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Solar Power Generation in Bangladesh: Status, Challenges and Measures

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Renewable energy; solar power production; Global trend; Existing challenges; Potential measures.

Abstract
Efforts toward generation of electricity from solar source by various application technologies is now emerging in Bangladesh. To date, almost 3% of total electricity generation comes from various renewable resources, where 2% is contributed by solar power. Since inception of solar practice in mid 90's, a collaborating effort by government and private organizations successfully set up a strong foundation of solar culture in the country being financially stimulated by the world donor agencies. In fact, the expectation of renewable sharing where solar is the major contributor is much higher in terms of near extinction of country's fossil fuel, fore-coming energy demand and environmental concern. The status of current solar power production, existing challenges to be commensurate with national vision as well as global solar trend, and potential measures have been focused and analyzed in this review paper based on reported data and information.

1. Introduction

Sunlight is cost-free for plants as they possess their own machine and mechanism for photosynthesis. On the contrary, sunlight and solar heat are also free but not cost-free for human being to generate electricity by photoemission and thermo-emission that require technology and technocrats. Currently, Bangladesh has been confined with ready challenges for energy crisis due to rapid declination of its indigenous natural gas which is predicted to be run out by 2030 (Mirza & Rahman, 2017; Zahed *et al*., 2016). Natural gas is the major contributor (52.7% in 2019 and 45.15% in 2024) of general energy-mix of the country (BPDB, 2019 & 2024). When exploration of natural gas from some new potential gas-fields is challenging and global Green House Gas (GHG) concern is uprising, then Renewable Energy (RE) appears to be a key solution to adopt as the future energy shield for Bangladesh. Although Bangladesh has a great potential for renewable energy, especially with solar and wind resources due to its geographical and climate condition, only 3% of total electricity generation comes from various renewable resources to date, where 2% from solar technology as a major contributor (Deb *et al*., 2013; Khan *et al*., 2012; Khanam *et al*., 2018).

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Among renewable energy resources, hydro-electric power plant offers maximum conversion efficiency (80% - 95%) as compared to other competitors such as solar, wind, tidal, geothermal, biogas and biomass (Barua *et al*., 2014; Chowdhury, 2015; Hasnat *et al*., 2014; Rahman *et al*., 2013). But due to the country's topological inconvenience, Bangladesh has a limited option to add much more electricity from additional new hydro-electric power plants to the national grid. However, Government of Bangladesh (GoB) has been taken a series of initiatives including set-up of Private Sector Power Generation Policy of Bangladesh (1996), Infrastructure Development Company Limited (IDCOL, 1997), Guideline for Remote Area Power Supply System (2008), Renewable Energy Policy of Bangladesh (2008), Sustainable and Renewable Energy Development Authority (SREDA, 2012) and Power System Master Plan (PSMP, 2016) to ensure energy security and conservation as well as promotion of national renewable energy for long run (Bagdadee & Fakruddin, 2014; Khanam *et al*., 2018; Marro & Bertch, 2015).

2. Status of Solar Power

In the beginning of 2019, Bangladesh has been capable of producing around 18.98 GW of electricity where the major sharing of energy-mix is natural gas (52.7%) as shown in Figure 1. Besides, dependency of Heavy Fuel Oil (HFO, 22.31%), Auto producing Captive power plant (11.59%) and High Speed Diesel (HSD, 2.31%) is also significant. On the other hand, the graph shows the sharing of RE which is 2.75%, when scheduled sharing was 5% by 2015 as planned by Bangladesh Power Development Board (BPDB) (Hasan *et al*., 2014; Wikipedia, 2019). Current sharing of energy-mix in 2024, where total generation is 27 GW, is also depicted in Table 1 for comparison (BPDB 2024). The SREDA had set-up a schedule of sharing for RE mix to be implemented annually up to 2021 as depicted in Figure 2 and compared with the current generation status as shown in Table 2 (Khandker *et al*.,; SREDA, 2019 & 2024).

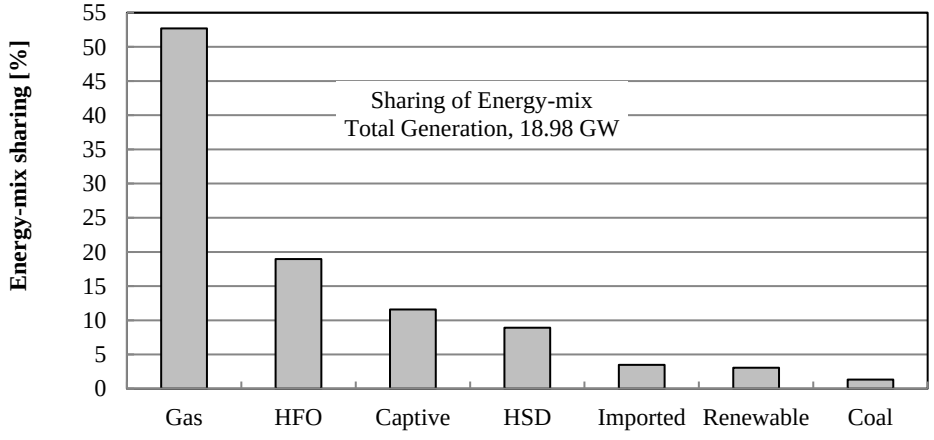

Figure 1. Sharing of energy-mix commonly used for electricity generation in Bangladesh [Source: Website of Bangladesh Power Development Bowad (BPDB, 2019].

Table 1. Sharing of energy-mix in power generation of 2024.

Fuel Type	Capacity [MW]	Capacity [%]
Coal	6604	24.41
Gas	12216	45.15
HFO	6035	22.31
HSD	290	1.07
Imported	1160	4.29
Renewable	459	1.70
Total	27054	100.00

Figure 2 shows that hydro-power, as a most efficient contributor among RE, does not have that much opportunity to add more power with 230MW as currently delivering by one and only Kaptai hydro power plant (Karim *et al*, 2016). The biogas and biomass appear to be the negligible contributors, whereas solar and wind appears as promising RE resources that are expected to have a linear and successive growth in future.

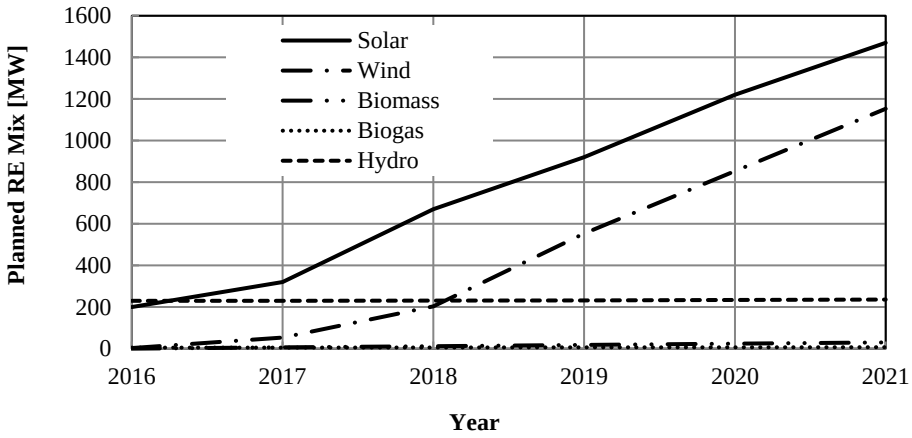

Figure 2. Sharing of RE mix as year-wise planned by SREDA.

Table 2. Contribution and sharing of renewables in power generation of 2024.

Technology	Total (MW)	Total [%]
Solar	1078.77	78.58
Wind	62.9	4.58
Hydro	230	16.75
Biogas	0.69	0.05
Biomass	0.4	0.03
Total	**1372.76**	100.00

But one finds the practical scenario is different when comparing the RE sharing for actual generation and that of scheduled one as clarified in Figure 3. The solar resource, as a major contributor, has been planned to produce 920MW by 2019, while the actual generated power is 344.63MW up to date. Planned expectation from wind was significant (553MW) but the actual generation is far below (3.18MW) the touchline.

3. Current Solar Trends

The Government of Bangladesh (GoB) made a vision of achieving electricity access for all by 2021 and a policy to supplement conventional fossil fuels by RE resources gradually (Islam & Khan, 2018; Sharif *et al.*, 2018). Figure 4 shows the target of RE sharing by GoB for upcoming years, where 10%, 20% and 30% of total electricity generation are planned to cover by 2021, 2030 and 2041 respectively. But the National Committee (NC) to Protect Oil, Gas, Mineral Resources, Power and Ports claims more sharing of RE as also highlighted in the figure as dotted line. The NC demands, on the other hand, 39% and 55% of RE sharing by 2031 and 2051 respectively for the sake of saving nature and ecology for the nation.

In fact, this creates a challenging stand for the government to make an effective strategic plan based on ongoing energy demand, socio-economic stability, GHG emission and ecology issues, drift with global energy trends for a feasible, secured and sustainable electrical power generation in the country. Particularly, solar PV generation, which has an immense potential for the country among other renewables, might be the ultimate target to the government as adopted by the other countries as shown in Figure 5. Currently, European Union (EU) along with China, Japan and India producing GW level of electrical power through solar PV technologies although some of them possess solar insolation much below than Bangladesh.

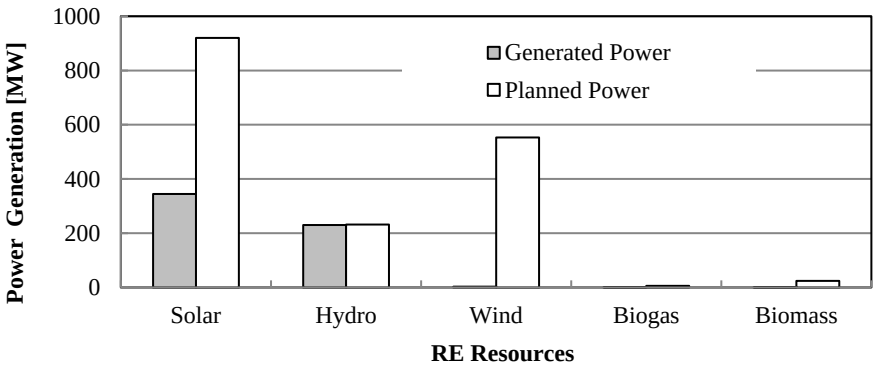

Figure 3. Comparsion of actual generated power and planned power comes from Renewable Energy (RE) resources as for 2019.

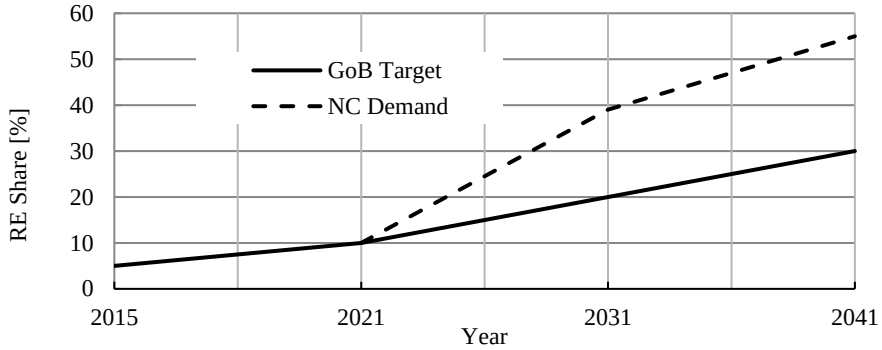

Figure 4. Comparison of RE sharing between Government of Bangladesh (GoB) target and National Committee (NC) demand.

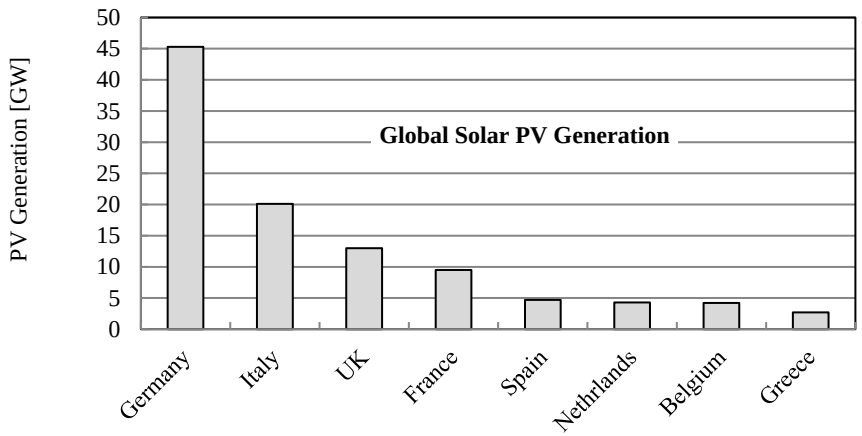

Figure 5. A view of global solar PV generation [Source: Wikipedia, 2019].

4. Expected Solar Trends

The tendency of PV solar growth in Bangladesh based on global PV growth mode is formulated for a clear vision. It has been cited that global solar PV growth is very rapid and that trend is captured to be exponential as illustrated in Figure 6. In order to be merged with the similar trend, Bangladesh is required to take necessary steps and strategies for accelerating solar PV generation in the country.

To find the required gradient of PV growth in Bangladesh, the exponential index, m is estimated by extrapolating the data of global PV growth as shown in Figure 6. Accordingly solar PV generation of each subsequent year is estimated based on Equation 1.

$$G_n = G_1 \times N_y^m \qquad (1)$$

Where,

G_n = Generation for *n*-th year

G_1 = Initial generation

N_y = Number of years

m = Exponential index.

The expected solar PV generation to be commensurate with the global PV growth is estimated based on Equation 1 and depicted in Fig. 7. The graph shows an exponentially rising tendency from 2019 with 344.63MW as initial generation. In 2021, the expected generation was found to be 1119.7MW while SREDA planned 1470MW to generate by the same time period. Again, it has been reported that the national electricity demand is going to jump to be 24GW and 40GW by 2021 and 2030 respectively. Thus the planned sharing of RE (where, mostly is solar PV) was 2400MW in 2021 based on 10% sharing and will be 8000MW based on 20% sharing in 2030 (Sharif *et al.*, 2018). However, the exponential tendency of PV growth reveals that the expected PV generation will be much higher in the subsequent years which will turn into 22.5 GW by 2031. This is apparently a huge amount and quite difficult to achieve but it opens up a challenge and combat to tackle the obstacles encountered with mass growth of solar power generation across the country.

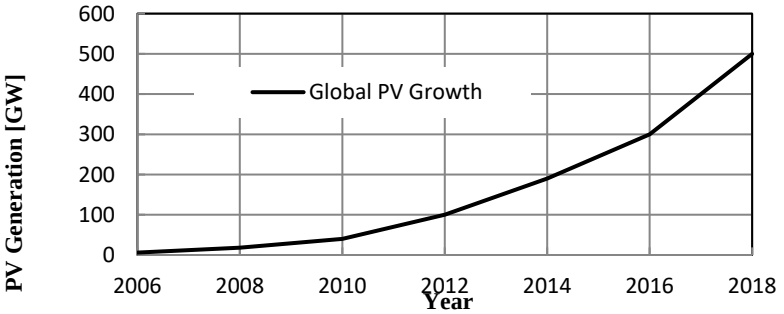

Figure 6. Tendency of global PV generation growth is exponential.

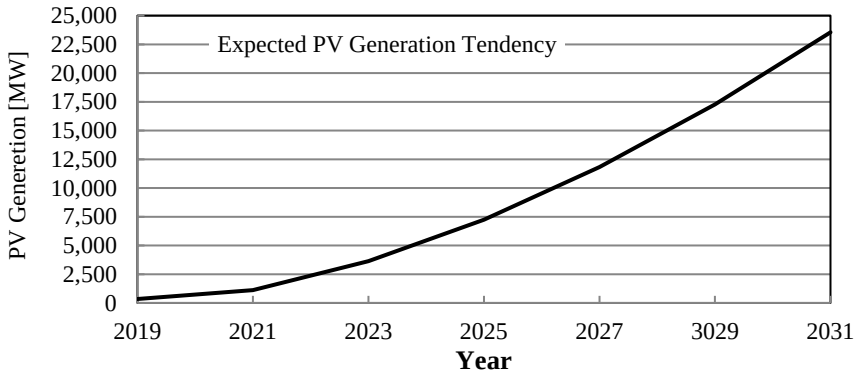

Figure 7. Expected solar PV generation tendency for Bangladesh to be able to merge with that of global growth.

5. Solar Challenges and Measures

Solar energy is abundant in the world but it exists for a fraction of 24 hours and offers very limited conversion efficiency compared to hydro-electric generation. However, in order to compile a success story with solar power generation in Bangladesh, the following challenges and potential measures could be identified:

5.1. Solar Cell Efficiency

The conventional materials used for solar PV cell offers very limited conversion efficiency of up to around only 22% for monocrystalline silicon, which is comparatively expensive than polycrystalline one that is used extensively for solar cell in the country. However, Bangladesh has a limited scope to work for upgrading cell efficiency as facilities for material development is inadequate. In fact Bangladesh usually selects cheaper and low efficient (about 10%) PV cells that require much more panel area for specific load demand. The better option, however, is to select the material with higher available efficiency to reduce the required rooftop area.

5.2. Solar Technology

This is the key option for Bangladesh to exploit diverse but efficient solar technologies for countrywide solar application. Comparison of efficiency of solar PV cell using in Bangladesh with respect ot the efficiencies of various standard PV cells. In recent years, the summer temperature in Bangladesh spikes to around 35°C for most of the days. This allows an opportunity to incorporate solar concentrator and solar thermoelectric generation system with solar PV as a combined technology for generating more power with higher efficiency.

5.3. Available Solar Space

Available space for solar panel installation is a big challenge for a small country like Bangladesh. In order to resolve the issues, versatile and innovative technology must be adopted. The domestic and commercial rooftops, unused plain and hilly areas, island and coastal areas are the suggestive scopes for solar power revolution. Recently developed flexible solar panel is also a breakthrough to setup curvy and wall-mounted solar power system at any places. To facilitate such a distributed solar power systems, versatile application technology and microgrid system is crucial.

5.4. Microgrid System

The remote zones like island, hilly and coastal areas, where national power grid is not extended, require mini or microgrid for ensuring supply and demand of electricity locally. The main concern of microgrid system is the proper steps and policy how to commensurate the generation and consumption cost of solar power. The government policy and intensives might enhance the microgrid projects in remote places to increase the utility of electricity including solar home system (SHS).

5.5. Energy Storage System

The energy storage system for reliable and uninterrupted solar power generation is a must as solar power is vulnerable in cloudy weather and absent in night time. The Battery Energy Storage System (BESS) for small loads like vehicles and appliances are easier to adopt in terms of costing and technology. But for large scale of

commercial energy storage, (some MWh level), costing and technology is a big concern and is not introduced yet in the country. In order to promote renewable energy generation, Government should come forward to import reliable and effective technology for BESS and SMES (Superconducting Magnetic Energy Storage).

5.6. Solar Charger Station

Recently, the use of electric vehicles and smart appliances boost up which put a substantial pressure on the national power grid for electric recharging. In order to resolve the issues, set-up of small distributed solar charger station is useful in urban area as well as country side. The public awareness and national policies are crucial to promote such projects across the country.

5.7. Ready Use of Solar Power

Solar kitchen might be a wise option besides available solar technologies such as Solar Home System (SHS), PV mini grid, roof-top solar generation, Street lighting, solar pump, solar air-conditioning, battery recharging etc. In urban areas, most of the kitchens are operated with natural gas that creates huge pressure on the national reserve of natural gas. Therefore, government might take initiatives to set-up solar operated national grand kitchen for mass production to cover city's major lunch demand.

5.8. Government Policy

Existing government policies have a roll of steering the trend of solar evolution in the country. Therefore, gradient of solar growth greatly depends on the policy and strategy adopted by the government. However, value and ethics of solar system, sharing of RE, national investment and incentives, proactive measures, social awareness, attracting foreign aid agencies and fixing per unit tariff (Biswas *et al.*, 2014; Chakraborty *et al*., 2014) might be the key concerns for the government to promote solar growth spike in near future.

5.9. Extenssive Research

In order to achieve solar breakthrough, extensive research on solar power technology is recommended to carryout for exploiting versatile scopes of application to place the entire country under solar umbrella.

5. Conclusion

Bangladesh, as a subtropical country, possesses a good potential for solar power application. But the overall achievement and sharing of solar resources in national energy-mix is still tiny in terms of MW production. In order to accelerate solar growth, a comprehensive formula has been introduced and referred based on the global solar growth tendency. Besides, the discrepancy between planned and actual solar power production has been focused and analyzed. Finally, visible challenges for progressive solar evolution in the country have been discussed and potential measures have been recommended for solar breakthrough in the country.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the author.

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