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EFFICACY OF SOLAR ENERGY ADOPTING IN BANGLADESH: A REVIEW ON PV PROJECTS OF RURAL AREAS

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Abstract: *Ever growing demand of energy consumption causes Conventional modes of power, besides running out and also aggravating the environment. For this purpose, New and renewable forms of energy are the requirement of the day. The profusion, inexhaustibility and non-polluting nature of the sun's energy to the earth, have made solar energy the right supplement for conventional energy sources, which are getting scarce and exhausted. There exists several potentiality of solar energy as a way to reduce greenhouse gas emissions, load shading in urban areas, providing low cost electricity in rural areas and public places of Bangladesh, but only a few is found in practice. The country receives annually from the sun about 900*1018 joules of energy; but the progress of utilization of this energy using solar PV system is very insignificant. Most of this un-electrified segment of humanity of Bangladesh lives in the rural areas of the world. Already solar power has proved to be a viable solution for remote communities where grid power is not a particular option. Utilization of solar energy for rural household, small scale water pumping application for rural area's agriculture and effectiveness of the PV system installed in the cyclone shelter that acts as a guide house during disasters without grid electricity is prospective one. The cost effectiveness by adopting solar energy in these three sectors is very significant and very consistent proves of the potentiality of the solar energy adoption in Bangladesh. This paper is conducted by considering the commercial point of view of remarkable solar projects already implemented in Bangladesh and the great potentiality to adopt other place and to extent the jurisdiction of those projects.*

Keywords: solar energy, rural area, photovoltaic, electrification, renewable energy.

1. INTRODUCTION

Bangladesh is now facing acute energy supply problem. This is because high dependency on natural resources for daily use of fuel in every sector of national and local as well as individual level. The per capita energy consumption of about 77 kg oil equivalent (kgoe) in Bangladesh is very low compared to the world average of about 1,474 kgoe [1]. Biomass fuels account for 73% of total energy consumption. The shares of the major fuels are wood (65%), agriculture residue (22.1%), and animal dung (7.8%) [2].

The government of Bangladesh has a noble vision to provide electricity for all citizens by the year 2020. But at present only 32% of the total population is connected to grid electricity [3]. Besides, there are many difficulties in providing electricity in very low density area like rural and suburban areas.

Expanding the national grid in those isolated areas is very expensive and not cost effective, solar PV could be an effective alternative to fulfill the electricity demand in these off-grid areas [4]

By considering the above facts, already many project and programs are initiated to adopt solar PV system in rural areas of Bangladesh to ensure electricity supply by facing minimum problems. This research is conducted in light of reviewing three of those success stories.

2. METHODOLOGY

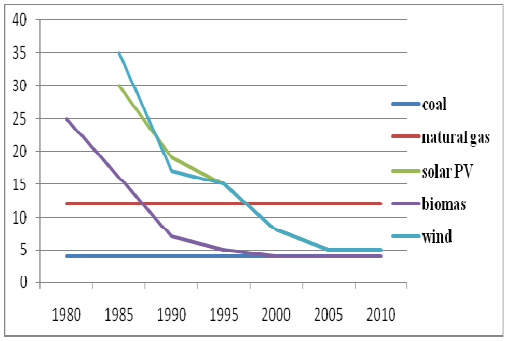
This research involved reviewing previous research reports, newspapers and journal content also collection, collation and synthesis of existing project reports of governmental and nongovernmental organizations interventions relating to solar PV technology in Bangladesh.

3. SOLAR ENERGY SUITABILITY IN BANGLADESH

Bangladesh is highly potential to use solar energy for daily activities because of its geographical location and socio-economic scenario of the people and so on.

Bangladesh is situated between 20.30 - 26.38 degrees north latitude and 88.04 - 92.44 degrees east which is an ideal location for solar energy utilization. Daily average solar radiation varies between 4 to 6.5 kWh per square meter which is 50-100% higher than in Europe [5]

Taking an average solar radiation of 1900 kwh per square meter, total annual solar radiation in Bangladesh is equivalent to 1010 X 1018 J. present total yearly consumption of energy is about 700 X 1018 J. this shows even if 0.07% of the incident radiation can be utilized, total requirement of energy in the country can be met [5]



Source: Tariquel Md, *Solar Electrification in Cyclone Shelters in Bangladesh: LGED's Experience,* Solar Photovoltaic Systems in Bangladesh, 2005. [6]

Figure 1: Levelised energy cost comparison to various power generation technology

Figure 1 is presenting the comparison of cost among different energy options in Bangladesh from 1980 to present. This graph is showing the most suitable energy option as solar PV system.

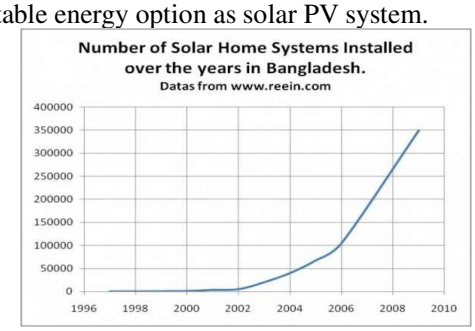


Figure 2: Number of Solar Home System Installed In Bangladesh

Figure 2 is showing the extent of solar power usage in Bangladesh. It is showing the progressive result from the year 2006 till present.

3.1 POTENTIALITY FOR GHG MITIGATION

At present, Green House Gas emission and their long-term devastating effect is one of the main problematic issues related with the fuel and other energy options. Mainly, the developing and underdeveloped countries like Bangladesh are the most vulnerable is case of suffering from GHG emission from self and other developed countries.

In this case, alternative energy adopting with minimum combustion is the best and utmost solution to overcome this devastating problem.

Required tables are presented here which proves the suitability of solar PV system adoption in Bangladesh in the aim of reducing GHG emission.

Table1: Summery of Sector-Wise GHG Emission

Sources and sinks	**Emissions of green house gases**				**CO_2 equivalent**		**Percent of CO_2 equivalent**
	CO_2	**CH_4**	**N_2O**	**NO_x**	**CO**		
Fuel combustion and fugitive emission	12,863	331	44	200	4,205	21,186	29.43
Industrial processes	1,491				6.49	1,491	2.07
agriculture	0	1,363	0.11	3.84	97.30	28,667	39.82
Landuse change and forestry	19,738					19,738	27.41
Waste management		44				918	27.41
Total national emissions	34,092	1,739	4.51	203.84	4,309	72,000	100.00

Source: Uddin Ahsan, *Application of Solar Energy for Mitigation of Green House Gases in Bangladesh*, Solar Photovoltaic Systems in Bangladesh, 2005. [6]

Table 1 is showing present status of GHG emission from every sectors of Bangladesh. Tables 2 to 4 are is showing the potentiality of solar PV system to reduce GHG emission in supply-side, transport, industrial and commercial sectors respectively.

Table 2: Summery of Potential Suppy-Side GHG Mitigation Opportunities

Supply-side emission reduction option	Estimated investment cost of option (US$/unit)	Mitigation potential TCE/YR	comment
Combined cycle power plant	140 milliuon for a 210 MW plant	247,064	Activities of AES Meghnaghat power project 450 MW is now being initiated
T&D loss reduction	N/A	N/A	Estimation has not been attempted

Source: Uddin Ahsan, *Application of Solar Energy for Mitigation of Green House Gases in Bangladesh*, Solar Photovoltaic Systems in Bangladesh, 2005.[6]

Table 3: Potential GHG Mitigation Opportunities in Transport Sector

Demand side emission reduction option in transport sector	Estimated investment cost of options	Mitigation potential TCE/YR	Comment
Vehicle maintenance (cars)	20	36000	Engine, tuning, replacement of old spark plug, CB point, condenser and high tension lead etc considering 100000 cars
4 stroke engines in 3 wheeler	2100	90000	Estimated on the basis of a total cost 4 strokes 3wheeler. Recently the govt. has given a market incentive by waiving off tax on it
Switching of fuel in CNG	410	135600	Conversion of CNG are going on a very slow rate
Mass transit system (new CNG buses)	75000	68000	Private operators are engaged in business by taking daily/monthly lease from BRTC

Source: Uddin Ahsan, *Application of Solar Energy for Mitigation of Green House Gases in Bangladesh*, Solar Photovoltaic Systems in Bangladesh, 2005.[6]

Table 4: Potential GHG Mitigation Opportunities in Industrial and Commercial Sector

Demand side emission reduction option in industrial & commercial sector	Estimated investment cost of options $/unit	Mitigation potential TCE/YR	Comment
Retrofitting of broilers	4000	19360	Assuming retrofitting of a 200 medium sized unit
Enhancing motor efficiency	190	30000-37000	Assuming 25000 small sized motors 2 HP capacity
Brick making	625000	1.14 million	Assuming 500 brick making industries all over Bangladesh
Paddy per boiling	210	12-14 million	Considering conversion of all paddy per boiling unit
Industrial cogeneration	1050000	36600	Assuming introduction in 10 industrial unit
Commercial cogeneration	50000	28000-30400	Assuming cogeneration of 20 medium sized commercial cum residential units

Source: Uddin Ahsan, *Application of Solar Energy for Mitigation of Green House Gases in Bangladesh*, Solar Photovoltaic Systems in Bangladesh, 2005. [6]

From the above discussion, it is clear that the potentiality of adopting and installing solar PV system in every major sectors of Bangladesh can be the best option to reduce GHG emission and its effect.

3.2 POTENTIALITY OF SOLAR WATER PUMP

The economy of Bangladesh depends on agriculture. About 35% of GDP comes from agriculture and about 62% labor forces are directly related with agriculture. The demand of food grain is increasing day by day with the increase of population. To meet this growing demand of food grain, introduction of modern technology at farm level is must. Bangladeshi farmers are dependent on monsoon based agriculture because of water. If farmers have own water pumping system, they would not need this dependency.

The use of solar energy for pumping irrigation water on small farms in the developing country like Bangladesh is one of the great promises and has excited imagination of solar technologists, irrigation engineer and development planner in recent year. This application of solar energy has a number of attractions:

- It is available just when the need for pumped water is the greatest
- It can be tapped at the point at which it is to be applied
- It is under the control of the farmer who wants to use the water.

The areas of many of the farms in Bangladesh are in the range of 0.5 to 2 hectares. The quantity of water needed to irrigate a given area depends on the crop, cropping pattern, cropping calendar, soil, land topography, climate and method of water distribution; but typical figures vary from 4000 m^3/ha with good distribution and management to 13000 m^3/ha per crop. If a crop matures in 120 days the average daily requirement for water can range from about 35 m^3/ha to over 100 m^3/ha. Assuming an average of 6 hours pumping capacity required for one hectare will be in the from 2 to 6 liters/s.

3.2.1 MECHANISM OF THE SOLAR WATER PUMP

Solar Photovoltaic (PV) systems find large market in the developing countries in Asia, Middle East and Africa. Most of these areas are characterized by solar energy availability over large part of the year. Solar radiation received on earth's surface has wavelengths between 0.3 to 4m. It is observed that visible light rays consist of 47% of total energy of radiation on earth. Bangladesh has a total area of 147570 km^2 and an average of 3.5 kWh/m^2 solar intensity falls per day on this land over 300 days per annum. Even if 1% of this land is used to harness solar energy for power generation at an efficiency of 10%, a total of 5.2E + 09 kWh electricity can be generated annually. By using PV technology solar energy can be directly converted into DC electricity, which, in turn, can be used for pumping water through a solar PV pump.

Utilization of solar energy for small scale water pumping is a promising application for rural areas without grid electricity. A DC photovoltaic pumping system may well be used which should consist of three major components:

- a PV array
- a DC motor
- a water pump

The PV array converts solar energy into direct current that powers the DC motor. DC motor is directly coupled to the water pump. When the PV array supplies enough electrical power; the motor produces sufficient mechanical torque and the pump draws water.

There are two important characteristics for a PV pumping system. First, sufficient insolation must be available for a PV system to start its pumping operation; this radiation level is called the insolation threshold. After the system starts up, it will pump water at a rate that depends on the intensity of the insolation. The second important characteristic is the non-linear relationship between pumping rate and insolation. At high insolation levels, the rate of increase of pumping rate with increasing insolation is smaller than for intermediate insolation levels. Solar powered systems for irrigation water pumping have created considerable interest in the recent years. Despite the present high prices of solar cells the application of small units of direct coupled centrifugal pump driven with photovoltaic electricity has multiplied during the past few years, because, solar powered pumping systems appear to have the potential for long life, low maintenance and zero fuel cost. Again, a correlation exists between the availability of solar energy and the requirement for water pumping in Bangladesh. The direct coupling between the solar motor pump set, makes the system simple and autonomous. The system starts up pumping in the morning and stops in the evening without any external intervention.

PV technology is socially acceptable and its impact on local and regional development is of immense value. This technology can create job opportunities to for people. Strong political commitment is necessary at regional level in order to stimulate the development of this technology.

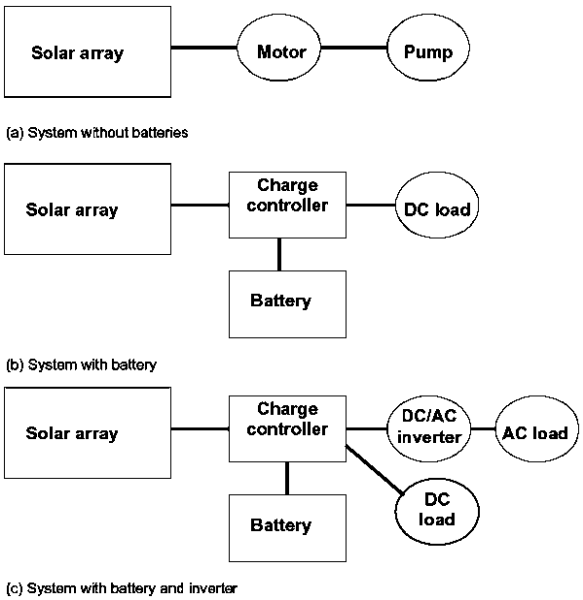


Figure 3: Mechanism of Using Solar Panel for Various Purposes

Mechanism of using solar energy for various purposes is designed in above figure (Fig. 3)

3.3 POTENTIALITY OF SOLAR ENERGY IN CYCLONE SHELTERS

Coastal part of Bangladesh is a disaster porn area. Bangladesh, due to its unique geographic location, suffers from devastating tropical cyclones frequently. The funnel-shaped northern portion of the Bay of Bengal causes tidal bores when cyclones make landfall, and thousands of people living in the coastal areas are affected. Some of the most devastating natural disasters in recorded history with high casualties were tropical cyclones that hit the region now forming Bangladesh. Among them, the 1970 Bhola cyclone alone claimed more than 500,000 lives. Cyclone shelter is an important fact of these areas. Electricity is a major component of cyclone shelter. But at coastal part of Bangladesh grid electricity is frequent or available. For that reason, cyclone center needs independent electrical system. Another reason is that during the cyclone grid electricity is turn off for safety.

Local Government Engineering Department (LGED), with its major mandate of sustainable rural development and environmental conservation, has embarked on a number of programs to improve the physical environment and to promote the natural resource base of the country. As a first step, LGED has taken initiative to electrify cyclone shelters with solar photovoltaic systems in the coastal region of Bangladesh.

Table5: Solar system installation at cyclone shelters

Sl no	Solar system	Capacity (wt)	location
1	Solar household system	12,635	Kuakata in patuakhali, noakhali, cox's bazaar, madaripur, kushtia, kishoreganj, kutubdia, shittagong, khagrachhari
2	Solar battery charging station	150	Kazikanda, patuakhali
3	Solar street light	2640	Kutubdia and Chakoria of Cox's bazaar and Bashkhali and Anwara of Chittagong
4	Solar pumping system	300	Bandarban Prantik Lake
Total in KW		**15725**	

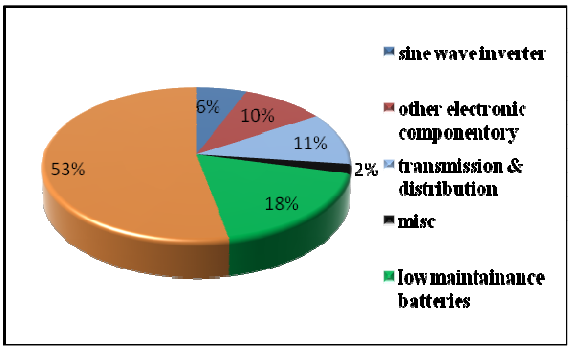
Source: Tariquel Md, *Solar Electrification in Cyclone Shelters in Bangladesh: LGED's Experience,* Solar Photovoltaic Systems in Bangladesh, 2005. [6]

Solar power has greater potential in Bangladesh, since it receive a substantial amount of solar radiation and does not have extensive systems of grid-based electricity. The alternative approach to grid supply by establishing the isolated diesel stations has yielded disappointing result, not only for causing environmental pollution but also for high cost of maintenance. A solar photovoltaic system gives fewer environmental problems than any other means of generating electricity, making power anywhere, thus leapfrogging the present prohibitively expensive process of extending electrical grid anywhere. There is no doubt that most of the early solar PV projects failed to provide a reliable supply of energy for many reason. The major reasons were availability of good quality batteries and Balance of System among them. However, as a result of technological advancement, many of the problems associated with solar PV systems have been overcome. On an overall basis, the experience indicates that under the right circumstances they can be an economical alternative to diesel generation.

Table6: Cost Distribution of a Typical Stand-Alone Solar PV Installation

Sl no	item	size	price
1	Solar panels	2 kw	945000
2	Low maintenance battery	1600 AH	315000
3	Sine wave inverter	30 AMP	112000
4	Other electronic componentory		180600
5	Installation and commissioning		17000
6	Transmission and distribution		200000
7	Transportation		6000
8	Misc		10000
Total 1785600			

Source: Source: Tariquel Md, *Solar Electrification in Cyclone Shelters in Bangladesh: LGED's Experience,* Solar Photovoltaic Systems in Bangladesh, 2005. [6]



Source: Tariquel Md, *Solar Electrification in Cyclone Shelters in Bangladesh: LGED's Experience,* Solar Photovoltaic Systems in Bangladesh, 2005. [6]

Figure 4: Distribution of Costs of Various Components of a Solar PV System

LGED has already established more than 15 kW of solar photovoltaic system in several cyclone shelters in the coastal districts of Bangladesh. In each of the cyclone shelters, the solar installations have been designed to operate 18 lamps and one TV. The solar installations have tremendously reinforced the importance of cyclone shelters and their effective utilization during the period of natural disasters. Earlier, it has been experienced that these shelters were remaining under used even during the disaster period. One of the main reasons attributed to this fact is that the clear approach to these dispersely located remote centers cannot be maintained because of not being used during normal period. It has been observed from past experience that many of the cyclone shelters constructed long back could not provide shelters to the local people at the time of cyclone or tornado hitting the coastal belt. Since the local community and consequently clearance of the access road had not frequently been used, these centers could not be maintained. Local people find it difficult to reach the cyclone shelters during the time of natural disasters.

Now, solar installations at the shelters have increased its wide and diversified use by the local community. It enables the local community to continue adult education and similar program at night. It grows awareness of the local people to take shelter at the time of disaster. Moreover, solar lighting at night transforms this shelter to act as guide house for the ocean-going vessels and fishing trawlers to safety reach to the shore.

4. CONCLUSION

Solar energy is the best alternative from using ever reducing natural resources as fuel and from the effects of combusting them. On the other hand, from the perspective of Bangladesh, where 70% people lives in rural areas and 80% people are directly and indirectly depending on rural livelihood, here solar energy adoption can be the best option to enlighten the lives of those villagers.

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