

## Climate Change Mitigation Approaches in Bangladesh

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Opportunities of Climate Change Adaptation Approaches and Introducing Renewable Energy in Bangladesh

### Abstract

Being a densely populated country with limited natural resources, Bangladesh is deadly suffering from the energy crisis since the past few decades. The geographical location of the country has even made it more vulnerable to the natural disasters. As a result, the country is experiencing the impact of current weather change and the economy is struggling to improve against the periodic occurrence of natural calamities such as cyclones, floods and drought. In spite of being in the row of least carbon producers, Bangladesh is one of the worst sufferers. Due to the limitation in fossil fuel reserve, the only way to minimize the supply-demand gaps in the energy sector is switching towards the alternative renewable energy sources. The initiatives in sourcing out alternative energy resources with low carbon emission from both the government and the private investors are still on the infancy stages. Local investors have started the initiations to switch towards renewable energy systems. There have been some remarkable achievements as the rural people have started using these green energy systems. Government has already taken necessary steps to energize the local economy through inspiring them by low interest loan schemes, and introducing the energy usage in the government owned offices. The renewable energy system is showing a lot of promise in Bangladesh, with the proper technical support and large-scale production Bangladesh will be one of the world leaders in adaptation of renewable energy system.

**Keywords:** climate change, adaptation, low carbon emission, renewable energy, green energy

### 1. Introduction

Bangladesh is a poor, densely populated country, with about 146 million people, which is facing major challenges to the economic development strategy, since it records the lowest rate of access to modern energy services among the South East Asia. In 2010 (Akter, 1997), only about 40 percent of population had access to electricity, which loomed as a major constraint to economic growth and quality of life. The energy consumption is mainly in the form of electricity and about 82% (Ministry of Power, Energy and Mineral Resources [MPEMR], 2008) electricity of the country is produced by natural gas.

However, the energy usage and awareness among the people of this country still lies within the process of traditional concept. With the limited amount of natural gas there is a shortage of about 2000 MW of power generation with a growing demand of 650 MW per year (Bhowmik, 2008). As on September 2012 (Bhowmik, 2008) only 1800 MMSCFD of natural gas is being supplied to an overall demand of 2300 MMSCFD. The current gap in the demand and production in the power sector have forced hundreds of manufacturing firms across the country to shut down.

In FY 2007-08, the total installed generation capacity of Bangladesh Power Development Board (BPDB) was 5202 MW including 1330 MW in Independent Power Producers (IPP) and 58 MW in rental Power Plant. On the Renewable Energy Report of Economic and Social Commission for Asia and the Pacific (ESCAP), Dr. Neem Chandra Bhowmik (Bhowmik, 2008) stated the country's total power generation from different fuels, as shown

in Table 1.

Table 1. Installed Capacity of power in Bangladesh (Bhowmik, 2008)

Fuel	Power Generation	By type of plant	Power Generation
Gas	4251 MW (81.72%)	Hydro	230 MW (4.42%)
Furnace Oil	280 MW (5.38%)	Steam Turbine	2638 MW (50.72%)
Diesel	191 MW (3.67%)	Gas Turbine	897 MW (17.24%)
Hydro	230 MW (4.42%)	Combined Cycle	1206 MW (23.18%)
Coal	250 MW (4.81%)	Diesel	231 MW (4.44%)
Total	5202 MW (100%)	Total	5202 MW (100%)

In 2005, in a mission of addressing immediate and urgent adaptation activities, National Adaptation Program of Action (NAPA) has been founded by GOB along with other least developed countries prepared. The Bangladesh NAPA contains 15 priority projects for implementation with the support of the Least Developed Countries Fund (LDCF) created under the United Nations Framework Convention on Climate Change (UNFCCC). The first priority adaptation activity - Community Based Coastal Forestation Program under NAPA - is currently being implemented by the Department of Forests at a cost of US\$ 4 million (Nayak, 2011). Recently NAPA has been updated by the Department of Environment and Forests.

The government has also created a window to introduce the green energy to the rural people of Bangladesh. The local investors have made the first move and further technical and economic support will lead them to the achievement of greater success.

## 2. Renewable Energy with Low Carbon Emission: An Opportunity for Bangladesh

A decline in fossil fuel availability, their predicted gradual extinction in the next few decades, the need to drastically cut global emissions for mitigating climate change (80% reduction by 2050) (Walsham, 2010), and finally the issue for the energy security have demanded to switching towards the renewable energy sources. To meet the demand of 2020, additional power production should be made from the following sources, as listed in Table 2.

Table 2. Tentative combination of energy in 2020 (Bhowmik, 2008)

	For 6% economic growth		For 8% economic growth
Conventional	3000 MW	Conventional	6000 MW
Atomic sources	1000 MW	Atomic sources	2000 MW
Renewable sources	2000 MW	Renewable sources	4000 MW

The utilization of renewable energy with the aid of modern technology has not yet geared up to the commercial dimensions. Fortunately, rational policy dissemination on renewable energy has been moved to a higher pace. The size and economic potential of the renewable energy resources (e.g., solar photovoltaic, solar thermal power, wind power, biogas, etc.) in Bangladesh are quite high and there have been some remarkable initiation in this sector so far.

Due to the last few years energy crisis and limitation in resources, the government has been forced to focus on the implementation of setting up a guidelines along with the follow up current progress in establishing renewable energy sources along with the private investors. As a part of the planning, an independent institution, Sustainable Energy Development Agency (SEDA), has planned to be established under the Companies Act, 1994, as a focal point for sustainable energy development and promotion. SEDA Board will comprise of the representatives of stakeholders that includes business community, academics and/or representatives from Bangladesh Solar Energy Society, NGOs, and financial institutions and implementing agencies.

Besides domestic approaches, a lot more industrial entrepreneurship in the renewable energy sector can encourage the local efforts. As the local technology has some technical limitations, foreign investments can ensure the maximum profitability using the latest technical knowhow. Bangladesh is the worst sufferers for

climate change, the countries who are responsible for high carbon emission should step ahead to encourage the usage of renewable energy sources.

According to the Renewable Energy Policy of Bangladesh (MPEMR, 2008), a Renewable Energy Financing Facility shall be established that would be capable of accessing public, private, donor, carbon emission trading (CDM) and carbon funds in case of the investments and fiscal incentives. Bangladesh Energy Regulatory Commission (BERC) along with the Government of Bangladesh (GOB) and SEDA have been planned to create a regulatory framework encouraging generation of electricity from renewable energy. As per the provision of the BERC Act 2003 (Bangladesh Energy Regulatory Commission [BERC], 2003), the organization is currently working on the approval of the energy tariff in consultation of renewable energy project(s) with the capacity of 5 MW or more. A proposal has been made to offer “green energy” tariffs, which provide consumers an opportunity to co-finance through their electricity bills. Some private companies such as Infrastructure Development Company Limited (IDCOL), Grameen Shakti, BRAC, and Rural Services Foundation have already initiated the program and set up their target for the next few years.

### **3. Climate Change Adaptation Approaches by the Government of Bangladesh**

A Climate Change Cell (CCC) at the Department of Environment has been setup by GOB in 2004. The primary mission of CCC was to develop a Comprehensive Disaster Management Program, analyze and monitor the climate change impact and facilitate the climate change activities. GOB has allocated BDT 7000 million (Chowdhury, 2012) (US \$96 million approximately) under the banner of Climate Change Trust Fund. GOB has already sought proposals from different public and private sector organizations and NGOs for funding specific adaptation and mitigation activities in the country.

In a mission of providing food security, health protection and social security during the critical time of natural disasters Bangladesh Climate Change Strategy and Action Plan 2009 has been launched by GOB. The coordination of climate change activities in the country along with comprehensive disaster management, infrastructure, and research and knowledge management and finally mitigation and low carbon management have been pointed out as the primary area of concern in this regard. From 2009, Bangladesh Climate Change and Action Strategy Plan have been financed through GOB’s own resources, which included Climate Change Trust Funds and support from different nations.

For the support of the above mentioned activities for the most relevant pieces of environmental legislation in Bangladesh are (a) Bangladesh Environment Conservation Act 1995 (Bangladesh Environment Conservation Act No.1, 1995) (“BECA”), (b) Climate Change Trust Fund Act 2010 (Bangladesh Environment Conservation Act No.1, 1995) According to Bangladesh Environment Conservation Act (1995) (“CCTFA”) and (c) the Right to Information Act 2009 (Bangladesh Gazette, Supplement, 2009) (“RTIA”). BECA was promulgated for conservation of the environment, improvement of environmental standards and control and mitigation of environmental pollution. CCTFA was introduced following acknowledgement of the need for a specific legislation to deal with GOB’s Climate Change Trust Fund in a transparent manner to ensure that the benefits resulting from any project financed by the CCTF could reach the affected people properly. The RTIA ensures, subject to certain restrictions, general right of access to information and makes provisions for ensuring the free flow of information to the public.

The initiation and the platform has been quiet an encouragement for launching a bigger Green Energy Program across the country. The number of the beneficiaries from the solar, wind, bio, hydro and other forms of renewable energy is still running low, but the programs launched by the government along with environmental regulations and economic platforms have clearly encouraged the other national and international private investors and undoubtedly there will be a significant growth in the renewable energy sector in the next five years or so on.

### **4. Threat of Projected Climate Change for Bangladesh**

During the past few decades Bangladesh has been one of the worst sufferers among the nations affected by natural disasters. The country is beset by extreme poverty, overcrowding and flooding that frequently render large numbers of people homeless and damage crops and other resources. A long term climate change will eventually produce environmental effects and exacerbate existing environmental vulnerabilities which will make it rather difficult or in some cases impossible for some people to survive where they are. Especially in the coastal areas like Khulna, Shatkira, Bagerhat and Pirojpur are the most vulnerable points of the country that are exposed to different natural disasters and weather events such as cyclones, tornados, droughts and floods (Intergovernmental Panel on Climate Change [IPCC], 2007). Floods are the most common natural disaster in Bangladesh that naturally occurs every year, and in an average it covers 20 to 40% of the country’s total area.

Most people living in these areas have adapted, raising their houses on plinths and adjusting their farming systems. Besides the periodic occurrence of floods in each year Bangladesh has experienced some severe floods that have covered more than half of the total area of the country, have lasted a prolonged period of time and most importantly took a lot more lives and livelihoods.

In the last 25 years, Bangladesh has experienced six severe floods, with the 1988 and 1998 floods alone causing 2000-6,500 and 1,100 deaths respectively and displacing as many as 45 and 30 million people (Ibid. and National Adaptation Plan of Action, 2005). In the most recent severe floods of 2007, around 32,000 km<sup>2</sup> were inundated, affecting almost 16 million people in around 3 million households. Around 85,000 houses were severely damaged, with 1.12 million hectares of cropland affected and an estimated loss of BDT 5.8 million in livestock (Disaster Management Bureau, 2007).

Bangladesh is also among the worst sufferers of the tropical cyclones that occur, on average, every three years. They are accompanied by high winds and storm surges of up to seven meters, leading to extensive damage to houses and loss of lives and livelihoods. Tropical cyclones in 1970 and 1991 killed 500,000 and 140,000 (Ministry of Environment and Forests [MoEF], 2009) people respectively. Currently Bangladesh is working on the process about warning system, proactive measures and post disaster management. But due to the limitation in resources, the Government can hardly provide support to all the populations that have lost their properties due to such disasters. A weather-related disaster is a certainty in Bangladesh, regardless of climate change. In 1991, a cyclone killed 140,000 people, though a \$10 billion program to build concrete storm shelters has since cut the threat. In 2007, a relatively small number (3,500) died in Cyclone Sidr after 2 million (Walsham, 2010) people were sent to the shelters.

Another threat of river-bank erosion is evident to the people living alongside the rivers. But the worst sufferers are those who live in the river island (Char). Since 1973, over 158,780 hectares of land has been eroded and in 2010 (Lein, 2009) alone, river bank erosion is expected to displace 11,000 people living on the banks of the Jamuna, and more than 5,000 living alongside the Ganges and Padma rivers. More than 2 million peoples are expected to live on the river islands created by land accretion.

Apart from the statistical analysis of the recent past, there have been some alarming projections for the projected years according to which everyone needs to act quickly. Globally, the average sea levels rose by a rate of 1.8mm per year from 1961 to 2003 and the most severe of the IPCC six scenarios in the Fourth Assessment Report predicts a further total increase of between 26 and 59 cm by the end of the 21 Century (or between 20 and 43cm).

The global rate projections have not been always supported the evidence at the local levels as some additional contributing factors such as tectonic setting, sediment load and deltaic subsidence influence the relative rise of the sea level. An OECD study in 2003 concluded that sediment loading may broadly balance out the effects of compaction and subsidence and therefore suggested a figure of between 30 and 100cm by 2100. In contrast, Bangladesh's NAPA, which relied on the IPCC's Third Assessment, recommended figures of 14, 32 and 88cm for the years 2030, 2050 and 2100 respectively (Ibid. and National Adaptation Plan of Action, 2005). If the projections are right, more than 20 million people will become homeless and cultivation of rice and other crops will be severely hampered, according to the U.N. IPCC.

Farmers in Bangladesh already have to deal with a highly variable climate including significant variations in the onset and end of the monsoon, unpredictable rainfalls patterns and problems with excessive temperatures, dry spells and low soil moisture etc. Climate change is expected to exacerbate these problems, with the IPCC's Fourth Assessment Report suggesting that temperatures will increase globally by 0.2°C per decade for the next two decades. After that point there is considerable divergence in models depending upon the IPCC's six scenarios with between 1.8 and 4°C warming projected by 2100. Importantly, temperature changes will vary regionally, with greatest warming expected over land and at high northern latitudes and South Asia as a whole is projected to experience warming greater than the global mean.

The social and economic losses endured by the country in the last few decades and the limitations in the adoptability in the energy sources have jointly demanded the switching towards alternative renewable energy sources with low carbon emissions. As the demand of energy is rising exponentially with the increase of populations, there is no other option by which Bangladesh can achieve a sustainable development. The main natural resource; the natural gas has a limited storage (Remaining Reserve 12.9 Tcf) (Bhowmik, 2008) that ensures a further decrease in supply after the year 2025 unless some new proved reserve are added to the national grid. About 2500 medium and small scale industries in the Chittagong area have been kept shut as there has not been any electricity and gas supply. It is high time, the country has started thinking for alternative energy

sources.

## **5. Present Opportunities and Methods for the Future Development in Different Renewable Energy Sectors**

Through the combined effort from GOB and private investors, there have been some remarkable initiations in every sector of renewable energy in Bangladesh. The current activities and the existing platform are expected to ensure remarkable growth in the green energy system in the next few years. Though the initial erection demands larger investment, the low operating cost along with minimum maintenance and the increasing demand ensures profitability and proper economic growth for the investors.

### *5.1 Solar Energy*

The most common source of renewable energy is the solar energy which is inexhaustible and pollution free. Considering the direction of light and heat from the sun, the most favorable spot for the consumption of solar energy lies between the area of 15° and 35° latitude north and south. Fortunately, Bangladesh is situated between 20°43' north and 26°38' north latitude and as such Bangladesh is in a very favorable position in respect of the utilization of solar energy.

Annual amount of radiation varies from 1840 to 1575 kWh/m<sup>2</sup> which is technically feasible compared to the other areas in South East Asia. The total annual solar radiation in Bangladesh is equivalent to 1010 × 10<sup>18</sup> J considering the average of 1900 kWh/m<sup>2</sup>. Present total yearly consumption of energy is about 700 × 10<sup>18</sup> J. So this is evident that utilization of about 0.07% radiation will be able to meet the energy crisis of Bangladesh. At present energy utilization in Bangladesh is about 0.16 W/m<sup>2</sup> land area, whereas the availability is above 208 W/m<sup>2</sup>. Apart from the availability, the country has a winter lasting about three to four months when there is nearly zero rainfall across the country. So, the energy consumption could be diverted from the fossil fuel sources during that period of a year.

Currently “Rural Electrification and Renewable Energy Development Program” is being implemented, Initial target was to finance 50,000 SHSs by the end of June 2008. Current target is installing 64,000 Solar Home Systems (SHS) by the year 2012 (Islam, 2009). The Rural Electrification Board (REB), Local Government Engineering Department (LGED) and Bangladesh Power Development Board (BPDB) are jointly working on the scaling up process of solar PV systems along with the necessary process up gradation and necessary modification. PV is being used to meet the electricity need of remote areas. However, the activities in fields other than SHS are not significant. PV has already been introduced to supply electricity in some rural areas for vaccination refrigeration, PV electrification, railway sailing and operating battery charging station.

### *5.2 Wind Energy*

The potential of wind energy is mainly limited into the coastal area where the velocity of wind is considerably higher. Bangladesh Centre for Advanced Studies (BCAS) with the assistance from Overseas Development Administration (ODA) of UK launched the Wind Energy Study (WEST) Project in October 1995. The aim of this project is to assess the potential of utilizing wind energy as mechanical and electrical power. They collect and analyze wind speed data at seven areas of Bangladesh (Akter, 1997).

The locations are widely dispersed along the vast coastline in the district of Cox's Bazar, Chittagong, Noakhali, Bhola and Patuakhali. The average wind speed of those locations is shown in Figure 1.

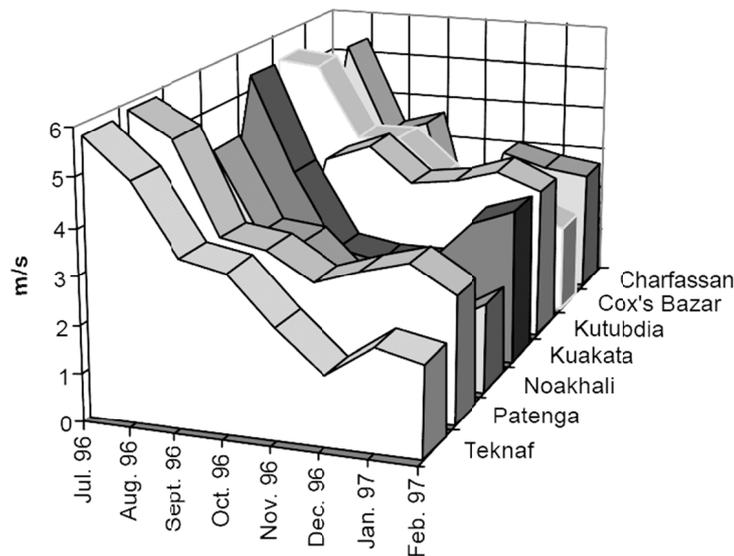


Figure 1. Wind speed at 25 m in different coastal areas (Akter, 1997). The figure shows wind speed at different coastal areas during six-month period of time from July 1996 to February 1997. The figure peaks at 6 m/s in case of Teknaf and Patenga on July, and gradually drops down to 2 and 3 m/s respectively

Presently there are 2 MW of installed wind turbines at Feni and Kutubdia. Only 5 small plants each of up to 10 kW capacity have been installed for demonstration purpose. A 10 kW wind-solar hybrid system is planned in a small island of Bay of Bengal. A Govt. Entity is currently installing a  $4 \times 225$  kW wind farm in a coastal location. A project on wind-pump for drawing underground water has been implemented, which has shown that even low wind speed can be utilized for water pumping for irrigation.

### 5.3 Biomass

Common biomass resources available in the country such as sugarcane baggage, husk from rice, crop residue, waste wood, animal and municipal waste, etc. The sugarcane baggage produced from different sugar mills could be utilized in this regard. This project still lies within the thought of the entrepreneurs but in the next few years can add substantial amount of electricity to the national grid, as can be seen from Table 3.

Table 3. Estimates of Energy Supplied By Traditional Biomass Fuels ('000 Tons of Coal Equivalent) (Bangladesh Council of Scientific and Industrial Research [BCSIR], 2005)

Fuels	2000-01	2001-02	2002-03	2003-04
Cow-dung	2471	2471	2471	2502
Jute stick	966	1010	966	922
Rice straw	1429	1409	1418	1218
Rice hulls	2810	2854	2898	2854
Baggage	310	366	366	392
Fire wood	1166	1219	1219	1272
Twigs/ leaves	1378	1431	1484	1537
Other	1230	1273	1131	1161
Total	11760	12033	11953	11858

### 5.4 Biogas

Biogas mainly from animal and municipal wastes may be one of the promising renewable energy resources for Bangladesh. Up to the year 2004, about 10,000 small biogas plants were in operation in the rural areas of

Bangladesh. BCSIR has developed bio-gas plants suitable for Bangladesh. Under an implementation program 20,000 plants have been installed (Hossain & Khalequzzaman, 2004).

On a feasibility study prepared for the Danish investors about the market potential of Bangladesh it has been indicated (Bhowmik, 2008) up to 800 MW of electricity could be produced in Bangladesh using organic city waste and poultry litter. 12 gasification-based biogas plants equivalent to 5 MW capacities are now being considered by donor-financed IDCOL. As on 2012, only a fraction of the total of 15,000 tons of waste is being recycled annually. About 80% of produced waste is organic which have a high potential for biogas production. The amount is expected to rise up to 47,000 tons in 2025 (Bhowmik, 2008).

### 5.5 Hydro

The only hydro power station of the country, the Karnaphuli Hydro Power Station has a generating capacity of 230 MW. Micro-hydro and mini-hydro have limited potential in Bangladesh, with the exception of Chittagong and the Chittagong Hill tracts. Hydropower assessments have identified some possible sites from 10 kW to 5 MW but no appreciable capacity has yet been installed. By LGED another two projects have been planned to be erected.

The Sangu project will be a new Project with an annual energy of about 300 GWh per year, for an installed capacity of 140 MW. However, this project needs a detailed environmental, social and economic study in the present context. The Matamuhuri development would be a new project of capacity 75 MW and an approximate average annual energy 200 GWh per year (Bahauddin & Salahuddin, 2012).

To explore potential sites of micro-hydro, several studies have been conducted by Bangladesh Water Development Board (BWDB) and BPDB in 1981. In 2004 Sustainable Rural Energy, Local Government Engineering Department has explored some potential micro-hydro sites in Chittagong Hill Tracts (CHT) region which is listed in Table 4.

Table 4. Potential Micro Hydro Sites in Bangladesh (Local Government Engineering Department [LGED], 2004)

Site	Expected Power Generation
Nunchari Tholipara, Khagrachari	3 kW
Chang-oo-Para, Bandarban	30 kW
Bangchari, Bandarban	25 kW
Liragaon, Bandarban	20 kW
Kamalchar, Rangamati	20 kW
Thang Khrue, Rangamati	30 kW
Monjaipara, Bandarban	7.5 kW

Other renewable energy sources include bio-fuels, gasohol, geothermal, river current, wave and tidal energy. Potentialities of these sources are yet to be explored.

The opportunities mentioned above have shown some sign of initiation but the initial promise should be encouraged through large scale industrial application with latest technological content. Foreign investments in this sector will encourage the local entrepreneurs to go for the next step of extension. The government will also participate when this promising sector(s) show actual sign of improvement and wider range of applicability. The combined effort from the locals, foreign investors and Government would be able to create a long lasting partnership. Government can contribute to the international research by providing expats and the international investors can provide the latest technologies to optimize the profitability.

## 6. Challenges

Given the opportunities in the renewable energy sector in Bangladesh, there have been plenty of obstacles that need to be overcome. Unavailability of technical information on the feasibility study discourages the investors to go for a bigger plan of action. Bangladesh currently does not have any central database for the primary survey report that will be reviewed on the pre-feasibility study before any new installation on the commercial scale. Nevertheless, the current environmental goals have not clearly considered on the environmental laws and acts of this country, as they were brought into force quiet a long time ago.

Currently GOB is only focusing on the quick rental power generation which can only be considered as a short term solution for the projected energy crisis of the country. Investment on every renewable energy sources will be a certain encouragement for the private investors, but the initial investment for those projects with the current economic condition will be a challenging job for the Government.

Apart from the electronic databases and Government initiatives another area of concern lies in the sector of building up efficient manpower through international trainings, seminars and workshops.

## **7. Solutions**

Bangladesh has succeeded to make an impact to build up the awareness among public but further challenge awaits the country to make a practical move in every renewable energy sector for the next few years. With a number of diversified approaches for switching towards the renewable energy systems, Bangladesh will be benefited in a number of ways.

Firstly, the country will be able to shift the load and dependability from the fossil fuel sources and provide the assurance and security for long term availability.

Secondly, as one of the worst sufferers for climate change, Bangladesh needs to set up an example for the others by which the carbon producers who should be aware about the impact on the environment they are creating. Setting up an example should be an encouragement for the other nations that are producing significant amount of carbon and polluting the environment.

Thirdly, though the initial investments are higher but low operation and maintenance cost will be a factor of encouragement for a less developed country like Bangladesh.

Fourthly, to cope up with the latest technological inventions in process industries and energy conversions, the quickest reaction in this regard will empower the country to go for further advancement in the upcoming years.

Finally, to become one of the global leaders for battling against the carbon emission, Bangladesh needs to look upon its own techniques and energy sectors first. Depending upon the fossil fuels entirely will not certainly help them create an impression for going for the greener energy sources. Bangladesh may be the least contributors regarding the amount of emission of carbon, but considering the total percentage of carbon emission within the country, the result is quiet alarming. The terrible sufferings throughout the periodic occurrence of natural disasters are definitely the main hindrance for the sustainable development. Bangladesh needs to act for its own sake and needs to act quickly.

## **8. Conclusion**

Accessing the opportunities for switching towards the low carbon emitting technologies some remarkable R&D activities have been observed along with the logistics from the government. The renewable energy policy has been formed but it is yet to be implemented. Another concern is the goals are not clearly specified for a given timeframe. Long and short term investments have been encouraged by the government but Climate Change Trust Fund and The Right to Information Act do not necessarily reflect any benefit that will be applicable for the private investors. Awareness among the policy makers and general people are increasing about Renewable Energy Target (RET) and climate change, Solar and Wind Energy Resource assessment has been done.

There are plenty of barriers hindering widespread deployment of potential RETs in Bangladesh. Lack of information among the public and policy makers about renewable energy resources, unavailability of the technical and economic information are the main barrier in this regard. There are some technical barriers as the local manufacturing and assembly of renewable energy technology components and equipment are currently limited. The high installation cost is probably the main barrier for switching towards the Renewable Energy sources. The human expertise on system design, installation, operation and maintenance of renewable energy technologies and on project development is also very much limited.

However, the barriers and limitations should be accounted as the encouraging factor for the area of future improvement, as the idea of renewable energy sources is still in the early days in Bangladesh. The ongoing projects could be a motivating factor for the future planning in this area. Being among the countries that emit least amount of green house gasses Bangladesh aims to be within the first few row of the nations that have adopted the renewable energy effectively. In spite of having limited natural resources and technological drawbacks the current initiatives and upcoming opportunities has clearly set up a convenient platform for a better solution the energy crisis. A coordinated effort of the concerned authorities and stakeholders and effective implementation of the action plan may surely improve the adaptation approach to mitigate the challenges of carbon emission due of climate change in Bangladesh.

## 9. Methodology

Primarily the current energy consumption situation of Bangladesh has been reviewed with the limitations and future challenges. The analytical and statistical data mentioned in this paper have been collected from different references. The data provided by the government have been considered when more than one energy sources were found. Identification of the current problems and reason to switch to the renewable energy sources have been mentioned by describing the current problems, limitations in natural resources and exponential increase in demand.

After identification, the objective was to find out the energy sources that are capable to handle the increasing demand along with minimum pollution level. The initial approach and future potential of these energy sectors have been discussed with examples.

Finally, after the identifications of the problems and possible solutions, the actions required in this context have been discussed briefly. There have been a lot of examples about the initiatives taken by the government, local investors. The reason why foreign investors should consider this market and the possible rate of return of this investment have been mentioned.

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### **Appendix: Nomenclature**

BCAS	Bangladesh Centre for Advanced Studies
BCCSAP	Bangladesh Climate Change and Action Strategy Plan
BERC	Bangladesh Energy Regulatory Commission
BPDB	Bangladesh Power Development Board
BWDB	Bangladesh Water Development Board
CHT	Chittagong Hill Tracts
ESCAP	Economic and Social Commission for Asia and the Pacific
GOB	Government of Bangladesh
IDCOL	Infrastructure Development Company Limited
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producers
LGED	Local Government Engineering Department
LDCF	Least Developed Countries Fund
MMSCFD	Million Standard Cubic Feet per Day
MPEMR	Ministry of Power, Energy and Mineral Resources
NAPA	National Adaptation Program of Action
ODA	Overseas Development Administration
OECD	Organization for Economic Co-operation and Development
REB	Rural Electrification Board
RET	Renewable Energy Target
SEDA	Sustainable Energy Development Agency
SHS	Solar Home System
UNFCCC	United Nations Framework Convention on Climate Change
WEST	Wind Energy Study

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