

An Analysis on Renewable Energy and Prospect In Bangladesh

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Abstract – Renewable energy is plentiful, and the technologies are improving all the time. There are many ways to use renewable energy. We have realized that our fossil and atomic fuels will not last forever, and that their use contributes to environmental pollution. Renewable energy – which basically comes from the sun in one way or another – provides opportunities for an unlimited, sustainable energy supply with low environmental impact. This paper reviews the prospects of available renewable energy resources along with various private and government future project plans to incorporate renewable energy sources and their potentials as per context of Bangladesh. According to the approved renewable energy policy, the Government of Bangladesh (GOB) is devoted to facilitating investment in both public and private sectors in renewable energy projects to substitute contemporaneous non-renewable energy resources and to escalate the contributions of renewable energy based electricity generation. This paper reviews the prospects of available renewable energy resources along with various private and government future project plans to incorporate renewable energy sources and their potentials as per context of Bangladesh. This paper also highlights the sources of renewable energy as well as the prospects in Bangladesh. More so this paper recommends some possible solutions basing on the key challenging factors prevails in Bangladesh for promoting the uses of renewable energy in various sectors.

Keywords – Renewable energy, sources, prospects, challenges, private sectors, non-government organizations, Government, Resources

I. INTRODUCTION

“A transition to clean energy is about making an investment in our future”

- Gloria Reuben

Renewable energy is energy that is obtained from renewable resources, which are naturally restocked on a human timescale, such as sunlight, wind, rain, tides, waves and geothermal heat. The present renewable energy arrives from biogas, hydro power, solar and wind. Bangladesh is a developing country which offers many options and opportunities for utilizing renewable energy sources for generating electric power. In Bangladesh there are many natural resources such as coal, gas and petroleum. The main source of energy in Bangladesh is natural gas (24%) [1]. The government issued its prospect and policy assertion in February 2000, with the plan to provide electricity service to the entire country. At present, total electricity generation capacity is 15,351 MW as of February 2017 (ES in Bangladesh) and this energy sector is increasing day by day. To meet the cumulative demand of electricity coal, gas, diesel, etc. based power generation methods are being used. However, this is not sufficient. The government and non-government organizations are working both independently and jointly to promulgate renewable energy technologies (RET)

throughout the nation as reported in the extant literature. Therefore, prospective planning and comprehensive understanding of this dynamic field require continuous assessment. Moreover, the progression, as well as regressions, in this sector should be continually scrutinized. In this paper, the present scenario of renewable energy sources in Bangladesh and prospects is discussed in details.

There are three primary motivators that stimulate the growth of renewable energy technologies: energy security, economic impacts and carbon dioxide emission reduction. According to a 2011 projection by the International Energy Agency, solar power generators may produce most of the world's electricity within 50 years, reducing the emissions of greenhouse gases that harm the environment. Considering that the major component of greenhouse gases (GHGs) is carbon dioxide, there is a global concern about reducing carbon emissions. In this regard, different policies could be applied to reduce carbon emissions, such as enhancing renewable energy deployment and encouraging technological innovations. In addition, supporting mechanisms, such as feed-in tariffs, renewable portfolio standards and tax policies, are employed by governments to develop renewable energy generation along with implementing energy use efficiency for saving energy. Renewable energy is plentiful, and the technologies are improving all the time. There are many ways to use renewable energy. Most of us already use renewable energy in our daily lives.

Bangladesh has very good solar and wind energy resources due to its geographic location. Several international research institutions have studied its potential for solar and wind power generation; their conclusions vary greatly but provide insight into what can be achieved.

An in-depth study is carried out throughout the paper and the foremost objective of this paper is to highlight the sources of renewable energy and bring out the possibilities and prospects for Bangladesh. More so an extensive analysis is also done to discuss about the current energy scenario and current renewable energy scenario of Bangladesh. However, prospects, key challenges are also discussed with some possible recommendations. A well identified and well discussed matter in today's world that is renewable energy is need to brought into everyone's mind for a clean environment and saving energy for our future.

II. LITERATURE REVIEW

In the past decade, many countries have planned to shift from traditional energy to renewable energy, but this has faced different barriers. Several studies highlighted the importance of relying on supportive policies for renewable energy. For example, Ciarreta, Espinosa, & Pizarro-irizar (2017) argue that currently, without supportive policies, renewable technologies cannot compete against conventional energy technologies [2].

Md. Mamunur Rahman said that the renewable resources can be replaced through the natural process at a rate which is equal or greater than this rate at which they are used. Actually, renewable energy is generated from natural resources like sunlight, wind, tide, geothermal heat, ocean energy etc. that are renewable. A prediction is that in 2030, energy comes from renewable sources is 28% of total generation. Though Bangladesh having lots of natural resources, but still now facing and struggling with the shortage of power, while our neighboring countries are utilizing their sources properly and being richer with better economic growth [3].

A.K.M Sadrul islam discussed that Bangladesh is endowed with plentiful supply of renewable sources of energy. Out of the various renewable sources, solar and biomass and to a limited extend, wind and hydro-power are effectively used. This paper, discusses the effective applications of these resources. Bangladesh receives an average daily solar radiation of 4–6.5 kWh/m². Solar photovoltaic (PV) are gaining acceptance for providing electricity to households and small business enterprises in grid remote rural areas [4].

Energy has always been a major necessity for the day-to-day human life. For the socio-economic development, continuous supply of sufficient energy is very important. As a developing country, Bangladesh is finding it difficult in recent times to produce and transmit enough energy to fulfill the ever-growing demand. The natural resources are limited and are being exhausted at such an alarming rate, it is feared that natural gas, which is the main energy source of Bangladesh will be depleted by the year 2020[5].

Studies have shown that Bangladesh has less wind potential than solar potential. Therefore, solar PV installation capacity is proposed to account for between 70 and 80 percent of total RE capacity and wind between 20 and 30 percent of the total to be installed [6].

Shariful said that according to the approved renewable energy policy, the Government of Bangladesh (GOB) is devoted to facilitating investment in both public and private sectors in renewable energy projects to substitute contemporaneous non-renewable

energy resources and to escalate the contributions of renewable energy based electricity generation. A plan has been initiated by the GOB to generate 5% of the total energy from renewable energy resources within 2015 and 20% by the year 2020 [7].

Samrena Jabeen discussed that The rapid growth of the human population of the planet has led to mounting energy demands; conventional sources of energies are not enough to fulfill the energy demand. Therefore, the search for alternative sources has become the most profuse challenge. Presently, many alternatives are being studied and implemented in literature—the renewable sources which are less harmful and environmentally acceptable for future generations [8].

Kabel said that, by 2017, 128 countries have adopted renewable energy support policies, compared to just 48 countries in 2005. These policies played a crucial role in helping countries to shift from conventional energy to renewable energy by overcoming the barriers facing the development of renewable energy [9].

The world is fast becoming a global village due to the increasing daily requirement of energy by all population across the world while the earth in its form cannot change. The need for energy and its related services to satisfy human social and economic development, welfare and health is increasing. Returning to renewables to help mitigate climate change is an excellent approach which needs to be sustainable in order to meet energy demand of future generations [10].

III. OBJECTIVE OF THE STUDY

In this study, an attempt is made to study the sources of renewable energy present in the world in different capacity. However current energy scenario, current renewable energy scenario, prospect is also discussed deliberately finding out the challenges. More so at the end of the paper some recommendations are made for the best use of the renewable energy considering the future development and prospects for Bangladesh. However, the specific objectives of this research are:

- To study and identify the sources of renewable energy and current state of renewable energy in Bangladesh.
- To study and analyses the prospect and challenges for the use and development of renewable energy in the present context of Bangladesh.
- To bring out some recommendations for the best use of renewable energy.

IV. METHODOLOGY

The methodology is followed very meticulously for unfolding the research. Although the time was limited but requirements for the research were taken into due account for the best output from the survey and other form of collecting information.

- Case. An Analysis on Renewable Energy and Prospect in Bangladesh
- Independent Variables. Prospect in Bangladesh.
- Dependent Variables. Renewable Energy.
- Type. Research paper
- Study Site. In and around Dhaka city.
- Study Duration. January - June 2021.
- Quantitative Study Design. Survey in Different Stakeholders
- Qualitative Study Design. Interview and open sources.
- Data Collection Method. To operationalize this research, both quantitative and qualitative techniques were adopted for data collection.

V. DATA ANALYSIS AND DISCUSSION

Sources of Renewable Energy

There are several renewable energy sources that are in use today. Listed below are brief descriptions of these resources.

- **Hydropower.** Energy in water can be harnessed and used. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy. There are many forms of water energy: Hydroelectric energy is a term usually reserved for large-scale hydroelectric dams. Micro hydro systems are hydroelectric power installations that typically produce up to 100 kW of power. They are often used in water rich areas as a remote-area power supply (RAPS). Run-of-the-river hydroelectricity systems derive kinetic energy from rivers without the creation of a large reservoir. Hydropower is produced in 150 countries, with the Asia-Pacific region generating 32 percent of global hydropower in 2010. In 2013 hydropower generated almost 16% of the world's total electricity [11].
- **Wind Power.** Airflows can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5–3 MW have become the most common for commercial use; the power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases up to the maximum output for the particular turbine. Areas where winds are stronger and more constant, such as offshore and high altitude sites are preferred locations for wind farms. Typical capacity factors are 20-40%, with values at the upper end of the range in particularly favorable sites. This would require wind turbines to be installed over large areas, particularly in areas of higher wind resources, such as offshore. As offshore wind speeds average ~90% greater than that of land, so offshore resources can contribute substantially more energy than land stationed turbines. In 2013 wind generated almost 3% of the world's total electricity [11].
- **Solar Energy.** Solar energy, radiant light and heat from the sun, is harnessed using a range of everevolving technologies such as solar heating, photovoltaic, concentrated solar power, solar architecture and artificial photosynthesis. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Active solar technologies encompass solar thermal energy, using solar collectors for heating, and solar power, converting sunlight into electricity either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longerterm benefits. It will increase countries' energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating climate change, and keep fossil fuel prices lower than otherwise. These advantages are global [11].
- **Geo Thermal Energy.** Geothermal energy is from thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. Earth's geothermal energy originates from the original formation of the planet and from radioactive decay of minerals (in currently uncertain but possibly roughly equal proportions). The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. [12]
- **Bio Energy.** Biomass is biological material derived from living, or recently living organisms. It most often refers to plants or plantderived materials which are specifically called lignocellulosic biomass. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel. Conversion of biomass to biofuel can be achieved by different methods which are broadly classified into: thermal, chemical, and biochemical methods. Biomass can be converted to other usable forms of energy like methane gas or transportation fuels like ethanol and biodiesel. Rotting garbage, and agricultural and human waste, all release methane gas – also called landfill gas or biogas. With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feedstock's for ethanol production. [11].
- **Heat Pump.** A heat pump is a device that provides heat energy from a source of heat to a destination called a "heat sink". Heat pumps are designed to move thermal energy opposite to the direction of spontaneous heat flow by absorbing heat from a cold space and releasing it to a warmer one. A heat pump uses some amount of external power to accomplish the work of transferring energy from the heat source to the heat sink. While air conditioners and freezers are familiar examples of heat pumps, the term "heat pump" is more general and applies to many HVAC (heating, ventilating, and air conditioning) devices used for space heating or space cooling. In heating mode, heat pumps are three to four times more efficient in their use of electric power than simple electrical resistance heaters. In the context of renewable energy, heat pumps are able to use electricity

from renewable sources to provide heating and cooling of structures in a cost and energy effective way, displacing non-renewable sources [11].

Current Energy Scenario in Bangladesh

Bangladesh, at present, is facing tremendous shortage of electricity both in cities and rural areas. Various obstacles like security concerns over growing fuel imports, high dependence on conventional energy resources i.e., coal, gas limits the overall growth of electricity production.[13] Currently the power demand in Bangladesh is about 5500- 7000MW, whereas the generation ranges only 4200-4600 MW. As a result of power shortage causes excessive load shedding throughout the year. The average generation was 3378 MW in 2007 which has increased to 4103 MW in 2011 (May, 2011) with an annual average increasing rate of 181 MW.[14] Continuation of this rate indicates that the average generation would be 4828 MW by 2015 which is far away from the vision of 11500 MW generations by 2015.[15]

Table I. Peak Demand Forecast (According To Psmf-2010 Study) [16]

Fiscal Year	Peak demand(MW)
2011	6765
2012	7518
2015	10283
2020	17304
2021	18838
2025	25199
2030	33708

Additionally, the average load shedding has been increased to 656 MW in 2011 (May, 2011) with an average increasing rate of 35 MW per year from 2007. If this increasing rate remains the same, the average load shedding might be stood at 795 MW by 2015. The lower increasing rate of generation (5.37 percent) than that of the demand (5.43 percent) has accelerated the rate of load shedding which has increased at a rate of 6.72 percent per annum during the same period. According to BPDB (Bangladesh power Development Board), total electricity generation capacity was 8005MW, maximum demand served so far was 6066 MW as of report from March, 2012, with shortage of 1452 MW to meet the peak demand. [17]

Current Renewable Energy Scenario in Bangladesh

Bangladesh is blessed with abundant supply of renewable energy resources such as solar, wind, biomass energy etc. Unfortunately the country has not yet been able to properly utilize its resources to make it available for mass usage. Although investment costs of renewable energy technologies are generally higher compared to fossil fuel alternatives, this option becomes economically viable when all externalities (e.g. environmental cost, health hazards etc.) and lower operating costs are taken into consideration. The biggest advantage of renewable energy is that it is environment friendly and very suitable for a developing country like Bangladesh. It's a positive thing that government is undertaking plan to integrate renewable energy to meet the power demand and some private companies are also playing important role to harness the huge potential of renewable energy in some of the major parts in Bangladesh [18].

Table II: Long-Term Energy Mix for Power Generation (Global & Bangladesh) [19]

Type	Bangladesh		Global	
Energy	Current	2021	Current	2030
Gas	87.5%	30%	18%	28%
Oil	6%	3%	10%	5%

Coal	3.7%	53%	37%	38%
Hydro	2.7%	1%	17%	4%
Nuclear	0%	10%	17%	19%
Renewable	0.5%	3%	1%	6%

Prospects

Commendable progression has been compiled in the renewable energy sector in the last few years. At present, 404 MW is being generated from renewable energy sources. Solar home system is a success story in Bangladesh and day by day its popularity is increasing in the rural areas, especially in the off-grid regions[20]. The prospect of renewable energy in Bangladesh is very promising, especially in the case of solar energy. However, for the near future, renewable energy will remain annexed to the current energy genesis by non-renewable conventional means. Still, renewable energy will play an important role reaching consumers outside the national grid or in places where grid connection is delayed. Major sources of renewable energy in Bangladesh are as follows:

- Solar.** Bangladesh is a south Asian country located in between latitudes 20°34' and 26°39' north and longitudes 80°00' and 90°41' east. Therefore, it is an ideal location for solar energy utilization. Also, as it is a subtropical country, 70% of the year sunlight is plentiful [16]. This makes the use of solar panels very effective in Bangladesh. Daily solar radiation is 4-6.5 kWh/m² and maximum radiation is generally received in the months of March-April and minimum in December-January. Hence, solar energy can be a viable solution for the power crisis in Bangladesh [21]. Also solar energy offers some key qualities like having no waste and emission, resulting no adverse effects on the environment and ideally suited for distributed resource applications [22]. The government has recently taken many steps to address this fact. Concurrently, some Non-government Organization (NGO) is working to provide solar panels to consumers and the price of these panels, at present, is very affordable. Figure 1 below shows the approximate distribution of SHSs installation division wise and illuminates that the distribution of the SHSs is highest in Dhaka district and lowest in Sylhet district [23].

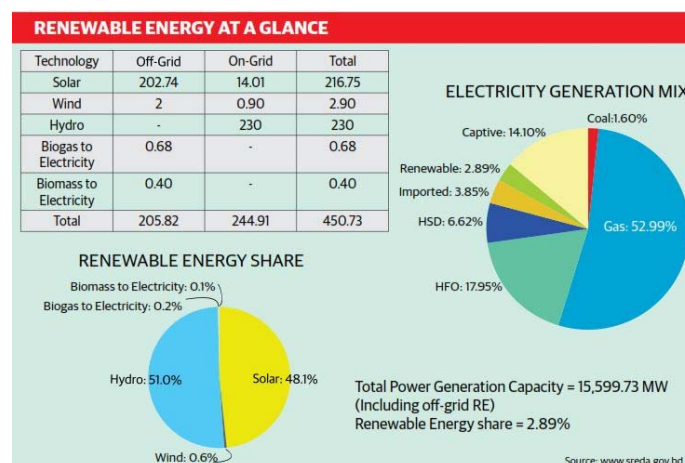


Figure 1: Approximate Distribution of SHSS Installation Various Divisions

- Biomass.** Bangladesh is an agricultural country. For this, there's available of a lot of agricultural residues. So, one of the most promising renewable energy resources are biomass resources. Bangladesh has a lot of biomass resources which can cover about 55% of the total energy that are needed for our country [24]. About 48% of the total biomass is covered by the various types of residues and these residues are divided into two types: (1) Field residue, (2) Processing residue. If the ways of sustainable optimized processes are invented, huge amount of energy can be got from waste like: crop residues, sugarcane biogases, rice husk, jute sticks etc. About 42 MT agricultural crops residues are got annually in Bangladesh from which 37% and 63% are respectively process residue and field residue [25]. If we think about wood and wood wastes, there are leaves,

roots, twigs, planer shavings, barks etc. which can confirm 100% recovery factor and annually recoverable amount is about 8.871 MT [25]. About 5000 poultry firm (commercial) are there in our Bangladesh from where huge amount of poultry wastes are got daily. For the poultry dropping the recovery factor is 50% and 60% is for animal waste with about 20619 MT of recoverable animal wastes and poultry dropping [26]. Besides, from the municipal solid waste and people produced solid wastes, a huge amount of energy can be generated. A statistical data by The World Bank says that 0.15 kg/capita/day is the rate of the production in rural and 0.4 - 0.5kg/capita/days is in urban areas from where recovery factor is 100% and the amount that is estimated is about 14.793MT and a one kg of dung can produce 0.037m³ of biogas and the available of the cattle dung can easily produce 2.50 billion m³ gas which is same as 1.28 MT of kerosene or 2.56 MT of coal [25] [26]. And as a report of IRRD, about a 4 million biogas plants can be established throughout the country. From where 75% is based on cow dung and 20% on poultry wastes and left 5% is on another biomass [27].

- Nuclear Energy.** As Bangladesh is having shortage of electricity, so she's needed a powerful and obviously established source to supply energy for a period of extended time continuously. For this problem, nuclear energy may be a solution. No other plants are as high as a typical nuclear power plant for it's the lifetime. Uranium is plentiful and technologies survive which can extend its use 60-fold if the demand needs it. And 6000 tons in a year is the world mine production. From several sources like: stockpiles, lots of markets are given supply. Most of the supplies are used for electricity [28]. In Bangladesh, for the first nuclear power plant, Ruppur site was selected in 1963; our country got a national nuclear power action plan. At last in 2010, Bangladesh made an agreement for making a nuclear power plant with Russia to generate 2400 MW which has two reactors and each reactor can able to produce 1200MW of power [29]. It's build on Ruppur at the side of the Padma and the Ishwardi which is the sub district of Pabna.

- Power Sector.** A study by the National Renewable Energy Laboratory (NREL) estimates Bangladesh's solar power generation potential to be 380 THz per year (240 GW) using 1.5 percent of total available land.18 It calculates solar energy potential as a function of land area per solar class (kWh/m²/day): for Bangladesh, between 4.5 and 5.5 kWh/m²/day. A NREL wind assessment in 2018 demonstrated that an area of more than 20,000 km² exhibits wind speeds between 5.75 and 7.75 meters per second, with gross wind potential of over 30 GW. However, this estimate may be reduced given that agricultural land is not currently available for wind power projects.

Table III: Power Sector Development Plan by 2041[30]

Items	2009	2020	2021	2030	2041
Installed capacity (MW)	5,823	20,383	24,000	40,000	60,000
Maximum demand (MW)	6,454	12,100	19,000	33,000	52,000
Transmission lines (km)	8,251	12,283	18,126	27,300	34,850
Substation capacity (MVA)	13,474	45,478	90,382	1,20,000	2,61,000
Distribution lines (km)	2,60,000	5,32,000	4,97,000	6,60,200	7,83,200
Electricity access (%)	47	97	100	100	100
Per capita generation (kWh)	183	426	700	810	1475

- Hydropower.** Hydropower is an energy source which is environment friendly. For being its land flat with of a few exception regions, Bangladesh has no opportunity of hydropower. During the monsoon season, the major rivers provide a high amount of water flow in 5 to 6 months, but in time of winter it's reduced [31]. For hydropower, the plant can be classified into 2 categories which are Large Hydropower Plants and Small Hydropower Plants. Kaptai dam is only one dam of Bangladesh in which there is production of electricity by hydroelectric power plant. It's on the bank of Karnaphuli at Kaptai and 65 KM away from Chottogram on Rangamati. The construction of Kaptai dam is started on 1962. The reservoir water storage capacity is 6477 million cubic meters and 230 Megawatts electricity when it runs on full capacity [32].

- Tidal Energy.** Bangladesh is really blessed for having the Bay of Bengal and longer coastal belt which is about 740 KM. Tidal power be a clean renewable energy, is a suitable source of power in coastal area of Bangladesh [33]. The tidal power can be produced through the tidal stream generator [34]. Though this isn't widely used but has a potential for generating the electricity for future. So, tidal energy is greatly expected than the solar and wind energy [35]. For having recent, new development and establishment in turbine technology and plan, the new availability of tidal power can be greater and higher than the power that was previously assumed. Bangladesh having a sea in the south may gain more energy from the tidal waves by given application of two technologies, which are Low head tidal movement (2 to 5 meters' head) and Medium head tidal movement (5 meters or over) respectively [33]. Here, the tidal movement of low head can be established in the coastal areas like: Khulna, Satkhira, Barishal, Bagerhat, Cox's Bazar in the region with sluice gates and levees. In time of high tide if the water is trapped into a coastal basin and if a dead difference is created in the time of low tide to drive the turbine, this water heads could be easily used. Many developed countries are using this method [36].
- Wind Energy.** Wind is a good source of renewable energy. For having a long coastal area, Bangladesh is suitable for it. Here in different seasons wind blows in several patterns. In the time of monsoon from Indian Ocean, the heavy south-westerly wind comes which passes coastal areas of Bangladesh. For this reason, in the time of March to September, the average speed of wind is 3 m/s to 6 m/s and similarly this rate remains lower during October to February. And in the time of June to July, maximum wind speed can be seen [37]. So, it would be better if wind turbine is established in the coastal areas and it will be the solution to meet up our demand supporting the national grid. According to the statistical data, Bangladesh Govt. has made a project which is named as Wind Energy Study Project (WEST) where, on the six potential coastal areas, the average wind speed is recorded for a year [38]. Wind energy is the first among renewable energy resources to become an economically viable source of power generation. Technological improvements have brought down the cost of wind power equal to that of coalfired thermal power plant. A site is considered suitable for fair energy generation where the wind speed is 4.3-5 m/s. [39]

Table IV: Analysis Of Wind Characteristics In Coastal Areas Of Bangladesh [40]

Location	Mean speed(m/s)
Teknaf	3.22
Kutubdia	5.17
Sandwip	5.12
Kuakata	3.58
Mongla	3.44

BPDB installed 4x225 KW = 900 KW capacity grids connected Wind Plant at Muhuri Dam area of Sonagazi in Feni. There are many other areas along the Bay of Bengal where the wind speed is quite high. For example, Kuakata, Sandwip and St. Martin islands are very prospective areas for this type of wind turbines. [41]

- Ocean Wave Energy.** From the ocean's wave, the ocean's wave energy is directly produced. This is obviously an energy which can help eradicating the risky emission of greenhouse gas coping with the generation of power. For this, it's a significant and possible source of electricity in Bangladesh. 'The oscillating Water Column Method' is exactly possible and has become economically good in this purpose. Already, many countries are using this type of wave energy harnessing device [42].
- Hydrogen Energy.** Hydrogen is the simplest and most common element in the universe. It has the highest energy content per unit of weight of any known fuel (52,000 Btu per pound or 120.7 kilojoules per gram). When cooled to a liquid state, this low-weight fuel takes up 1/700 as much space as it does in its gaseous state. This is one reason hydrogen is used as a fuel for rocket and spacecraft propulsion, which requires fuel that is light, compact, and has a high energy content. The only hydrogen plant of the country is an auxiliary unit of eastern refinery limited, Chittagong. The unit produces hydrogen of 99.9% purity from steam reforming of natural gas.[14] Hydrogen is a by-product of Eastern Refinery, but the production volume is low and the entire output is used up in different industries. World renowned companies like Coca-Cola, Google, Wal-Mart, Sysco, FedEx, UPS, Staples, -

Firestone, Nissan North America, Kimberly-Clark, Michelin and more have installed fuel cells made from hydrogen to help meet their power needs. Major Bangladeshi industries can use this energy resource for more power generation [43].

Key Challenges

- Land availability for projects is limited in Bangladesh because most of the land is designated as agricultural land, which cannot be used for renewable energy projects.
- Policy guidelines and incentives for the private sector do not always apply to renewable energy projects as they do for conventional fossil fuel projects.
- Renewable energy targets and plans are not synchronized with future electricity transmission infrastructure plans, as they are for conventional power plants.
- Different policies and support for new transmission infrastructure for conventional power plants and renewable energy plants.
- Limited renewable energy resource data for solar PV in specific regions, including measurements of seasonal variation.
- Absence of zoning for renewable energy projects where site-specific resource data can be measured.
- Local private banks are wary about investing due to a lack of experience in large-scale renewable energy projects.
- Limited knowledge of renewable energy technologies and benefits of renewable energy in the energy sector.
- Lack of experts with experience in large-scale renewable energy projects.
- Limited experience when it comes to procuring new renewables capacity.

Recommendations

- Private sector investment will be needed to reduce the investment gap from a shortfall of public sector financing capabilities. The private sector has been active in Bangladesh for many years and has been instrumental in the development of its conventional power plants.
- New technology advancements such as larger wind turbines and the increasing efficiency gains in solar PV panels mean that over time, the land requirements for RE projects will decrease. Unused government-owned land and floating solar systems should be sufficient to meet the land requirement. Agricultural land can now be used for agricultural activities and solar PV generation simultaneously, as demonstrated in other countries around the world. However, laws will need to be updated to allow it.
- Government of Bangladesh will need to develop infrastructure in order to create areas where developers can build projects with reduced infrastructure and land risks, thereby reducing expected tariffs from future projects.
- A broader energy development goal is crucial for the promotion of RE. Detailed guidelines need to include determining the broader energy development goals, identifying the likely technology options, and detailing the types of activities that are necessary to bring the new generation capacity to realization, including identifying and engaging with the likely stakeholders involved.
- The GOB needs to establish a transparent and publicly available RE development plan that provides clear direction for both public and private energy stakeholders. Bangladesh must take key steps to accelerate RE, including: set up a development plan; conduct a RE resource mapping to confirm technical potential; identify suitable project locations or create RE development zones, transmission and infrastructure facilities for project locations; and standardize RE procurement.
- Meeting these RE capacity targets will require a development plan that details specific actions to enable the development of RE projects. The plan will need to include short-term (two to three years), medium-term (2024-2030) and long-term actions. The short-term development plan should have yearly targets and include a resource assessment, zone identification, a project feasibility analysis, policy and regulation updates, development of a suitable RE competitive procurement system, pilot projects, and interventions to address infrastructure challenges such as land acquisition and land development, grid extension, connecting roads, etc. In the medium term, the main constraints and challenges will have been addressed. This phase will allow Bangladesh to expand large-scale RE project development and the mid-term development plan should fix yearly development targets. To create long-term

sustainability, the GOB needs to create opportunities for local manufacturing; it can achieve this by slowly escalating local content requirements set out during bidding, as well as ensuring enough annual procurement to sustain local manufacturing capacity.

- In Bangladesh, government organizations like the Sustainable and Renewable Energy Development Authority (SREDA) or BPDB can be made responsible for identifying land to site RE projects. Where applicable and required, project developers can use their own land for selected projects.
- The GOB should consider providing a minimum amount of infrastructure in areas considered for development, such as roads for access, water supply and even transmission lines for power evacuation. If the project location is close to rivers, the GOB should consider taking responsibility for river protection infrastructure.
- Capacity development in government agencies, relevant private sector stakeholders, non-governmental organizations, and academic and research institutions, individual energy experts and other entities will also need to be educated. Skills in project financing, public-private partnerships (PPPs), transaction advisory, environmental, and legal and commercial aspects will also be required to run a suitable procurement process and assist in project financing and construction.
- It is not always possible for governments to fund their infrastructure requirements by themselves, or to have the required technical capability and skills to develop projects. In most instances, governments require the private sector to play a role in infrastructure development. Providing the right incentives and signals to encourage private sector participation in the power sector is one of the most important levers that governments have to ensure that necessary infrastructure is built in time.
- The government needs to consider the idea of doing a land study that identifies options for land use for utility-scale renewable energy. The study should include the benefits of using public land, identifying land that might have lower agricultural value, and understand any advantages of designating zones for renewable energy projects.

VI. THEORETICAL IMPLICATIONS, LIMITATIONS AND FURTHER RESEARCH

The most important theoretical contribution of this paper lies in the extensive literature review of the topic of renewable energy, its use, source and prospect in terms of better future. I have conducted a literature review of research papers, containing as keywords the following phrases: “renewable energy”, “sources of renewable energy” and “prospect in Bangladesh”.

The results are interpreted in light of several limitations inherent in my research design choices. First, survey is conducted with limited number of audience that is the sample size was very less. So, the researcher should take more sample sizes to justify the research. Second, the timeframe for this sort of research demand more time. However I tried to collect the best possible samples within this stipulated time. Third, survey is conducted within Dhaka city. It would be much comprehensive if the survey would be done taking number of cities in Bangladesh. Fourth, survey would be more developed if the audience would get some actual sample of renewable energy. Future studies could use multi-informants and secondary data sources to validate the results.

Further research should be carried out in order to enhance the understanding of renewable energy, sources and prospect in Bangladesh as well as for a better healthy future life. Moreover a similar study could be conducted with a larger sample size so that results could be comprehensive to a large population to identify the feasibility of the best use of this energy in Bangladesh.

VII. CONCLUSIONS

Bangladesh has had significant year-on-year economic growth over the past decade, and its power system will need to keep pace with the expected increase in demand in the coming decades. As natural gas reserves in Bangladesh decline, future generation capacity will have to come from other primary resources. Moving to replace local gas with imported LNG and imported coal for power generation will likely translate into higher tariffs and put pressure on affordable access to electricity, as well as on the reliability and quality of the power system. This could have far-reaching consequences for the long-term sustainability of the power sector, including the inability to rise funding for future fossil fuel projects due to changes in sentiment from international lenders.

Considering the current business case for deploying largescale RE when solar and wind are many countries' cheapest options by far, Bangladesh should be well positioned to increase RE's contribution in its energy mix, like many of its South Asian peers. The country has good solar and wind resources and the potential to deploy both in large numbers, based on the studies listed in this paper.

On-going concerns about climate change have made renewable energy sources an important component of the world energy consumption portfolio. Renewable energy technologies could reduce carbon dioxide emissions by replacing fossil fuels in the power generation industry and the transportation sector. Due to negative and irreversible externalities in conventional energy production, it is necessary to develop and promote renewable energy supply technologies. Power generation using renewable energy sources should be increased in order to decrease the unit cost of energy and to make them compatible with a competitive alternative to the conventional energy sources. Two main solutions may be implemented to reduce CO₂ emissions and to overcome the problem of climate change: replacing fossil fuels with renewable energy sources as much as possible and enhancing energy efficiency regardless of type. In this review, we considered hydro, wind, solar and geothermal sources, because of their significant contribution to power generated by renewable sources.

The total development of a civilization is greatly depending on the electrical energy. Seeing per capital utilization of this energy, the total advancement can be easily realized. One of the most significant strategies cannot but be the improvement of the renewable energy. For generating the power, Bangladesh has to depend on fossil fuel yet now but these dependent resources are very limited. Through the carbon trading concept and changing global climate, renewable energy can make a significant contribution. This is the absolute time to go ahead and make a contribution in these renewable energy resources for generating electricity which include solar, wind, biomass, hydro-power etc. Bangladesh can produce electricity with the assist of these resources and will be capable of meeting the demand in future. Bangladesh has well RE potential, and recent trends in technology and fast declining costs create an opportunity to quickly increase RE's share in the electricity supply mix. As soon as we try to implement the recommendations as well as give due importance to generate ideas for the best use of RE, we are likely to get the best results for a better future.

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