5.1 Solar home system

Solar home system (SHS) is becoming popular day by day in rural areas of Bangladesh, replacing kerosene based conventional lamps for lighting as well as diesel used in generators to electrify off grid community. SHS program was launched to ensure access to clean electricity for the energy starved off-grid rural areas of Bangladesh. The program supplements the Government's goal of ensuring 'Access to Electricity for All' by 2021. Now-a-days, around 70,000 people are directly or indirectly involved with the program [11]. The program has become one of the largest and the fastest growing off-grid renewable energy program in the world. The cumulative power generation from this SHS program is about 180 MW, which is highest production until April, 2017. The Figure 9 and Figure 10 show the progress of power production from SHS program from year 2011 to year 2017. More than 65,000 SHSs are now being installed every month under the program with average year to year installation growth of 58% & the program replaces 180,000 tons of kerosene having an estimated value of USD 225 million per year [11]. More than 4.9 million SHSs have already been installed under IDCOL program in the off-grid rural areas of Bangladesh and about 13 million beneficiaries are getting solar electricity. Beside IDCOL, other organizations like BREB, GIZ, DoDM etc. also finance in SHS program.

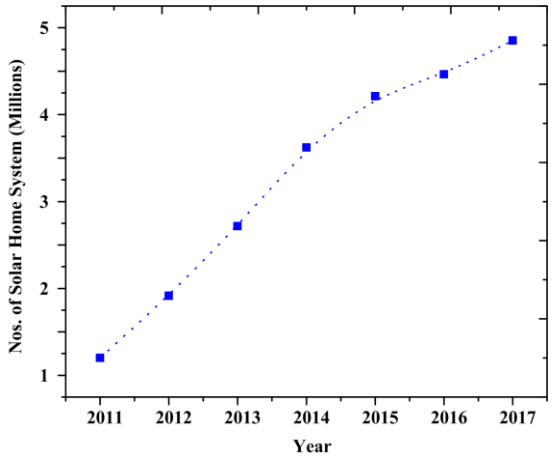

Fig. 9. Cumulative numbers of SHS installations

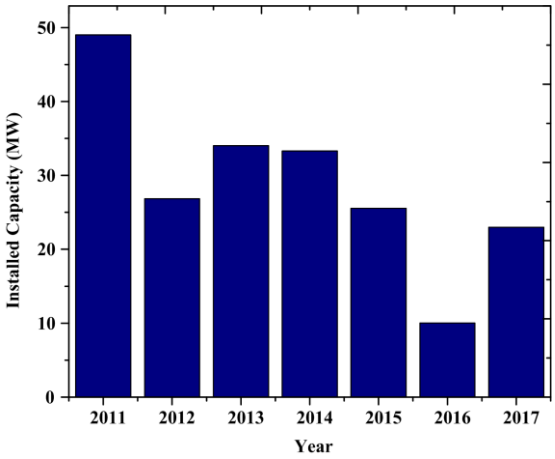

Fig. 10. Projected power generation from SHS

5.2 Solar mini grid

In rural areas, though solar home system is successful but power demand goes beyond simple lighting, small TV and mobile phone charging for small and medium sized enterprises. The demand of grid quality power to operate business items such as as fridges, fans, computers, rice mills, small shops and manufacturing devices enforces to discover a reliable electricity system. Whether grid connection is impossible, intermittent or normal, solar mini-grids increasingly are on their way as a guaranteed goto power source. They deliver interconnection between different off-grid producers and beside batteries, the mini-grid itself is a powerful storage by networking different consumer's profiles. Developing mini grid in remote areas, government has allocated 25 MW to be developed as solar mini grids by the private sector. At present, 11 solar mini grid with a cumulative capacity of 2.19 MW has been installed and are in operation along with 15 more solar mini grid projects are under implementation with a cumulative capacity of 3.17 MW. Majority of these projects are being financed by IDCOL. However BPDB has installed 650 kWp solar mini grid project at Shalla, Sunamganj which is the largest solar mini grid project in south Asia.

5.3 Solar Park

Now-a-days, Govt. has initiated the plan to set grid tied solar based power generation projects with an intention to reduce dependency on fossil fuel electricity generation, in the both Govt. owned non-agricultural lands & private lands owned by private investors. Power generated from the solar park will be directly feed into the grid on commercial basis. A 3MW Grid connected photovoltaic power plant at Sharishabari, Jamalpur by BPDB has produced power since July 2017. The GoB has a plan to harness 510 MW power from grid tied solar park by 2021.

Table 3. Six potential sites of solar park installation

Type	Location	Capacity (MW)
Solar park	Teknaf, Cox's bazar	200
Solar park	Gauripur, Mymensingh	50
Solar park	Dharampasha, Sunamganj	32
Solar park	Teknaf, cox's bazar	20
Solar park	Fulchari, Gaibandha	200
Solar park	Kaptai, Rangamati	7.40
Solar street lighting program	Whole Bangladesh	0.36
	Total capacity	509.76

5.4 Solar Irrigation

By contributing 18.64% of GDP of Bangladesh, using 64% of total labor force, agriculture becomes one of the major driving forces behind economic growth in Bangladesh. As a result, increasing food and agriculture production have always been major concerns for the Bangladeshi policy makers. Solar based alternative energy source can ensure food security as well as reduction of $C0_2$ emission from inefficient diesel based irrigation system which is used mostly. Solar powered irrigation is innovative, economic and environment friendly solution for the agro-based economy like Bangladesh. There are around 1.34 million diesel operated irrigation pumps are working for irrigation, which covers 3.4 million hectares of land [12]. To achieve sustainability in agriculture, it is necessary to promote solar irrigation system mainly in rural areas. With the increasing of

number of solar irrigation, the power production is also increased as shown in Figure 11 and in 2017 the total number of installations stand 719 unit with 7.35 MW capacity.

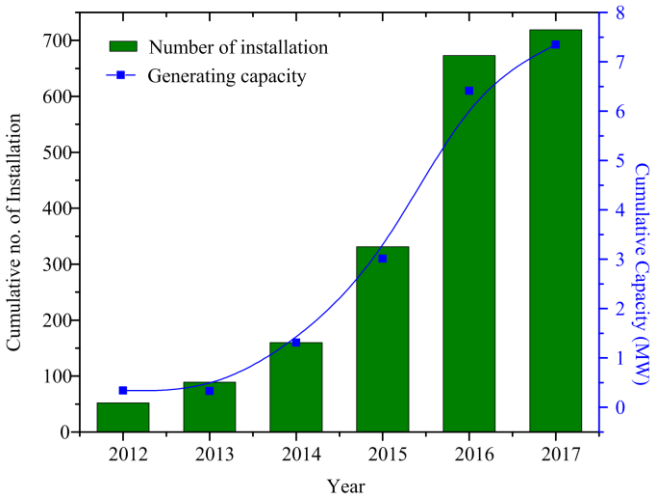

Fig. 11. Cumulative increasing number of solar irrigation for last 6 years.

5.5 Solar drinking water system

Solar-powered drinking water system can provide pure drinking water to the rural community especially in the saline prone areas, coastal and northern part of Bangladesh, where pure drinking water is a scarce. For ensuring safe water supply, solar drinking solution can be customized with the filtration system to remove arsenic, salinity and other impurities from water. Government has already installed 120 solar based drinking water systems in coastal areas through SED project. Almost 152 solar based drinking water system has installed with installed capacity 1.55 MW and about 120 of them are installed by GIZ and 32 by DPHE in different part of Bangladesh. Figure 12 presents the installation of solar drinking water system in different years in Bangladesh.

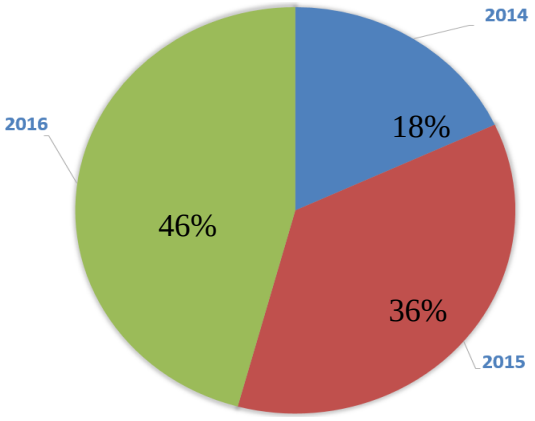

Fig. 12. Cumulative number of solar based drinking water system in Bangladesh

7. Research and Development of solar energy in Bangladesh

In every country research and development in energy and power sectors plays a vital role for sustainable development. To conduct coordination, monitoring and evaluation of research work in these sectors the Government of Bangladesh has established Bangladesh Energy and Power Research Council (BEPRC). Some departments and Energy center of Bangladesh University of Engineering & Technology (BUET) and Energy Institute of Dhaka University are involved in research related to Energy and Power in Bangladesh. In this research areas include power availability, power system planning, grid stability analysis, waster heat recovery, energy efficiency and renewable system design. Centre for Energy Research of United International University is also involved in this research which relates to the Solar Photovoltaic systems. A lot of organizations and companies like World Bank Global Environment Facility GEF, IDCOL, USAID, IDA, BAEC, BPDB, REB different NGO's like CMEC and BRAC are researching on rural power development to ensure rural electrification. Reliable information and best practices can overturn doubts, and show that renewable energy is

the promising and sustainable energy option for Bangladesh, and newly established SREDA can play a vital role in catering to the same.

9. Conclusion

From the above study, it is obvious that there is an enormous opportunity to meet the deficit energy demand as well as future economic development in Bangladesh through solar energy.

- The utilization of solar energy not only ensure future energy security but also produce zero emission thus protects the environment from harmful effect of fossil fuel.
- About 4.5 million SHS has been installed in Bangladesh and has acclaimed to be one of the largest and the fastest growing off-grid energy program in the world.
- Solar mini-grids provide grid quality electricity to remote households, small commercial users and thereby instigate commercial activities to bring mobility in rural economy.
- Solar based irrigation system is very popular in agriculture now a days and it could play a vital role to ensure food security as well as reduction of $C0_2$ emission from inefficient diesel based irrigation system.
- Besides, other solar based technologies such as solar drinking water system, solar thermal system, and solar parks have the significant potentiality to solve present energy crisis.
- But due to high initial cost, lack of subsidy and loan, lower panel efficiency, high maintenance cost and requirement of a backup power system to supply electricity during nighttime and cloudy weather, solar related technologies is not getting much popularity in Bangladesh.
- Development of sustainable energy storage system and growing awareness among the grid connected to community is necessary for development of solar energy technologies.
- Government should establish monitoring system, reduce taxes on solar accessories, grant very low interest loans to investor, subsidize initial installation costs, and organize proper training facilities to promote solar energy technologies among investor as well as the consumers.

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