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Prospect of renewable energy resources in Bangladesh

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ABSTRACT

The objective of this paper is to provide an overview of the current state of renewable energy resources in Bangladesh, as well as to examine various forms of renewable energies in order to gain a comprehensive understanding of how to address Bangladesh's power crisis issues in a sustainable manner. Electricity is currently the most useful kind of energy in Bangladesh. It has a substantial influence on a country's socioeconomic standing and living standards. Maintaining a stable source of energy at a cost that is affordable to everyone has been a constant battle for decades. Bangladesh is blessed with a wealth of natural resources. Bangladesh has a huge opportunity to accelerate its economic development while increasing energy access, livelihoods, and health for millions of people in a sustainable way due to the renewable energy system.

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1. INTRODUCTION

For the majority of Bangladesh's economic operations, electricity is the primary source of energy. The enhancement of the power industry is crucial to every country's progress. Bangladesh's economy is booming at the moment. Bangladesh has an average gross domestic product (GDP) growth rate of 8%, and electricity demand is increasing rapidly [1]-[3]. To accomplish projected economic growth of above 7% by 2030, the country will require around 34000 MW of power [4]-[6]. Bangladesh is experiencing a severe energy deficit and is attempting to address the issue via costly rental power plants. The renewable energy (RE) is, on the other hand, growing popularity and making a significant contribution to resolving the energy crisis [7]-[15]. The power sector is expected to be stable due to the use of renewable energy sources. Renewable energy is energy that is generated from naturally regenerated resources such as sunlight, wind, hydro, tidal, and geothermal heat and does not degrade the earth's resources. It is impossible to overstate the importance of energy and related services for human social and economic progress, welfare, and health. Table 1 depicts the various types of renewable energy and their applications [16]-[23].

The consistently increasing population and urbanization in Bangladesh is took place in exponential development in the building sector, which is becoming a main factor coming up with the energy demand in Bangladesh. Solar, biomass, biogas, hydro, and wind, all of which are abundant renewable energy sources, can provide potential for long-term energy development. Bangladesh has a growing energy demand brought about by a population explosion which has led to the continual use of fossil fuel-based energy sources such as Coal, Oil and Gas. However, the use of fuel-based energy sources results to several challenges. The depletion of fossil fuel reserves, greenhouse gas emissions and other environmental problems, geopolitical and military

conflicts, and constant fuel price fluctuations are only a few of them. These issues will exacerbate unsustainable situations, potentially posing an irreversible threat to human society [24]. Renewable energy sources, on the other hand, are the most impressive option and the only solution to the escalating issues [25]. For heating, lighting, industrial equipment, transportation, and other purposes, all economies require a steady energy supply [26]. When renewable energy sources are substituted for fossil fuels, greenhouse gas emissions are considerably reduced. Renewable energy sources should be sustainable because they are obtained organically from ongoing energy flows in our environment. Over 4.5 million solar household systems have been distributed in locations where grid expansion and electrification have been particularly difficult. This paper is to evaluate the current state of renewable energy resources in Bangladesh and their possibilities.

Table 1. Renewable energy sources and their use(s)

Energy sources	Energy conversion and usage options
Hydro power	Power generation
Modern biomass	Heat and power generation, pyrolysis, gasification, digestion
Geothermal	Urban heating, power generation, hydrothermal, hot dry rock
Solar	Solar home systems, solar dryers, solar cookers
Direct solar	Photovoltaic, thermal power generation, water heaters
Wind	Power generation, wind generators, windmills, water pump
Wave	Numerous designs
Tidal	Barrage, tidal stream

Bangladesh's power sector is heavily reliant on fossil fuels, with natural gas and coal serving as the primary sources of electricity generation. Bangladesh intends to enhance its coal-fired capacity in order to fulfill its rising energy demands. Table 2 shows the energy production scenario in December 2020 [21]. From Table 2 it is seen that renewable energy contributes about 265 megawatt (MW) of the total electricity production of 20,282 MW, which can be a supportable solution to the demand-supply crisis. Figure 1 shows that arround 55% of generated electricity comes from natural gas, while 1.3% from renewable sources [27]. From Figure 1, it depicts that Bangladesh is heavily relying on natural gas although government has already taken steps to generate electricity from renewable energy sources. The dominance of fossil fuel-based power generation (coal, oil, and gas) during the previous decades has resulted in an exponential increase in energy consumption. As a result, worldwide concerns connected with significant growth in carbon dioxide (CO_2) emissions [28]. A significant climate change has become one of the greatest challenges of the twenty-first century though it is possible to avoid the grave impacts through transforming the current energy systems. Renewable energy sources have a significant potential to reduce greenhouse gas emissions from fossil fuel-based power generation, hence reducing climate change [29]. From 2011 through 2020, Table 3 depicts energy output and distribution [30]. It is observed from Table 3 that per capita power generation is increased with increasing number of consumers from 2011 to 2020. Electricity consumption per capita is one of the indicators, which is mostly applicable by the researchers to compare the energy consumption of different years and countries. A On the other hand it is perceived that power generation capacity is escalated from 2011 to 2020 because of the energy demand by the consumers. This paper, outlines the current energy situation of Bangladesh and examines the available renewable energy resources and their future prospect.

Table 2. Energy production scenario on December 2020

Fuel Type	Capacity (MW)
Gas	11097.00
Coal	444.00
Heavy Fuel Oil	5505.00
High Speed Diesel	1811.00
Imported	1160.00
Hydro	230.00
Solar	35.00
Total	20282

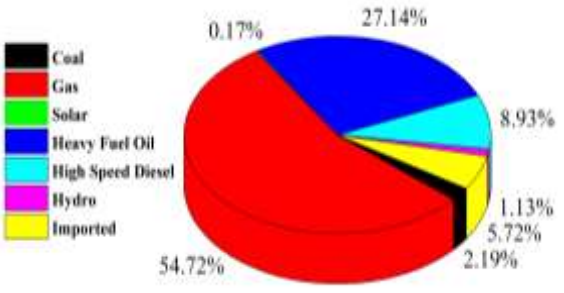

Figure 1. Energy production scenario on December 2020

Table 3. Energy production and distribution from 2011 to 2020

Item	October, 2011	September, 2016	September, 2020
Power generation capacity (MW)	7119	15755	21419
Transmission line (km)	8600	9695	11123
Distribution line (km)	270000	341000	590000
Access to electricity (%)	59.6	77	93.5
Per capita power generation (kWh)	321	371	510
Number of consumers	1250000	2526594	38900000
Average system loss (%)	14.51	14	8.73

2. METHODOLOGY

Various types of power such as solar, wind, biogas, hydro and total power can be calculated by using different [7]. The total generation capacity is calculated by using following formula:

$$\frac{\text{Installed renewable energy capacity (MW)at 2021}}{\text{Installed all generation capacity (MW)at 2021}} \geq 10\% \quad (1)$$

The individual power equations and total power equation are given:

$$\text{Solar power, } P_{solar}\ (W) = (\text{area per sq} - \text{ft} \times \text{watts per sq} - \text{ft}) \quad (2)$$

$$\text{Wind power, } P_{wind}\ (W) = \frac{1}{2} \times \rho \times A \times V^3 \quad (3)$$

$$\text{Biogas generator power, } P_{biogas}(W) = \frac{\text{50\% of 100 kgs per day animal waste} \times 1000}{\text{2 kgs animal waste per kWh} \times \text{5 hours operation a day per year}} \quad (4)$$

$$\text{Hydro power, } P_{hydro}\ (W) = H \times Q \times g \times 1000 \quad (5)$$

Where, A is the area perpendicular to the direction of flow (m^2), V is the wind velocity (in m/s), ρ is the density of air which is about 1.2 kg/m^3, H is the gross water head (in m), Q is flow of water (in m^3/sec) and g is the gravitational force (i.e. 9.81 m/s^2). Now, the total power:

$$P_{total}(W) = P_{solar} + P_{wind} + P_{hydro} + P_{biogas} \quad (6)$$

3. DISCUSSION

It is a global trend to encourage renewable energy as part of energy security and greenhouse gas emission reduction, regardless of economic situation. Many countries have implemented renewable energy promotion strategies that include a variety of financial incentives. The renewable energy sources consolidate biomass, solar, wind, geothermal and hydropower energy, but except conventional nuclear fuels. The Government of Bangladesh has also taken up number of initiatives to enhance the penetration of renewable energy. One example is the development of a renewable energy policy that requires at least 10% of total generation to come from renewable sources by 2021. Available sources of renewable energy and future plan in Bangladesh are described below.

3.1. Solar energy

The conversion of solar energy into thermal or electrical energy is known as solar power. solar energy can be used for a variety of purposes, including generating electricity, lighting or creating a comfortable interior environment, and heating water for household, commercial, or industrial use [31], [32]. Solar photovoltaics for electricity, passive solar design for space heating and cooling, and solar water heating are the most often used solar technologies for homes and businesses. Solar technologies are used by businesses and industry to diversify their energy sources, enhance efficiency, and save money. Solar energy is seen as the future of alternative energy sources since it is non-polluting and helps to mitigate the greenhouse effect caused by the use of fossil fuels on the global climate [33]-[35]. Solar energy is a fully free source of energy that is plentiful Bangladesh is located at 241 0' 0″ N latitude and 901 0' 0″ E longitude in terms of solar radiation, with an average of 4–4.5 peak sunlight hours per day and an average solar irradiation of 5kWh/m^2 per day. Bangladesh has a success story in producing off-grid rooftop solar power, known as the solar home system (SHS), which has provided electricity to a huge number of people living in distant off-grid

locations who would not otherwise have access to it. Bangladesh's energy needs are partially met by solar photovoltaic (PV) systems. More than four million SHS installed domestically have uplifted the lifestyle of these impoverished people by providing small-scale power at their homes. However, in terms of national power consumption and generation, the contribution is negligible, at around 250 MW, or less than 2% of the country's overall power producing capacity. Table 4, the total capacity of SHS installations by organization as of September 2020 [36]. The solar power plant at Mymensingh connected to the national grid that has the capacity to generate 73 MW of electricity since the beginning of October 2020. Table 5 shows that it will help meet the government's target of generating electricity through using renewable energy by 2021 [37], [38].

Table 4. The major installed solar park with capacity on September 2020

Organization	Number of SHS	Capacity (MW)
Infrastructure Development Company Ltd	4494162	187.12
Ministry of Disaster Management and Relief	1294410	60.14
Bangladesh Rural Electrification Board	15250	0.83
Deutsche GIZ	400	0.2
Rural Development and Cooperative Division	200	3.15

Table 5. Solar park installation and rated capacity of Bangladesh

Plant Name	Capacity (MW)	Location	Completion Date
Solar Park by HETAT-DITROLIC-IFDC Solar Consortium	50	Gauripur, Mymensingh	04-11-2020
Solar Park by Intraco CNG Ltd & Juli New Energy Co. Ltd.	30	Gangachara, Rangpur	27-03-2020
Solar Park by Joules Power Limited (JPL)	20	Teknaf Upazila, Cox's Bazar	15-09-2018
Solar Park by Parasol Energy Ltd.	8	Panchagarh Sadar, Panchagarh	13-05-2019
Kaptai Grid-connected Solar PV Power Plant	7.4	Kaptai Upazila, Rangamati	28-05-2019

3.2. Wind energy

The process of using the wind to generate mechanical power or electricity is known as wind energy. Wind energy is a type of energy conversion in which turbines transform wind's kinetic energy into mechanical or electrical energy that can be used to generate electricity. We've gone a long way since the old-fashioned windmills. Today, turbines as tall as skyscrapers—with turbines nearly as wide in diameter—stand at attention around the world. For efficient operation of the wind turbines, the hub height is generally between 20 and 40 meters, and for optimal power extraction, the site is expected to have a wind velocity of at least 7 m/s [39]. Bangladesh is situated in the bay of bengal, between 20.30 and 26.38 degrees north latitude and 88.04 and 92.44 degrees east longitude, having a coastline of 574 kilometers. After height correction, it is observed that at 30 m, there is a great potential of electricity generation in the above regions due to the wind velocity exceeding 7 m/s. Table 6 represents the major wind power plant with its capacity, in September 2020 [40]. Several government agencies and non-governmental organizations (NGOs) undertook some activities for delivering electricity from smallscale hydro plants and wind turbines. A memorandum of understanding (MoU) with the United States and Vestas-Asia-Pacific Wind Technology Pvt Limited of Denmark (US-DK) Green Energy Ltd, was signed for 60 MW in total wind turbine power plant construction which is shown in Table 6 [40]. From Table 6, it is seen that in Bangladesh first ever generation of electricity from wind is at Muhuri Dam, Sonagazi, Feni having a capacity of 0.9 MW by 4 Turbines each 225 kW on September 2006.

Table 6. Wind power plant installation and rated capacity of Bangladesh

Name	Location	Capacity (MW)	Connection	Status
US-DK Green Energy (BD) Ltd	Chakaria. Cox's Bazar	60	On-grid	Under Planning
Wind power plant	Kalapara, Patuakhali	10	On-grid	Under Planning
Sirajganj wind power plant	Sirajganj Sadar	2	On-grid	Ongoing
Wind Batter Hybrid Power Plant-1	Kutubia Cox's Bazar	1	Off-grid	Running
Wind Battery Hybrid Power Plant-2	Kutubdia, Cox's Bazar	1	Off-grid	Running
Feni wind power plant	Sonagazi, Feni	0.9	On-grid	Running

3.3. Biogas energy

Biogas is a renewable energy source that is beneficial to the environment. It's created when microbes break down organic matter such as food or animal waste in the absence of oxygen, through a process known as anaerobic digestion. Anaerobic digestion, a fermentation process in which waste is

digested by microbes to produce methane gas (biogas), is used in biogas facilities. Biogas production helps to reduce reliance on fossil fuels like oil and coal. Biogas is a renewable and environmentally friendly energy source. Bio digestion produces non-polluting gas, lowering greenhouse gas emissions (i.e. reduces the greenhouse effect). Organic waste from industry and households is recirculated in an environmentally responsible manner. Biogas is now preferred by consumers in poor nations such as Bangladesh since it is both cost effective and environmentally benign. Its widespread use can reduce dependency on natural gas and firewood, saving forests and increasing soil fertility. Biogas allows poor people to save money by eliminating the need to purchase firewood for cooking and kerosene for lighting. To make biogas, cattle manure, human excreta, chicken droppings, and waste are processed in biogas facilities under anaerobic circumstances. The majority of the country's biogas plants were built to treat animal dung. Tens of thousands of households and village-level biogas plants have been installed around the country. It could be used to harness basic biogas technology in rural regions for cooking and lighting, as well as peri-urban electrification to provide electricity during power outages. Biogas is created by anaerobic processing that can be utilized for cooking, lighting, and power production and the residue can be utilized for fertilizer, fish feed and compost. Table 7, the major biogas power plant developed by infrastructure development company limited (IDCOL) with capacity on September 2020 [41], [42].

Table 7. Large biogas plant with developed by IDCOL

Project Name	Capacity (kW)	Location	Completion Date
Phenix Agro Ltd	400	Gazipur	30-09-2016
KKT Bio Electricity Project	100	Ponchgorh	31-12-2015
UAL Bio Electricity Project	60	Gazipur	30-04-2016
RKKL Bio Electricity Project	50	Mymensingh	30-06-2010
UKAL Bio Electricity Project	30	Tangail	21-10-2014

3.4. Biomas energy

Biomass is one of the prospective sources of renewable energy to produce electricity in different countries in the world. Biomass has been in use since people first began burning wood to cook food and keep warm. Today, wood remains the most abundant biomass energy source. Food crops, grassy and woody plants, agricultural or forestry residues, oil-rich algae, and the organic component of municipal and industrial wastes are among the other sources. Biomass is a major fuel in many countries, particularly in underdeveloped countries for cooking and warmth. Many developed countries are boosting their use of biomass fuels for transportation and electricity generation as a way to reduce carbon dioxide emissions from fossil fuel consumption. Bangladesh has strong potential for biomass gasification-based electricity because of the availability of biomass resources. since agriculture is the primary source of revenue in Bangladesh's rural areas, agricultural waste, along with animal and household waste, generates considerable amounts of biomass resources, resulting in the country's vast biomass potential [43]-[48]. Biomass, along with natural gas, is regarded as the country's primary energy source. Based on consumption, biomass accounting for 70% of the country’s total energy consumption. The only off-grid biomass power plant which is the SEAL biomass based electricity project starts functioning at Thakurgaon having a capacity of 0.4 MW in December 2015.

3.5. Hydro energy

Hydro energy uses flowing water that usually directed through a dam or other structure. The force of gravity acting on water turns turbines and power generators, producing electricity. Hydroelectric power, often known as hydropower, is created when flowing water is caught and converted into electricity. Hydropower evaluations have found various potential locations with capacities ranging from 10 kW to 5 MW, but only a few of these have been installed. There is one hydropower plant at Kaptai established in the 1960s with a current installed capacity of 230 MW. The first Pico hydropower plant (10 kW of electricity) is installed at Aung Thuwai Pru village Thanchi sub-district of Bandarban district by a private company named Oporajeo Social Energy. The second pico power plant of 10 kW power is located at Nitong Para village, Ruma sub-district Bandarban under the PPP partnering with a development partner, UNDP and Ministry of Power Energy and Mineral Resources [49]. Today's hydroelectric plants have an efficiency of around 90%. Hydroelectric facilities do not pollute the air, and the fuel-falling water is not consumed, thus they last longer than other sources of energy generation. Hydroelectric generators also respond swiftly to changing system circumstances. Although hydropower is an inexpensive and environmentally friendly form of energy, it is often overlooked as an energy source.

3.6. Geothermal energy

Since heat is constantly produced inside the earth, geothermal energy is a renewable energy source. Geothermal heating is used for bathing, heating houses, and generating power. Natural geothermal energy can be found in geysers, hot springs, lava, and fumaroles. The use of geothermal heat pumps to control the temperature in a building is becoming more widespread in households and businesses. Geothermal power plants use steam to produce electricity. The steam originates from hot water reservoirs a few kilometers or more beneath the surface of the earth. Steam turns a turbine, which turns a generator, which generates energy. To overcome the current power problem, Bangladesh has a tremendous chance to create electricity using geothermal energy. The North-East region of this country is suitable for planting geothermal power plant. The geothermal gradient in the South-East region varies from 19.8 to 29.5°C/km along the North-East 20.8 to 50°C/km. Figure 2 shows the geothermal gradients of the deep well at various location of the country [50]. Figure 3 represents the country's geothermal status of various region at 3 km depth from the earth surface [51]. Thermal expositions and shallow aquifers in the Thakurgaon district, in the northwestern region of the country, indicate the presence of a geothermal resource.

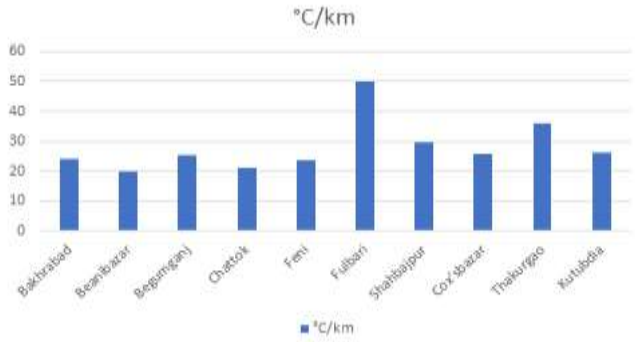

Figure 2. Geothermal gradients for the deep well at various places

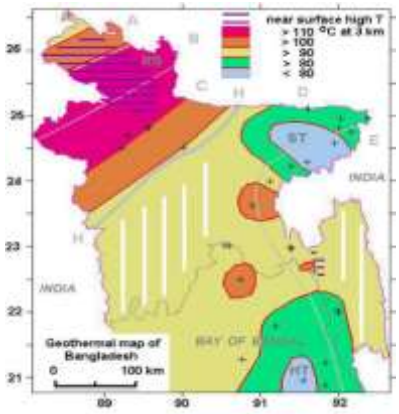

Figure 3. Geothermal map showing the temperature at 3 km depth

3.7. Ocean energy

Electricity can be generated using tides, waves, and currents. Wave energy, which uses converters to absorb the energy inherent in ocean waves and use it to generate electricity, is a promising ocean technology that is currently in the research and development stage and not yet commercially viable. Wave power devices extract energy directly from the surface motion of ocean waves. Ocean waves contain tremendous energy potential. The apparatus floats in the ocean and harvests energy from the waves, which generate relative motion in various areas of the structure. As the wave height in Cox'sbazar is 2.8 m, it is no doubt that satisfactory results will be obtained in Saint Marteen. Considering the tidal wave height, duration, water depth, cost and durability, Bay of Bengal has good prospect for large-scale production of electricity using this type of generator. At present, the generated electric power is not enough based on the demand of Bangladesh. Ocean wave energy can provide a suitable low cost and permanent solution.

Tidal power is a dependable energy source that can be used to replace fossil fuels. It also produces no greenhouse gases or waste of any kind. Tidal energy leads to a reduction in all forms of greenhouse gas emissions, including methane (CH_4) and nitrous oxide, in addition to a large reduction in CO_2 emissions (N_2O). These gases are generated when fossil fuels like coal, oil, and natural gas are burned to generate electricity. Bangladesh's southernmost region is flanked by the Bay of Bengal's about 710-kilometer-long coast line. It boasts a 37,000-km-long continental shelf with a depth of up to 50 meters, a tidal stream speed of more than 2 meters per second, and tidal height peaks and falls of 28 meters. Bangladesh has many available coastal spots that are suitable for constructing a large tidal power plant such as Hiron Points, Sundarikota, Char Changa, Golachipa, Patuakhali, Sandwip [52]. Bangladesh can take tidal power generation as a challenge and can easily overcome at least a part of the power crisis.

3.8. Future plan

Renewable energy sources can help to maintain existing economic growth or, in a larger sense, to propel the country toward sustainability [52]. Renewable energy sources, particularly solar PV solutions,

have played a key role in pushing the global energy access frontier in recent years. In this sense, Bangladesh's Solar Home System Program has garnered a global reputation [26]. The Bangladesh government had previously created a Power System Master Plan in 2010 and 2016, with the goal of improving and expanding energy supply to sustain GDP growth of 7 to 8%. In order meet the demand with reasonable reliability, installed power generation capacity need to increase to 24,000 MW and 39,000 MW by 2021 and 2030 respectively. The Renewable Energy Policy obligates the renewable energy share to be 10% by 2021 which means that it would be 2,000 MW [26], [38].

4. CONCLUSION

Energy is a basic human necessity as well as a societal building block. Renewable energy not only helps to solve the energy crisis, but it also helps to alleviate poverty and combat environmental degradation in Bangladesh, such as desertification, biodiversity loss, and climate change effects. Bangladesh, which is experiencing a severe power shortage, is now focusing on creating renewable energy sources in addition to its regular fossil fuel sources. Apart from fossil fuels, renewable energy sources such as solar, wind, hydro, biomass, biogas, and geothermal energy can assist Bangladesh in addressing concerns such as energy scarcity and price fluctuations in a self-sustaining and environmentally friendly manner. The country will be decarbonized in this case.

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