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PROSPECTS AND CHALLENGES OF SOLAR PHOTOVOLTAIC BASED POWER GENERATION IN BANGLADESH

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Abstract- *At present, over 80% of world's total energy demand is fulfilled by fossil fuel. The continuous depletion of fossil fuel reserves and threats on climate change makes it essential for searching alternative energy sources. Renewable energy can play a vital role in this regard. In this paper, the availability of solar energy in Bangladesh and the prospects of solar photovoltaic based power generation is discussed and compared with power generation from different forms of available energy sources. It is expected that solar PV, because of its flexibility and trends of cost reduction, will be the largest contributor on the overall share of renewables by 2050. This paper finds how to utilize the full potential of PV technology to improve the quality of life. It also highlights the role of government and non-government organizations, government policies and PV module manufacturers in contributing to the total power generation in Bangladesh. Some social, economic and environmental impediments regarding the implementation of PV technology are discussed and the possible measures to be taken have been proposed.*

Keywords: Renewable energy, Solar Photovoltaic, Socio-economic development, PV market etc.

1. INTRODUCTION

Electricity is a vital ingredient for both economic and social development in today's world. Adequate, reliable and reasonably priced supply of electricity is an essential prerequisite for national development. Due to the growing energy consumption around the world and the eminent exhaustion of fossil-fuel reserves, a great interest on alternative energy sources can be noticed nowadays. Bangladesh is a densely populated country having 160 million people with high energy consumption rate. To sustain the current development rate, Bangladesh needs to overcome the problems of power crisis. Renewable energy, especially solar photovoltaic (PV), would be a potential source to solve this. In this paper, the present energy scenario of Bangladesh is presented and the prospects of solar PV based power generation are discussed. The present overall scenario of solar home system (SHS) has been highlighted. The initiatives already taken by the government, future projects, barriers and challenges are described. A few suggestions are also presented to face and overcome the barriers and challenges.

2 WORLDS PRESENT ENERGY SCENARIO

In 2012, worldwide energy demand was averaged 17 TW. For 2050, projected amount is as much as 30 TW. The World Energy Council (WEC) gives a global proven coal reserve of around 850 BT (Billion Tones) which is likely to last 150 years. World Coal Association (WCA) and British Petroleum (BP) suggest that this is enough to provide us 118 years at current rates of production. WEC suggests that 37 percent of the estimated recoverable oil has been consumed. In 2010, the remaining oil reserves are thought to be around 1.3 trillion barrels of oil. The BP estimates a total remaining reserve of 187 trillion cubic meters of natural gas in 2011. The WCA estimates that this will last until around 2070 assuming current production rates. The WEC suggests that natural gas could be a significant supply of energy for the next 130 years [2].

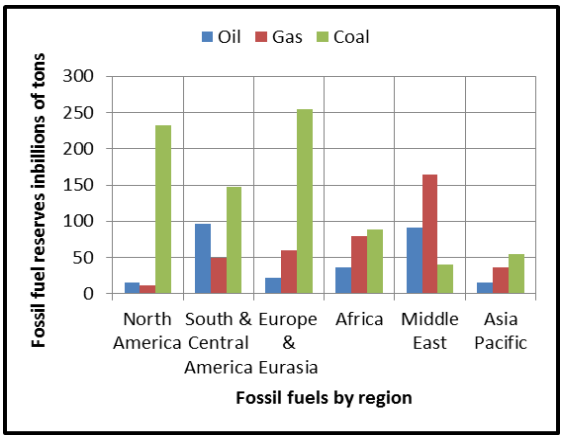

Fig. 1: Fossil fuel reserves in the world [2]

Fig. 1 shows that the whole world is divided into five major fossil fuel reserves area. It is seen that the lowest reserve is in Asia Pacific region. The oil and gas reserves are highest in Middle East, the coal reserve is highest in Europe and Eurasia zone. The whole America (North, South and Central) has also significant reserves of fossil fuels.

Fig. 2 shows the contribution of three separate energy sources to the total world's energy supply in 2010. Here fossil fuel is 80 percent, renewable energy is 17 percent and nuclear energy is only 3 percent.

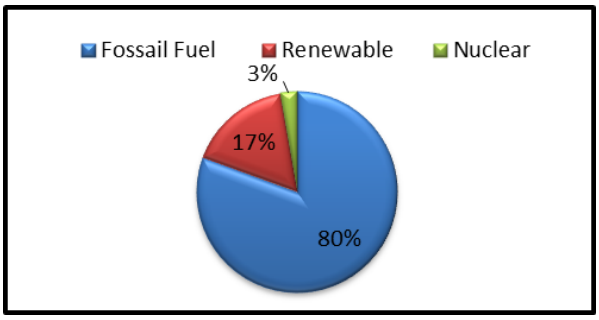

Fig. 2: Ingredients of total world's energy [3]

Fig. 3 shows the contribution of six different renewable energy sources to the total world's 3 percent renewable energy supply in 2010. Here biomass is 70 percent taking the highest place. hydro is 20 percent and solar is only 2 percent.

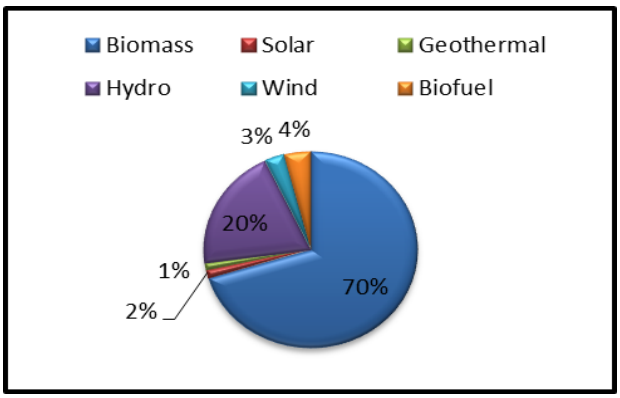

Fig. 3: Ingredients of total world's renewable energy [3]

3. PRESENT POWER SCENARIO OF BANGLADESH

3.1 Overall Energy Scenario

According to the recent estimation, Bangladesh has about 3,300 MT (Million Tons) of coal resources out of which 800 MT are proven reserves. Till now, total number of gas fields discovered is 24. Total recoverable reserves are 20.605 trillion cubic feet (TCF). Total gas consumption up to June 2011 is 9.788 TCF. Total remaining reserve is 10.817 TCF. A total of 708.92 billion cubic feet (BCF) gas was produced in the fiscal year 2010-2011. Though smaller in quantity compared to gas and coal reserves, oil deposits of about 40 million barrels also have been discovered in Bangladesh. To meet the demand we import oil from abroad. In Table 1 the amount of imported oil from 2006 to 2012 fiscal years is described. From Table 1, in 2011-12 fiscal year imported crude oil amount is 15,50,232 MT, Kerosene, Octane & Diesel 2732301 MT, Lubricating Oil 4986 MT, Furnace Oil 253576 MT [4].

Table 1: Statistics of imported oil in Bangladesh

Fiscal Year	Quantity in MT (Million Tons)			
	Crude Oil	Lubricating Oil	Furnace Oil	Octane, Diesel & Kerosene
2006-07	12,11,037	4277	-	2536535
2007-09	10,40,084	5006	-	2227753
2008-09	8,60,877	4828	29959	2507819
2009-10	11,36,567	7262	-	2634212
2010-11	14,09,302	4749	230524	2488456
2011-12	15,50,232	4986	253576	2737301

3.2 Electrical Energy Scenario

Bangladesh ranks third among the top 20 countries where people lack access to electricity. Until 2010, 66.6 million people which are 45 per cent of the country's population were out of electricity. The number of Bangladeshi people under electricity coverage increased from 22 percent to 55 percent in two last decades. Only 43 percent of the rural inhabitants and 88 percent of the urban people were brought under electricity coverage until 2010 [5].

Table 2: Present Electricity Generation Capacity

Sectors	Sub-sectors	Capacity in MW
Public	BPDB	2620
	APSCL	606
	EGCB	255
	Sub-total	3481 (59 percent)
Private	IPP	1271
	SIPP	99
	15 years rental	168
	5 years rental	441
	Quick rental	250
	Sub-total	2455 (51 percent)
Total		5936

In Table 2, generation capacity up to January, 2011 both in public and private sectors is described. In 2011, total generation capacity was 5936 MW. Public sector contribution is 3481 MW and private sector contribution is 2455 MW. Access to electricity is only 48.5 percent of total population. Considering 15-20 percent maintenance available generation capacity is 4600 to 5000 MW [6].

3.3 Energy Plan of Present Government

The perspective plan of the planning commission of the government of Bangladesh for the period 2010 to 2021 has recommended an energy mix to achieve the generation of 20,000 MW by 2021. Targets of electricity production by 2013 and 2015 are 7,000 MW and 8000 MW respectively. The energy mix for power generation is given in Table 3.

Table 3: Energy mix of the Perspective Plan from 2010 to 2025 for power generation [7]

Energy Sources	Target contribution in percent		
	Current	2021	2030
Gas	88	30	28
Coal	3.7	53	38
Oil	6	3	5
Hydro	2.7	1	4
Nuclear	0	10	19
Renewable	0	3	6

3.4 Renewable Energy (RE) Scenario

Globally renewable energy sources generate 3.47 percent of total electricity demand, while in Bangladesh it is only about 0.45 percent. Table 4 shows the present production of electricity under RE.

Table 4: Electricity generation under RE [7]

Renewable Energies	Sectors	Generation capacity in MW
Solar Home System	IDCOL	14
	REB and Others	2.5
Wind Turbine	BPDB	2.0
Biomass Plant	IDCOL	0.25
Total		Around 19

The policy encourages the private and public sectors to develop alternative sources of energy to meet up to 10 percent of total electricity demand through renewable energy such as solar, wind, biomass and hydropower by 2020. Due to natural flat terrain, the hydroelectric potential is relatively small and it is estimated to be around 330 MW, out of which 230 MW has already been developed. The only hydro power station of the country, generating capacity of 230 MW by 7 units is located in Kaptai across the river Karnafuly [8].

Based on the information obtained, a comparative scenario of the five leading renewable energy sectors of Bangladesh is illustrated in Fig. 4 in terms of the installed capacity [9].

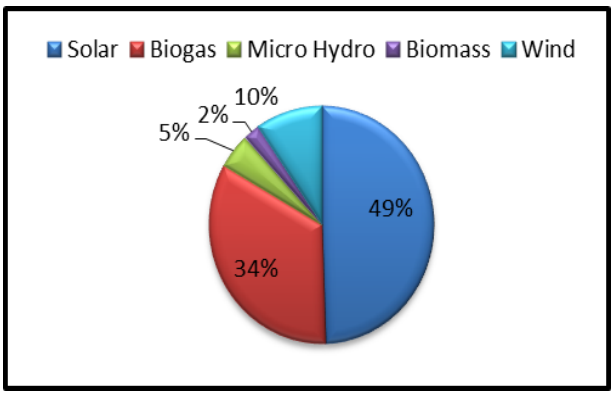

Fig. 4: Contribution of different implemented renewable sources in Bangladesh [9]

Contribution of different sectors to the overall power generation is listed in Table 5.

Table 5: Contribution of different energy sources in percent to the total energy used in Bangladesh [10]

Year	Alternative Renewable Energy	Combustible Waste	Fossil Fuel Energy
2003	0.4	36.9	62.6
2004	0.5	36.1	63.4
2005	0.5	34.6	64.9
2006	0.5	33.0	66.5
2007	0.5	32.0	67.5
2008	0.5	30.7	68.8
2009	0.5	29.3	70.2
2010	0.5	28.1	71.4

From Table 5 we can see that for the last 8 years renewable energy share increased only a little from 0.4 to 0.5 per cent. The combustible waste decreased from 36.9 to 28.1 percent which is very encouraging. To meet the increasing energy demand the use of fossil fuel increased from 62.6 percent to 71 percent.

4. SOLAR ENERGY POTENTIAL

Bangladesh is one of the most promising countries of solar energy. It is situated between 20.30 and 26.38 degrees north latitude and 88.04 and 92.44 degrees east. It is an ideal location for solar energy utilization [11]. The country has on an average 300 sunshine days and sunlight of 4.0 - 6.5 kWh irradiance upheld the potential undoubtedly. This made it possible to achieve 80 percent growth of solar home system (SHS) annually. It enables people to use lights, fans and televisions etc. living in remote location without national grid. Maximum amount of solar radiation is available on the month of March-April and minimum on December-January [12]. The total solar energy reaching Bangladesh is 180×10^9 MWh per year which is 105 times the energy generated as electricity [13].

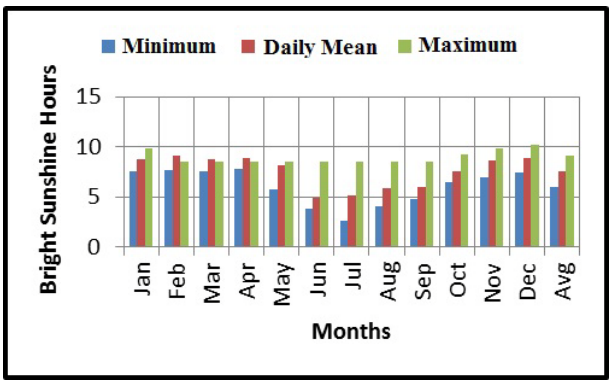

Fig. 5: The amount of bright sunshine hours in Dhaka [14]

The average bright sunshine hours available in a year in Dhaka city is shown in Fig. 5. It is seen in the Fig. that the maximum bright sunshine hour is 10.7 in February and minimum bright sunshine hour is 2.7 in July. These data are recorded for average period from 1961 to 1980. Their daily mean is also given in here.

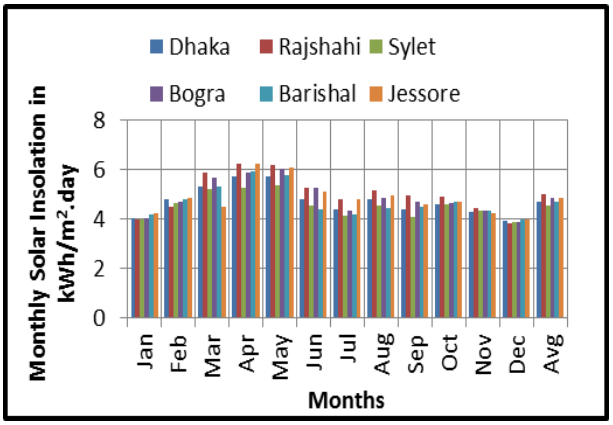

Fig. 6: Monthly solar insolation in various locations [14]

The monthly solar insolation at different locations of Bangladesh is given in Fig. 6. These data are recorded for 12 months from 1988 to 1998 in six different locations. They are Dhaka, Rajshahi, Sylet, Bogra, Barishal and Jessore. In Fig. 6, the maximum solar insolation is in the months of April-May and the minimum solar insolation is in the months of December-January. The highest value of solar insolation is 6.24 kWh/m^2 and the lowest value is 3.82 kWh/m^2, both in Rajshahi.

5. PHOTO VOLTAIC INITIATIVE

In Bangladesh photovoltaic applications are solely dependent on solar home systems (SHS). More than 50,000 new SHSs are being installed every month. Bangladesh has already celebrated the installation of 2 million systems by July, 2013. SHS consists of a solar panel, a battery and a charge controller which is an economically viable solution to power in villages where grid electricity would be too expensive. The battery is charged by solar panel, which in turn provides electricity to the households [15].

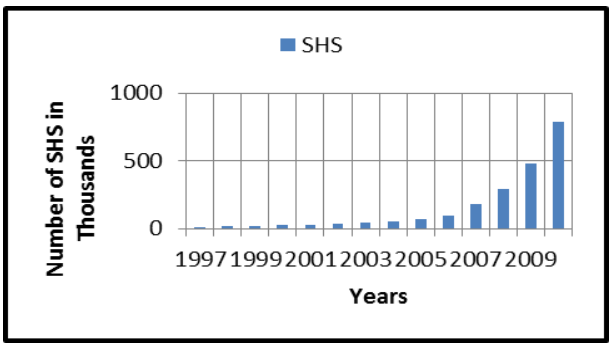

Fig. 7: Yearly SHS installation progress [16]

SHS is now the fastest growing program in the world which is depicted the Fig. 7. In this Fig. we can see that SHS were started before 2000 and gained momentum after 2003, starting from 50 thousand to 8 lacs upto 2010 which is a breakthrough.

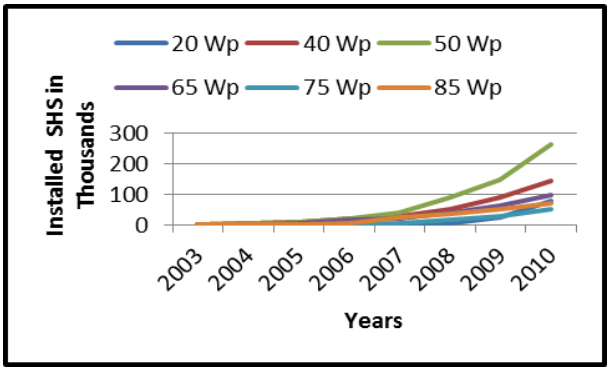

Fig. 8: Market trends of SHS by watt peak [16]

The power of solar panels are determined by Watt peak (Wp). A picture of different types of SHS installed are given in Fig. 8. From this Fig. we can clearly see that up to 2010, the number of 50 Wp SHS installed is the maximum (about 2.57 lacs) while lowest contribution is of 75 Wp SHS (about 30 thousands). The price of SHS is determined by the summation of different components like solar panels, battery and charge controller up to operational costs. The price break of 20 Wp, 40 Wp, 50 Wp and 65 Wp is respectively 13, 330, 22, 480, 28, 275 and 34,850 BDT respectively.

This success of disseminating the SHS to the remote places of the country has been possible because of the direct implementation of solar systems in rural households by NGOs that have received financial backing from donors. A flow chart is given about the fund flow in the Fig. 9. The international donors like IDA, ADB, IDB funds at interest rate for finite tenure to government. Government provides grants to IDCOL. Then IDCOL provides these grants to Partner Organizations (PO) like BRAC, GRAMEEN SHAKTY and other to reduce SHS cost, capacity building and soft loans. Donors give soft loans, grants and technical assistance through IDCOL to POs. Consumers are directly connected to POs and they get services from POs. Eventually, POs select areas, install SHS and provide after sales support and extend micro credit to customers.

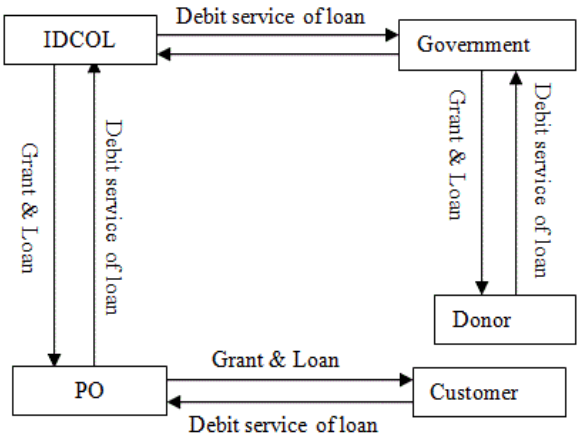

Fig. 9: Funding of Solar Home Systems

According to IDCOL, the total capacity of solar energy based installations in Bangladesh appears to be 20.75 MW [17]. The amount is significant considering the upward trend of the number of SHSs installations in the country.

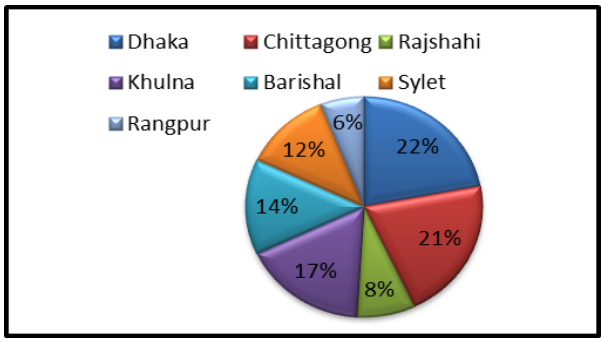

Fig. 10: Distribution of the SHSs in seven divisions of Bangladesh [18]

Fig. 10 shows the approximate division-wise SHS installation. The figure illustrates that the distribution of the SHSs is highest in the Dhaka division whereas lowest in the newly formed division Rangpur.

6. GOVERNMENT SCHEMES

In line with the Government's Renewable Energy Policy, government has planned to produce at least 500 MW power from renewable energy sources by 2015. Government has distributed the total demand between public sectors and private sectors. Government has exempted income tax for next 5 years from commercial production of renewable energy [19]. The schemes are given below successively:

(1) Solar Park: The Park will directly be connected to the grid. Nearly, 100 to 150 MW of solar power is primarily assessed for solar park in different locations.

(2) Roof Top Solar Power Solution: Aggregated 3 megawatt peak Solar Panel already installed throughout the country under consideration.

(3) Solar LED Street Lighting: There are 6 city corporations in the country that operates approximately 5000 kilometers streets. According to Asian Development Bank's (ADB) preliminary study, 33 LED units might be required to electrify 1 kilometer street. The project is aimed to add 10 megawatt solar power through Solar LED.

(4) Solar Home System in Educational Institutions: The project aims to provide 7000 solar power systems to selected government and non-government institutions [20].

(5) Solar Powered Irrigation System: Under the proposed program, a total of 10,000 solar irrigation pumps will be installed all over the country to replace diesel based pumps [20].

7. FUTURE PROJECTS

(1) In 2013, after successful completion of the first phase, World Bank has recently approved Rural Electrification and Renewable Energy Development II (RERED II) project to support another 550,000 systems in remote rural areas of Bangladesh [21].

(2) ADB is willing to fund for a 500 MW photovoltaic project in Bangladesh's off-grid areas. It plans to introduce 3,000 MW of solar-based power systems in Asia pacific regions by 2013 [21].

(3) Infrastructure Development Company Limited (IDCOL) is set to install 2,000 PV mini-grid power plants by 2014 in a bid to bring its off-grid areas under the power network. Plants with an average capacity of 25 kW will be installed in the off grid areas of Bangladesh, which will generate 113 kWh every year [22].

(4) Government has planned to enhance national power generation capacity to 16000 MW by 2015. The solar power contribution to this amount is estimated to be 500 MW [22].

8. BARRIERS AND CHALLENGES

(1) Policy and Regulatory: The lack of clear, long-term and consistent policy is the major issue in Bangladesh. There is recognition of importance of RETs but policy remains at guideline level without budgetary and legislative backup [23].

(2) Financial: The issues of providing subsidies, high initial costs, and high costs of these technologies result in lower rates of returns. Again, absence of financing options also acts as barrier [23].

(3) Institutional: Lack of high-volume supplier dealer chains, coordination among various ministries and institutions, lengthy and difficult process for permission, and time delays associated with decision making limits the growth [23].

(4) Technical: PV technology largely depends on the weather. Besides this lack of standards and quality control, domestic manufacturing or assembling of components stands before flourishing the industry [23].

9. IMPLICATIONS

(1) Both cost of traditional power generation and solar power has been almost in parity when compared with the government's subsidy on conventional power plants and millions of dollar investment needed for grid expansion. So funding on PV technology should be given on priority basis [24].
(2) There should be an investment friendly policy for attracting foreign investment for growth and development of solar PV panel manufacturing industries.
(3) There should be an extended legislative support for investors.
(4) There should be a provision for developing technical infrastructure to support PV products.
(5) Encourage local manufacturing and assembling of Renewable Energy Technology (RET) components.
(6) Ensuring proper use the knowledge, skills, expertise and facilities are available in the country.

10. CONCLUSSION

It's the best time to think different and not to go for power generation by only conventional means. Minimizing the reliance upon fossil fuels and focusing on a renewable energy like solar photovoltaic will be a way in which these developing countries can not only minimize their impact on the environment but also create efficient industries. Many developed and developing countries have already taken policy to go for 100 per cent renewable energy by 2050 where only impediment for Bangladesh is the lack of policy implementation. As Bangladesh's solar industry is almost solely dependent on import facility so we have to spend a lot of foreign currency in this field. We need grid connected system through utilizing the unutilized space. We hope that with the help of these resources Bangladesh can export electricity meeting the internal demand in near future.

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