RECENT TRENDS OF RENEWABLE ENERGY IN BANGLADESH

This thesis report is submitted in partial fulfillment of the requirements for the Degree of Bachelor of Science in Electrical and Electronic Engineering

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CERTIFICATION

This is to certify that this thesis entitled" RECENT TRENDS OF RENEWABLE ENERGY IN BANGLADESH" is done by the following students under my direct supervision. This thesis work has been carried out by them in the laboratories of the department of Electrical and Electronic Engineering under the faculty of engineering, Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

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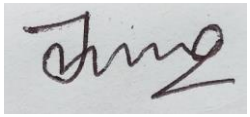

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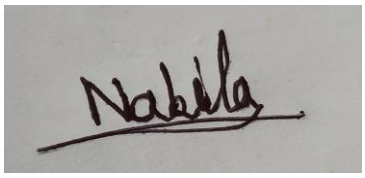

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Dedicated

To

Our Parents and Teachers

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LIST OF ABBREVIATIONS

RE	Renewable Energy
SREDA	Sustainable And Renewable Energy Development Authority
NREL	National Renewable Energy Laboratory
MW	Mega Watt
kWh	kilowatt-hour
IDCOL	Infrastructure Development Company Limited
PV	Photo Voltic
AC	Alternating Current
(DC	Direct Current
BAEC	Bangladesh Atomic Energy Commission
SHS	solar home systems
REB	Rural Electrification Board

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ABSTRACT

Bangladesh's need for power is growing every day. Due to increasing population density, energy is being used quickly, which will cause the conventional energy supplies to run out rapidly. To satisfy rising demand, it's critical to fore casting Bangladesh's energy reserves, their usage rate, and the potential time for nonrenewable energy use. Bangladesh has various renewable energy sources such as wind, solar, hydro power, biomass, biogas, etc. These renewable energy sources have much potential, but some challenges make them difficult to use correctly. Utilizing these resources will help save nonrenewable energy for the future and make the country self-sufficient in the long run. This research study is based on secondary data and analyzes Bangladesh's present energy condition, as well as renewable energy status, as well as its opportunities and problems.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Bangladesh has a large population. Humans need a lot of energy to live and produce products (Uddin et al., 2018). Due to demographic expansion, economic development, and technological innovation, the need for energy is rising daily (Halder et al., 2015). If current energy consumption rates continue, the energy discovered will decrease within decades (Bazilian et al., 2014). Power generation has shown to be a necessary component in our everyday life. Compared to the global energy landscape, Bangladesh's basic renewable energies are in bad shape. Coal, natural gas, oil, and hydro power reserves are all finite (Islam et al., 2014). In 2020, the government of Bangladesh provided electricity to 96% of the population, and the current per-person power output is 510 kWh (Achieved at a Glance Power Sector, 2020). According to Petro Bangla, gas is a major component of Bangladesh's electricity production. So the electricity demand is being met from local sources, and only 5% is imported. As a result, electrification in Bangladesh will face challenges in the future. Bangladesh Petroleum Corporation (BPC) imported 11.73 lakh metric crude oil and 55.42 lakh metric tons of refined oil in the 2017-2018 financial year. In 2017-18, the gas production capacity was 2750 MMcfd, the total reserve was 28.69 Tcf, the production till 2018 was 15.96 Tcf, and the remaining reserve was 12.72 Tcf (Energy and Mineral Resources Division). In the 2016-17 fiscal year, coal production was 1.2 million tons (Mandal et al., 2018). Meanwhile, Bangladesh only produces an average of 10958 MW of power in FY 2017–18, compared to the demand of 12610 MW, despite having an installed capacity of 17753 MW. This shows that the energy demand exceeds production capacity in Bangladesh (Department of Energy and Mineral Resources, 2019). As fossil fuel reserves dwindle, power generation from conventional systems will decline shortly. To fulfill the rising need for energy, scientists, engineers, and people throughout the world are converting to renewable energy sources (Uddin et al., 2018). Bangladesh is an agricultural nation, and it is the only source of food for people. Fossil fuels, which are a major source of greenhouse gas emissions and the cause of climate change, power the majority of farm equipment. Other industries are likewise plagued by this issue. The use of renewable resources can help to mitigate

such environmental harm (Chell & Kaushik, 2011). The geographical location of South Asian countries gives them easy access to a wide variety of renewable energy sources (Shukla et al., 2017). Bangladesh is a lovely country with lots of prospects for renewable energy. For cooking and electricity production, renewable energy sources like biomass or biofuels are utilized. Another significant energy source in Bangladesh is solar energy. Most of Kadesh's rural, hilly, and coastal regions use the common solar photovoltaic (PV) cell technology. In Bangladesh, the idea of hydropower generating is a long-standing one, and the country has already established a number of hydroelectric projects. Wind energy is a novel natural resource in Bangladesh, where several small- and micro-scale wind production sites have been established for the generation of electricity. As a result, renewable energy is essential for guaranteeing Bangladesh's energy security, however this energy output is insufficient (Uddin et al., 2019). In comparison to nonrenewable energy, renewable energy has a greater influence on sustainable development. As a result, a country's degree of sustainable development increases as its use of renewable energy increases (Güney, 2019). The paramount significance of this research paper is the current state of energy, such as energy production, energy consumption, the current status of renewable energy sources, and its possibilities and challenges, which will help identify crucial renewable energy needs in Bangladesh which are not only important for conservation.

1.2 Motivation

The country's natural resources but the environment. Goals for the Study The following are the specific aims of this review article:

1. To assess Bangladesh's present energy and renewable energy situation
2. Describe the potential and difficulties of renewable energy.

Chapter 2

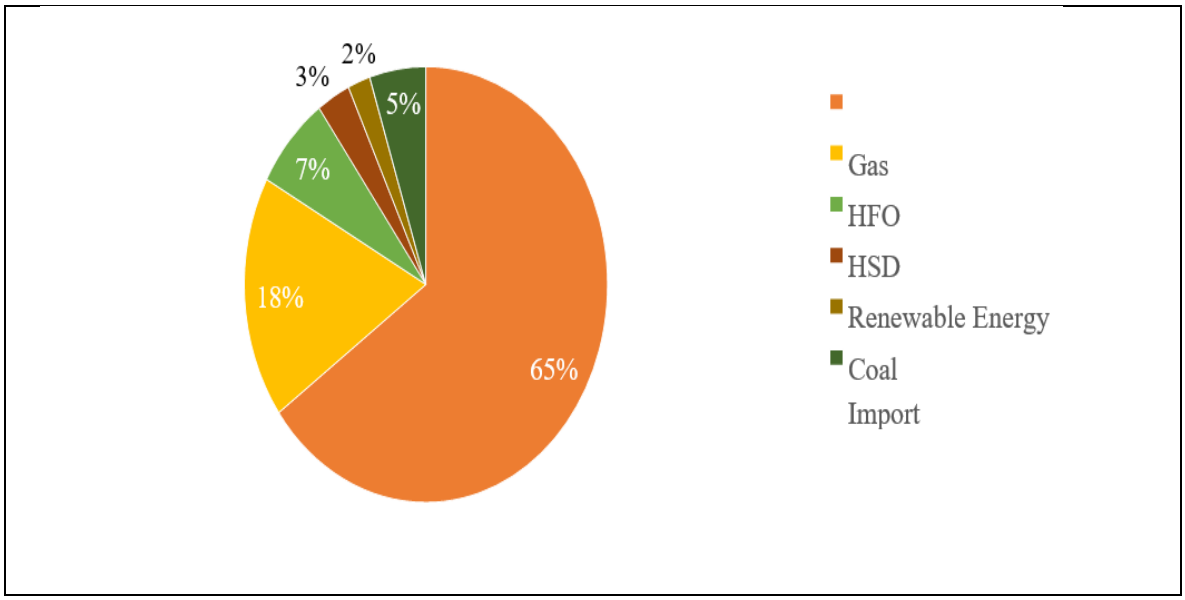
Current Energy Scenario

Energy is the entire quantity of electricity, which includes captive power from various sources, such as solar panels, wind turbines, biogas, biomass, natural gas, and hydro power. According to Master Plan 2010, Bangladesh is increasing energy production to satisfy the anticipated demand. The reduction, distribution, and transmission of progressive power generating losses as well as human access to Bangladesh's national grid are shown in Table 1. It also contains the notion of a country's growth, namely the development of Bangladesh.

Table 2.1 Bangladesh Power Sector at a Glance [4]

	2009	2018	Addition in 9 Years
Generation Capacity (MW)	4,942*	17,753 MW*	12811
Highest Generation (MW)	3,268 (6 January 2009)	10,958 MW (28 May,2018)	7690
Power Plants (No)	27	111 (2017)	84
Expired Plants	0	3 (2017)	3
Total Consumers (Million)	10.8	29.0	18.2
Transmission Line (Km)	8000	10,680	2,680
Distribution Line (Km)	260,000 km	446,000 Km	186,000
System Loss (%)	16.9	12. 19(June 2017)	-4.71
Distribution Loss (%)	15.2	9.98 (June 2017)	-5.22
Per Captai Generation (KWH)	220	433	213
Access Electricity (%)	47	90	43
Out of Accessibility (%)	53	10	-43

The whole energy scenario is depicted in Table 1. Bangladesh uses a limited amount of renewable energy. The proportion of energy generated from various sources is shown in Figure 1. It shows that just 2.95 percent of Bangladesh's 17,753 MW total power generating capacity, which includes off-grid RE, is generated by renewable sources. Bangladesh's main energy resources include coal, petroleum, liquefied natural gas, solar energy, hydro power, and wind energy. Figure 1 displays the price trends for various energy sources.



Source: (Uddin et al., 2019)

Figure 2.1: Primary energy consumption pattern in Bangladesh

Figure 1 shows that natural gas accounts for 65% of energy consumption, followed by heavy fuel oil (18%), increased diesel (7%), power imports (5%), coal (2%), and sustainable sources (3%). The installed power generating capacity of renewable resources is displayed in Table 2. This shows that Bangladesh produces energy both on or off the grid using the solar system, wind, hydro power, biogas, and biomass.

Table 2.2: Renewable Energy to Electricity Installed (MW)

Technology	Off-Grid	On-Grid	Total
Solar	267.27	17.35	284.62
Wind	2	0.90	2.90
Hydro	-	230	230
Biogas to Electricity	0.68	-	0.68
Biomass to Electricity	0.40	-	0.40
Total	270.35	248.25	518.60

The government aims to produce 2,000 MW of electricity from renewable sources by 2021. This national source produces 404 MW of electricity in total. By 2021 and 2030, respectively, 10% and 20% of total power will be the new targets for renewable energy. Rangunia has taken initiatives to produce 60 MW of renewable energy, and Dhaka has made 3 MW. 200 MW from Gangachhara, 200 MW from Mymensingh, 20 MW from Cox's Bazar, and 200 MW from the Sun Expansion pack Solar Power plant in Teknaf are among the available megawatts (MW) from Sharisabari. Additionally, in Kaptai, Hatia, Thakurgaon, Ishwardi, and Sirajganj Solar Home Systems (SHSs) installation is in progress.

Chapter 3

Prospective of Renewable Energy

3.1 Introduction

Bangladesh is merely making progress towards sustainable development. Power generation is becoming mandatory. Demand and supply of electricity The profile is discussed in detail in PSPM 2016. For energy security, fuel blends play an essential role. Bangladesh mainly depends on natural gas for power generation, which has reserves. The closed future power generation plan is based on coal and furnace oil. But for durability and environmentally friendly renewable energy is nothing more than essential in the long run. Following the establishment of the United Nations 2030 Agenda for Sustainable Development and its Environmental Goal 7, a global consensus has evolved (SDG 7).

The proportion of sustainable power in the future has to be amplified. The Paris Agreement also calls for global warming to be kept below two degrees Celsius. Because renewable energy emits greenhouse gases on a net basis, its proportion in the energy mix is rising. The pace of these objectives' execution has increased, significantly increasing user-generated energy. According to PSMP 2016, Bangladesh plans to generate at least 10% of its total electricity from renewable sources. Only 2.85 percent of Bangladesh's power is produced by renewable sources, mostly solar and hydroelectricity. By 2020, SREDA wants to generate 2000 MW, or 10% of its total electricity, from renewable sources. However, compared to the current Epidemic, the facts at hand makes this assertion appear like a pipe dream. SREDA anticipates a steady rise in the use of renewable resources. The Bangladeshi government has taken action. The Government of Bangladesh has taken steps to ensure good Use of renewable Technology. It is expected to complete about 2177 MW from renewable technology by 2021

Fuel/Resource	Installed Capacity	Share
Coal	524 MW	2.36 %
Gas	10678 MW	48.11 %
HFO	5208 MW	23.46 %
HSD	1795 MW	8.09 %
Imported	1160 MW	5.23 %
Renewable	631.94 MW	2.85 %
Captive	2200 MW	9.91 %
Total	22197 MW	

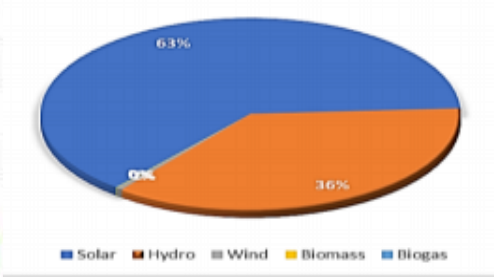


Figure 3.1: Current Generation Mix (2020) (source: sreda.gov.bd)

Technology	On-grid (MW)	Off-grid (MW)	Total (MW)
Solar	80.93	317.01	397.94
Hydro	230	0	230
Wind	0.9	2	2.9
Biomass	0	0.4	0.4
Biogas	0	0.63	0.63
Total	**311.83**	**320.04**	**631.87**

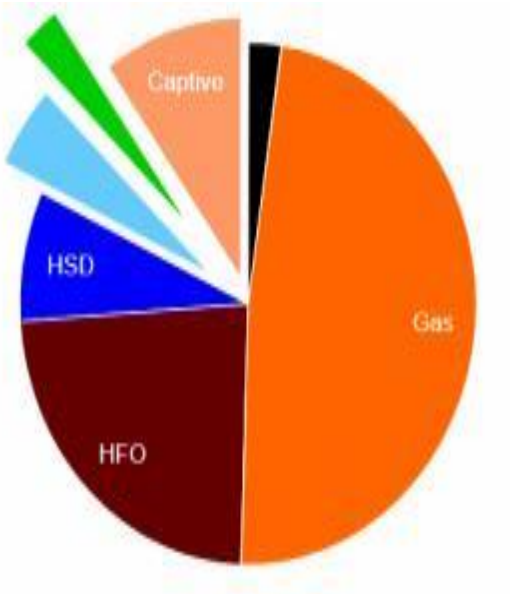


Figure 3.2: Current Renewable Energy Power Generation (2020) (source: sreda.gov.bd)

In the previous several years, there has been a considerable advancement in renewable energy. Sources of energy are used to produce 404 MW of electricity. The solar house system has been well received in Bangladesh; more and more off-grid rural areas are adopting it. Bangladesh's progress in the field of renewable energy is seen in the table below.

Table 3.1 Progress in the Renewable Energy Sector

Methods	MW
Installation of Solar Home System (3.5 million)	150.00
Installation of Rooftop Photovoltaic (PV) at Government/Semi-Government offices	3.00
Installation of PVs on commercial buildings and shopping centers	1.00
Installation of PVs by consumer during new electricity connections	11.00
Installation of Wind-based power plants	2.00
Installation of Biomass-based power plants	1.00
Installation of Biogas- based power plants	5.00
Solar Irrigation	1.00
Hydro Electric power generation	230.00
Total	404.00

3.2 Renewable Energy Sources in Bangladesh

Bangladesh has a great deal of potential for renewable energy, particularly solar energy. But soon, standard non-renewable methods will be used to connect renewable energy to the source of current energy. However, in order to provide consumers who live off the national grid or in locations where grid connections take longer than expected, renewable energy will be crucial. Bangladesh is utilizing both conventional and renewable energy sources to produce electricity. Bangladesh now uses solar, wind, hydro, biomass, and biogas as renewable energy sources. Bangladesh is presently concentrating on developing renewable energy in keeping with current trends throughout the world. Only Kaptai, Rangamati has a hydroelectric plant and one solar home system (SHS) in rural regions of Bangladesh, where it was formerly a sustainable energy source. But during the past few years, numerous initiatives have been developed. Numerous initiatives to produce power from renewable sources have been successfully implemented. The following pie chart displays the state of renewable energy at this time.

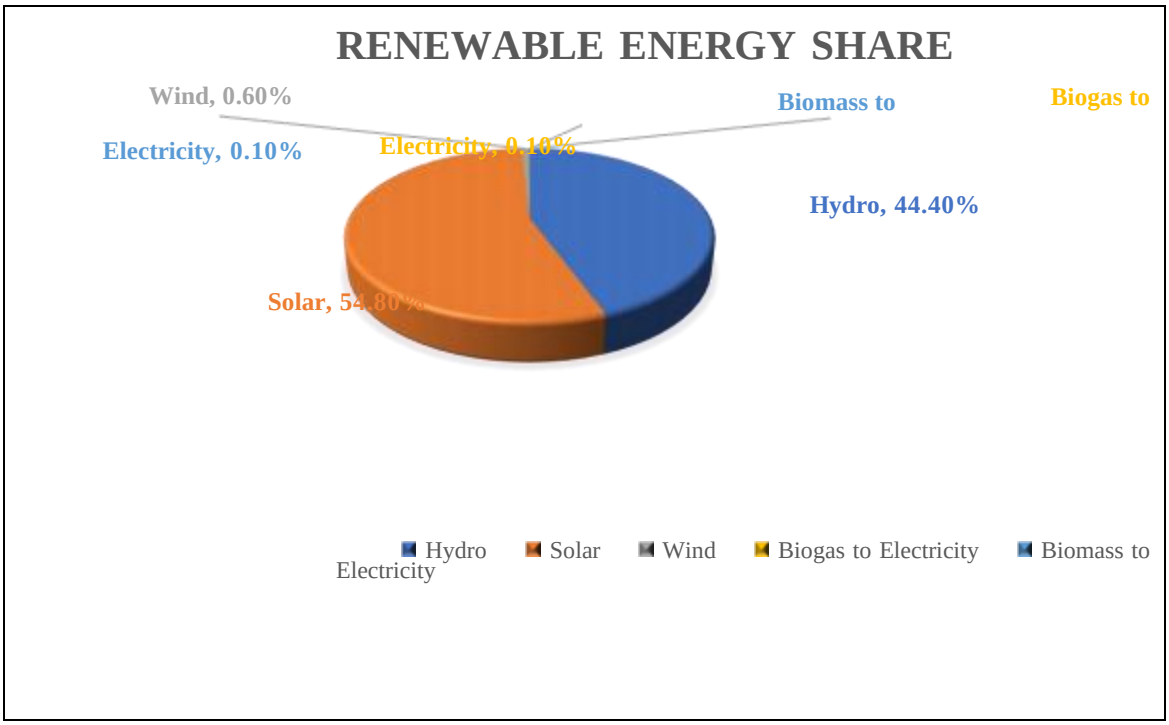


Figure 3.3: Current Renewable Energy share

3.3 Solar

Solar energy is Bangladesh's largest source of renewable energy. According to long-term average sunlight statistics, there are between 3 and 11 hours of strong sunshine per day in Bangladesh's coastal regions [Mohammad Aslam Ukaili; KhanjiHorizon (2011), Energy, Environment, and Sustainable Development, Springer, p. 19]. Bangladesh average daily solar radiation received is 4-5 kWh/m2. Bangladesh solar Solar power from SHS, a grid-connected solar PV power plant, is mostly used to transform energy into electricity. Littlegrid, etc. A total of 396.03 megawatts (MW) of power are produced from solar energy. The amount of non-renewable energy in Bangladesh's system is 80.93 MW, with the remaining 316.1 MW coming from off-grid sources.

Table 3.2: All Solar Technologies of Large Projects in Bangladesh

	PROJECT NAME	SID	Capacity	Location	RE Technology	Completion date	Present Status
1	Sirajganj 6.13 MW (AC) Grid Connected Solar Photovoltaic Power Plant	151	7.6 MWp	Sirajganj Sadar Upazila. Sirajgonj	Solar Park	2021-03-30	Completed & Ruiming
2	35 MW AC Solar Park by Consortium of Spectra Engineers Limited & Shunfeng Investment Limited	137	35 MWp	Shibalaya Upazila. Manikganj	Solar Park	2021-03-12	Completed & Rumiing
3	50 MW (AC) Solar Park by HETAT-DITROLIC-IFDC Solar Consortium	125	50 MWp	Gauripur. Mymensingh	Solar Park	2020-11-04	Completed & Running
4	Kaptai 7.4 MWp (6.63 MW AC) Grid-coimected Solar PV Power Plant	268	7.4 MWp	Kaptai Upazila. Rangamati	Solar Park	2019-05-28	Completed & Running
5	8 MW Solar Park by Parasol Energy Ltd.	361	8 MWp	Panchagarli Sadar, Panchagarli	Solar Park	2019-05-13	Completed & Ruiming
6	20MW (AC) Solar Park by Joules Power Limited (JPL)	128	20 MWp	Teknaf Upazila. Cox's Bazar	Solar Park	2018-09-15	Completed & Ruiming
7	3 MW Grid-connected PV Power	147	3 MWp	Sarishabari Upazila. Jamalpur	Solar Park	2017-07-14	Completed & Ruiming

	Plant at Sharishabari. Jamalpur						
8	Sonagazi 50 MW Solar Power Plant Construction Project	152	50 MWp	Sonagazi. Feni	Solar Park	2022-12-30	Implementation Ongoing
9	30 MW (AC) Solar Park by Bexhnco Power Company Ltd & Jiangsu Zhongtian Technology Co Ltd.	132	30 MWp	Tetnlia, Panchagarh	Solar Park	2022-03-26	Implementation Ongoing
10	32 MW (AC) Solar Park by Haor Bangla-Korea Green Energy Ltd.	126	32MWp	Dharanipasha. Sunamganj	Solar Park	2021-12-31	Implementation Ongoing
11	5 MW (AC) Solar Park by PV Power Patgrain Ltd.	133	5 MWp	Patgram. Lalinonirhat	Solar Park	2021-12-31	Implementation Ongoing
12	100 MW (AC) Solar Park by Energon Teclmologies EZE & China Sunergy Co.Ltd (ESUN)	136	100 MWp	Mongla Upazila. Bagerhat	Solar Park	2021-12-31	Implementation Ongoing
13	5 MW (AC) Solar Park by Sun Solar Power Plant Ltd.	340	5 MWp	Gowainghat, Sylhet	Solar Park	2021-12-30	Implementation Ongoing
14	200 MW (AC) Solar Park by Bexnnco Power Co. Ltd.	129	200 MWp	Sundarganj. Gaibandha	Solar Park	2021-10-26	Implementation Ongoing
15	30MW (AC) Solar Park by Intraco CNG Ltd & Juli New Energy Co. Ltd.	127	30 MWp	Gangachara. Rangpur	Solar Park	2021-09-26	Implementation Ongoing

source:SREDA | National Database of Renewable Energy

3.4 Solar Home System

In rural regions, solar photovoltaic (PV) systems are becoming more popular for supplying homes and small businesses with electricity. Several trial PV systems were installed by Bangladesh Atomic Energy Commission (BAEC) in 1988. With funding from France, the first substantial PV-based rural electrification program project was launched in the Narsingdi district. A total of 32.586 kWp of freestanding solar home systems (SHS) and three battery charging stations with a combined capacity of 29.4 kW were installed. Users of Rural Electrification Board (REB) networks paid a monthly charge for the services, which were owned. SHS quickly spread throughout the population starting in 1996. It is now Bangladesh's largest renewable energy initiative. 4.5 million units have already been placed, and more are being added thanks to a comprehensive program the government enacted through its financial institutions call. The campaign PVA technology is also supported by a number of other NGOs, including ASA, CMES, and BRAC. Most PV modules are imported, while a small number of private enterprises produce PV accessories. This Solar Home System (SHS) is robust and reliable and owes much to it. The success of a unique rural credit and 'cost by down' system enables it to improve access To rural families. In Bangladesh's rural, off-the-grid areas, more than 5.8 million SHS have already been built by BREB, IDCOL, GIZ, and MoDMR, benefiting around 13 million people. SHS has a capacity of roughly 248.29 MW overall. One of the biggest and fastest off-grid renewable energy initiatives in the world has been the project.

3.5 Grid Tied Solar PV Plant

Multiple solar panels are wired to generate large amounts of electricity from solar energy format formation together. Generates direct current (DC) energy that fluctuates with the intensity of sunlight. It is usually for practical use conversion is required using a specific desired voltage or alternating current (AC). The inverter is an inverter with this PV system, ensuring power supply at the desired voltage, preferred frequency, and phase angle. The whole system is commonly known as solar PV Plant or solar park. There are currently four grid-connected solar PV plants and a couple of ongoing projects. The first grid of solar PV power plant gridisgrid is a grid at Sharishabari in Jamalpur. Attached is the plant that went into commercial operation in August 2017. 2nd Solar PV Power Plant 20 MWp in Teknaf Upazila of Cox's Bazar started its activities on 1 November 2018. The 7.4 MWp Solar Park at Kaptai in Rangamati is another solar park started. Operation in September 2019. The project costing Rs 111.2 crore, was implemented Assistance of the Asian Development Bank on 22 acres of land of the Bangladesh PowerDevelopment Board. Work on the project began in October 2017. EPC of this project The Chinese company was ZTE, which will provide technical support for the next two years. Inauguration The latest solar park launched on 13 November 2019 is an 8 MW solar park In Tetulia of Panchagarh. The project is a joint venture between Simpa Solar Power Limited, Thailand-based solar PV developer Simbier Solar and Paragon Group, a leading agri-based firm in Bangladesh.

3.6 Solar Mini-grid

A mini-grid is a connection of off-grid power sources that generates modest amounts of electricity (wiki). In Bangladesh's distant regions, where grid expansion is uncertain, solar PV-based mini-grid installations have been established. These initiatives offer and promote grid-quality energy to homes and small businesses. Activities related to commerce in the project area. A total of 27 solar mini-grids with a rising generation capacity of 5.656 MW have been installed thanks to funding from IDCOL. An estimated 16,000 people now have access to low-emission power thanks to mini-grid installations. Country Bangladesh (IDCOL).

3.7 Rooftop Solar

Bangladesh has a lot of sunshine, and the use of solar energy is growing as the price of solar technology is falling. Promoting distributed generation based on RE requires encouraging grid-connected users. One method for promoting RE-based electricity generation in the nation is net metering. By enabling utility users to produce their own electricity from solar power, net metering is a political strategy intended to promote the growth of distributed renewable energy sources. The power produced by other renewable sources is fed into any access generation system and used to balance the quantity used from the utility grid, also known as the distribution grid. Only "net" electricity used by customers is billed and credited, often within one kilowatt-hour (kWh). The customer's net amount is transferred to. Net balances in favor of customers are carried over to the next month, whereas net balances in favor of utilities are paid at the end of the month. With the addition of 13 MW of power from net-metered rooftop solar systems to the national grid, the net-metering technology has swiftly grown in popularity.

3.8 Wind Power

Bangladesh has greater wind power potential than previously believed, especially in hubs at elevations of 140 to 160 meters, according to the US National Renewable Energy Laboratory (NREL). The Bay of Bengal, Kuakata, Sandwip, and St. Martin coasts have a combined potential area of 724 km. Locals who live off the grid will no longer lack access to electricity thanks to the installation of wind power in the region.The administration took steps in this regard previously. In December 2020, it approved a large 55 MW wind power project in Mongla. Other projects are also in the pipeline. Although wind energy has made considerable progress, its promise is mostly in coastal regions and on islands with strong wind systems. It offers excellent possibilities for coastal environments with wind-powered power production and pumping. Bangladesh only has three wind turbines with a combined capacity of 4.9 MW. Among the wind parks in Sonagazi Upazila, Feni and Kutubdia coastal areas have been operating for the last few years, where 2 MW. Wind Park in Sirajganj district was launched commercially on 16 February 2018.

Table 3.3: All Wind Technologies of Large Projects in Bangladesh:

SL.	PROJECT NAME	SID	Capacity	Location	RE Technology	Completion date	Present Status
1	1000 kW Capacity Wind Battery Hybrid Power Plant	172	1 MWp	Kutubdia Upazila, Cox's Bazar	Wind(Off-Grid)	2015-12-31	Completed& Running
2	1000 kW Capacity Wind Battery Hybrid Power Plant	171	1MWp	Kutubdia Upazila, Cox's Bazar	Wind(Off-Grid)	2008-12-31	Completed& Running
3	0.9 MW Grid Connected Wind Turbine Power Plant at Mahuri Dam,Feni	173	900 kWp	Sonagazi, Feni	Wind(On-Grid)	2006-09-27	Completed& Running
4	Design,Supply,Installation.Testing and Commissioning of 2 MW Capacity Wind Power Plant	370	2 MWp	Sirajganj Sadar Upazila, Sirajgonj	Wind(On-Grid)	2022-12-29	Implementation Ongoing

	on turnkey basis at the bank of the River Jamuna adjacent to the existing Sirajganj 150 MW Power Plant, Sirajganj,Bangladesh						
5	60 MW Wind Power Project at Coxs Bazar by US-DK Green Energy(BD)Ltd	158	60 MWp	Chakaria Upazila, Cox's Bazar	Wind(On-Grid)	2021-12-31	Implementation Ongoing
6	Matarbari 100 MW Wind Power Plant Project	4252	100 MWp	Maheshkhali Upazila, Cox's Bazar	Wind(On-Grid)	2026-12-30	Under Planning
7	30 MW Wind Power Plant by Consortium of Bhagwati products ltd(India),Regen Powertech Provate Ltd(India) and Siddhant Wind Energy Pvt.Ltd.	4176	30 MWp	Sonagazi, Feni	Wind(On-Grid)	2023-11-22	Under Planning
8	Mongla 55 MW Wind Power Plant by Consortium of Envision Energy (Jiangsu)Co.Ltd., SQ Trading and Engineering&Envision Renewable Energy Bangladesh Limited	4173	55 MWp	Mongla Upazila, a	Wind(On-Grid)	2023-11-15	Under Planning

source:SREDA | National Database of Renewable Energy

3.9 Hydro

With a current installed capacity of 230 MW, a hydroelectric station was built in Kaptai in 1962. Bangladesh's micro- and mini-hydro potential is limited outside of Chittagong and the Chittagong Hill Tracts. Although possible locations with capacities between 10 kW and 5 MW have been found through hydropower evaluations, no appreciable capacity has yet been reached. When compared to other traditional energy sources, hydropower is the cleanest and is frequently employed for power generation. Hydropower generating is a great way to save energy because it has relatively low supply costs and greenhouse gas emissions. Bangladesh has a large number of rivers, and rivers are vital to the country's population's ability to support themselves.

3.10 Biomass

Energy is an excellent way to provide heat and energy to your home and property, specifically if you've had a lot of natural waste or animals to care for. Biomass energy may be used in two ways to generate heat and power:

Biomass burning (energy recovery) emits relatively little ash, and the CO2 released is the same CO2 held by plants throughout the growing season.

Organic digestion - where we rely on microorganisms, such as bacteria and viruses, to naturally decompose organic matter into compost or humus can enrich your soil. There are two types of biomass digestion:

Gaseous biomass digestion - relies on gaseous bacteria and oxygen from the air to digest organic matter - the final product is compost,

Anaerobic Biomass Digestion - Depending on anaerobic bacteria and water for digestion of organic matter - The final product is humus. Bangladesh has a lot of potential for power generated through biomass gasification. Since agriculture is the main source of revenue in rural Bangladesh, a sizable proportion of organic matter, animal waste, and household garbage originate from agricultural waste. In terms of utilization, biomass accounts for 70% of the nation's total energy consumption, along with natural gas, which is considered the country's main energy source. Paddy, maize, wheat, coconut, peanuts, bean, jute, and sugarcane are the main agricultural leftovers from which biomass is harvested in Bangladesh. Paddy straws, husk, jute sticks, and sugarcane all contribute around 46% of Bangladesh's biomass energy residue. In Bangladesh, biomass gasification is a common and favored technology for producing electricity. 400 kilowatts of power have thus far been produced using biomass.

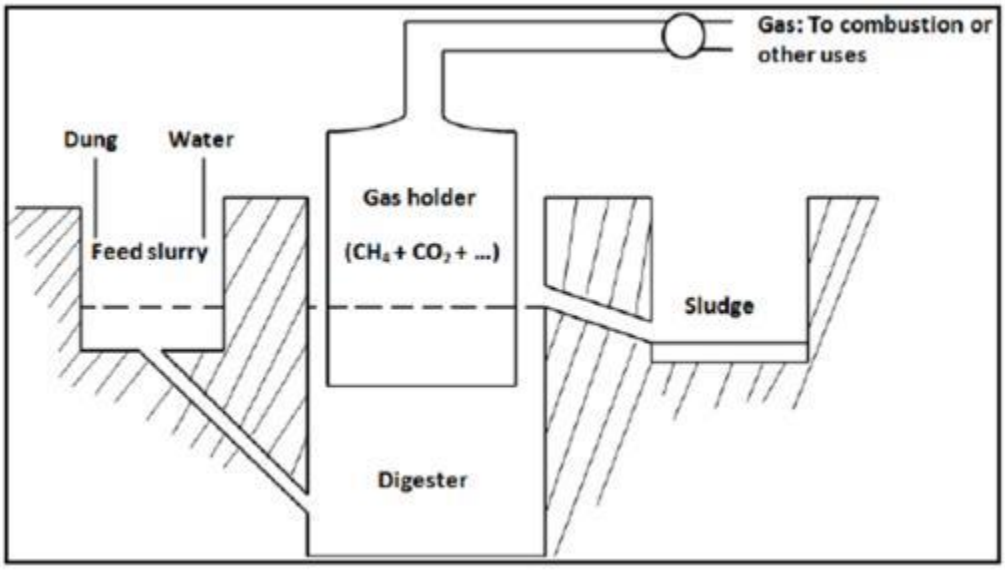
Table 3.4: All Biomass Technologies of Large Projects in Bangladesh

SL.	PROJECT NAME	SID	Capacity	Location	RE Technology	Completion date	Present Status
1	SEAL Biomass based Electricity Project	122	400 kWp	Whole Bangladesh, Thakurgaon	Biomass to Electricity (Off-Grid)	2015-12-31	Completed& Running
2	X	4233	0 MWp	Whole Bangladesh	Biomass to Electricity (On-Grid)	2023-06-13	Rejected from Planning Phase

source: SREDA | National Database of Renewable Energy

3.11 Biogas

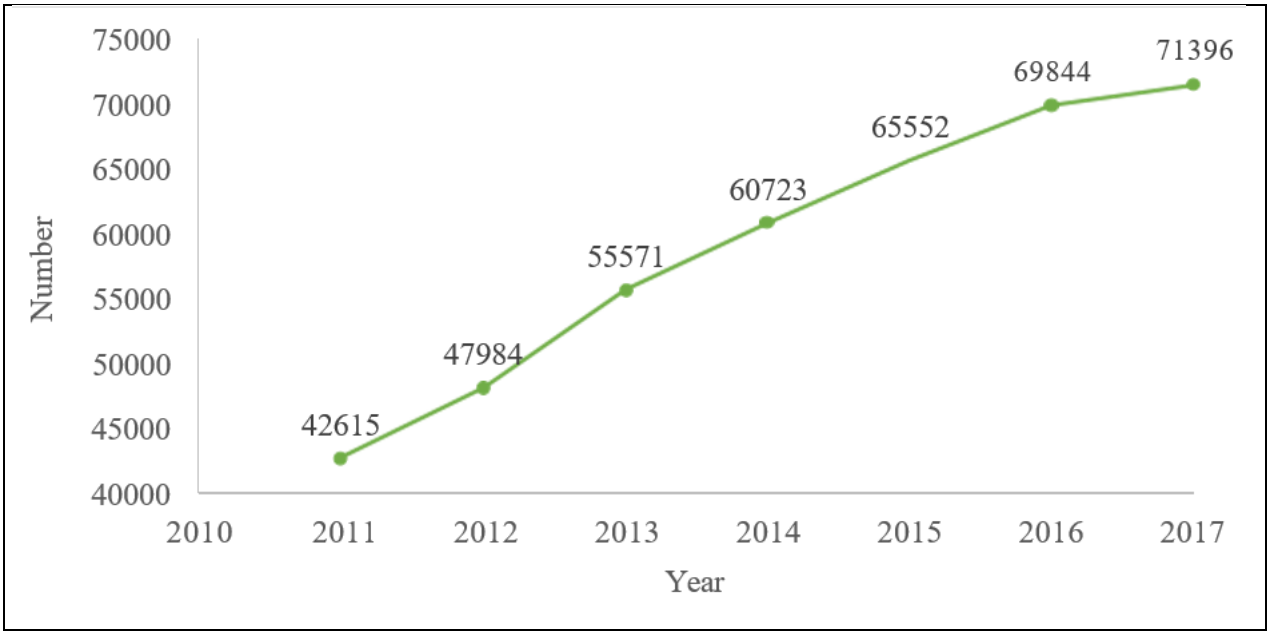
Biogas is a mixture of gases created by the decomposition of the organic materials. Animals frequently produce biogas. Municipal waste is a promising renewable energy resource for Bangladesh. About 70 percent of this gas is methane, better than wood as fuel, and the rest is carbon dioxide and some other gases. The nation is home to countless families and small-scale biogas facilities at the local level. Use of basic biogas technology for cooking and supplying power during shortages is a viable source of electrification for rural and peri-urban areas. About 0.22 million tons of dung were obtained from 22 million cows and buffaloes. Dung can generate 37 m3 of biogas every ton. 2.97 × 109 m3 of gas may be produced from the available cow dung, which is the same as 1.52 x 106 tons of kerosene or 3.04 x 106 tons of coal. Additionally, water hyacinth, human and environmental waste, and may be used to create a variety of biogases. In 1972, a floating dome-style biogas plant was constructed. Currently, biogas is used to produce 630 kilowatts of power. The magical decomposition of organic matter produces biogas, a combination of gases that doesn't include oxygen. Organic wastes are materials from dead animals and plants that are utilized in biogas facilities (Figure 10). Additionally, it may be converted into Biogas from animal manure and kitchen waste.



Source: (Sharif *et al* 2018)

Figure3.4: Construction of a typical biogas plant

Consequently, biogas is a kind of biofuel. Methane (CH4), carbon dioxide (CO2), and other gases make up 40–70%, 30–60%, and 5%, respectively, of biogas. It also has a few trace gases in it. Figure 10 depicts a biogas plant for producing electricity that has the piping and control systems necessary for effective operation, as well as a gas container, digester, and generator. In Bangladesh, biogas generation is well recognized thanks to the well-known NGO Grameen Shakti. 13,500 biogas plants have been installed. A 25 kW biogas-based power plant design has been put out by another organization named Seed Bangla Foundation. A biogas factory is intended to be built in northern Bangladesh, according to Infrastructure Development Company Limited (IDCOL), a government-owned investment firm.Several companies have built domestic biogas plants using their resources (Sharif et al., 2018). The amount of biogas plant set up is increasing. This growing trend is presented in Figure 6.



Source: (Islam *et al.*, 2017)

Figure 3.5: Year-wise cumulative installation of biogas plants in Bangladesh

Figure 6 demonstrates that there were 42,615 biogas plants constructed in total in 2011; this number nearly quadrupled in 2017. By offering subsidies through IDCOL, the Bangladeshi government promotes the construction of biogas facilities (Uddin et al., 2018).

Table 3.5: All Biogas Technologies of Large Projects in Bangladesh

SL.	PROJECT NAME	SID	Capacity	Location	RE Technology	Completion date	Present Status
1	Oasis Services(Agro) Ltd	3688	300kWp	Bhaluka, Mymensingh	Biogas to Electricity(Off-Grid)	2020-02-18	Completed & Running
2	Phenix Agro Ltd.at Member Bari,Gazipur	117	400 kWp	Whole Bangladesh, Gazipur	Biogas to Electricity(Off-Grid)	2016-09-30	Completed & Running
3	UAL Bio-Electricity Project	121	60 kWp	Whole Bangladesh, Gazipur	Biogas to Electricity(Off-Grid)	2016-04-30	Completed & Running
4	KKT Bio-Electricity Project	120	100kWp	Whole Bangladesh, Panchagarh	Biogas to Electricity(Off-Grid)	2015-12-31	Completed & Running
5	ZPL Bio-Electricity Project	119	30kWp	Whole Bangladesh, Chuadanga	Biogas to Electricity(Off-Grid)	2015-11-30	Completed & Running
6	UKAL Bio-Electricity Project	118	30 kWp	Whole Bangladesh, Tangail	Biogas to Electricity(Off-Grid)	2014-10-31	Completed & Running
7	Seed Bangla Foundation Bio-Electricity Project	116	20 kWp	Whole Bangladesh, Gazipur	Biogas to Electricity(Off-Grid)	2012-12-31	Completed & Running
8	RKKL Bio-Electricity Project	115	50 kWp	Whole Bangladesh, Mymensingh	Biogas to Electricity(Off-Grid)	2010-06-30	Completed & Running
9	Dutch Dairy Ltd.	3689	400 kWp	Lohajang Upazila, Munshiganj	Biogas to Electricity(Off-Grid)	2021-08-30	Implementation ongoing
10	Narayanganj 6 MW Power Plant by Consortium of UD Environmental Equipment	4172	6MWp	Naryanganj Sadar Upazila, Narayanganj	Biogas to Electricity(On-Grid)	2023-10-31	Under Planning

	Technology Co.Ltd, Everbright Environmental Protection Technical Equipment (Changzhou)Limited and SABS Syndicate						
11	42.5 MW Municipal Solid Waste-based Power Plant at Dhaka North City Corporation by China Machinery Engineering Corporation (CMEC)	4234	42.5 MWp	Dhaka City, Dhaka	Biogas to Electricity(On-Grid)	2023-06-13	Under Planning
12	1 MW Grid Connected Power Plant Based on Municipal Solid Waste under Pilot Project at Keraniganj on Turnkey Basis	160	1MWp	Keraniganj Upazila, Dhaka	Biogas to Electricity(On-Grid)	2020-12-31	Under Planning

source: SREDA | National Database of Renewable Energy

3.12 Geothermal Energy

Geothermal energy makes use of heat energy that is available from the earth's interior. Wells or other methods are used to harvest heat from geothermal sources. Hydrothermal reservoirs are those that are naturally hot and permeable, whereas advanced geothermal systems refer to reservoirs that are hot enough but were created by hydraulic stimulation. The earth may produce electricity once it is above the surface by using liquids of various temperatures. Since it has been in use for more than a century, the technology for producing energy from hydrothermal reservoirs is well-developed and dependable. The most pure, sustainable energy source and the lifeblood of the planet is geothermal energy. However, geothermal energy has the potential to be used in Bangladesh. Regional geothermal gradients range from 19.8 Northwest 20.8 to 48.7 °C/km in the southeast to 29.5 °C/km and 110-153 °C within 304 kilometers of the ground. However, the main source of geothermal energy is the Rangpur Saddle (700 m deep contour), Madhupur Clay (20 m single), Kuchma and Bogra (60-125 km), and Thakurgaon warm water area. The Bangladeshi government and Anglo MGH have previously discussed plans to build a 200 MW geothermal power station at Thakurgaon.

3.13 Atomic Energy

The sole nuclear reactor in Bangladesh is owned and operated by BEC. A 2.4-gigawatt nuclear power station is operated by Rooppur Nuclear Power Station in Bangladesh. A nuclear power station is now being built in Rooppur (Rooppur), inland of Ishwardi Upazila in Pabna district, on the banks of the Padma, 6 miles (140 km) west of Dhaka. Depending on the two units, it will be the first nuclear power plant in the country and the first to be allocated in 2023.

Chapter 4

Challenges and Future of Renewable Energy

4.1 Challenges of Renewable Energy

By 2020, 10% of Bangladesh's power must come from renewable sources, according to the country's renewable energy strategy. Bangladesh is significantly more reliant on energy produced from fossil fuels. Plants that contribute little to renewable energy. While solar energy, wind energy, and ocean energy all endure as long as the planet does, fossil fuels will eventually run out globally. In just one hour, sunlight reaches the surface of the globe and produces enough energy to provide all of the world's energy needs for the rest of the year. Therefore, solar energy is the most important source of energy in the globe. Water covers one of the Planet's surfaces. At the same time, the earth's surface is surrounded by infinite air. Hence, renewable sources of power are out of the end. But unfortunately, the installation of renewable energy in Bangladesh is being hampered due to geographical reasons and the mentality of the people. Some Bangladeshi interest groups hold the false belief that electricity is more expensive than renewable energy. The discussion of solar, wind, and hydro expansions will go through some of the brilliant reasons for this.

The three main renewable energy sources used in Bangladesh are solar, wind, and hydro, as seen in the image above. Bangladesh has a lot of potential for developing renewable energy sources. However, significant development activities in Bangladesh, including green systems and sustainable power sources, face several technical, commercial, and regulatory challenges. Investors in this industry may have severe financial difficulties that adversely impact the development and commercialization of future renewable energy projects and technologies because renewable energy projects are more complicated, unpredictable, and full of unanticipated risks and dangers (Quek et al., 2018). It might be difficult for investors to convince banking institutions and other financiers to secure the required capital. Various renewable energy-related initiatives can demand substantial expenditures (Williams et al., 2015). Again, there are already well-established, reasonably priced competitors, so this poses a huge issue for business owners. Regional factors

also have an effect on the effectiveness of renewable energy installations. As a result, factors like sunlight-based variables, biomass, wind, and seas between tropical and other nations in the area make it unlikely that a renewable energy plant will be effective in another country. Typically, small businesses with minimal resources are the participants in renewable energy initiatives (Sovacool & Drupady, 2012). As was previously said, Bangladesh must overcome all of these obstacles in order to develop and promote renewable energy in the future. Without examining these barriers, it will not be possible for Bangladesh to achieve its national renewable energy goal (Karim et al., 2019). Bangladesh hasenormouhas enormouspotentialtoward for sustainable energy.

Considerable development initiatives in Bangladesh, especially those involving green technologies and sustainable energy sources, must overcome significant technical, commercial, and regulatory challenges. These initiatives include increasingly complicated, unpredictable, and risky renewable energy projects. The future development and commercialization of renewable energy projects and technology might be seriously hampered by major financial challenges for investors in this industry (Quek et al., 2018). It might be difficult for investors to convince banking institutions and other financiers to secure the required capital. Again, this presents a significant challenge for business owners because there are already established, affordable alternatives on the market. The efficacy of renewable energy projects is also impacted by regional considerations that may be effective in one country would probably not be feasible in another. The location has a lot of components that depend on sunshine, biomass, wind, and oceans between tropical and other countries, thus a renewable energy project makes sense. Typically, small businesses with little resources are the ones to launch renewable energy initiatives (Sovacool & Drupady, 2012). All these challenges are essential in order for Bangladesh to develop and promote renewable energy in the future. Bangladesh won't be able to meet its goals for renewable energy without looking at these obstacles (Karim et al., 2019).

4.2 Solar

Realistically, several factors are limiting the expected increase in utility-scale power. The difficulty of acquiring land is a considerable obstacle. Government regulations prohibit solar power plants from using agricultural land. In Bangladesh, the location for this photovoltaic (PV) system is heavily inhabited with fertile agricultural land, and non-agricultural land is not easily accessible. For instance, Ekushey would need roughly 300 acres of land for a 100MW solar park. Future technological advancements are anticipated to boost the new solar panel's efficiency, resulting in a reduction in the amount of space needed to produce one unit of power. Land acquisition, however, will be a serious problem for Bangladesh's quick deployment of utility-scale solar power until that time. Inadequate government incentives are another issue with Bangladesh's utility-scale solar power development.

Employ a firm The solar business in Bangladesh is still in its infancy and requires support from youth and local officials, according to the debate and implementation of Solar Park. Setting pricing on power generated is one of the important challenges. Companies building solar power plants in Bangladesh believe that without solar power prices, their attempts to establish the solar sector would not be commercially viable. The companies consider that the 9 US cents per unit fee paid by the government for the construction and profit of the solar plant is meager. Government negotiators should be good at paying tariffs biased toward people, not companies. However, Bangladesh's solar energy sector is still in its infancy and need incentives to develop into a viable business. Tariff incentives are probably crucial for the future of a company in Bangladesh. Another problem with Solar and wind is breathing. The sun does not shine at night, and the wind does not blow. So uninterrupted power management will be much more difficult.

4.3 Wind

Bangladesh has a low to moderate wind regime. As a result, Bangladesh's chances of experiencing a significant coastal air expansion are slim. In the Muhuri Dam region of the Feni district, the Bangladesh Power Development Board (BPDB) developed a trial project in 2005 to produce electricity from wind power for the first time in Bangladesh with an installed capacity of 0.9 MW. There isn't currently a utility-scale commercial wind power facility operating in the nation. In terms of cost, wind power still has to contend with traditional production sources. Despite the fact that wind power has substantially lowered over the past few decades, wind projects still need to be able to economically compete with low-cost power sources, and certain locations may not have windy enough conditions to do so. Property wind opportunities are typically discovered in remote locations, away from communities with a need for electricity. To bring wind farms to the city, transmission lines must be constructed. But even a small number of transmission connections may drastically lower the cost of increasing wind power. The most lucrative use of land may not be the development of wind resources. The most cost-effective use of land isn't wind energy production. Alternative land uses, which may be more valuable than energy production, must compete for suitable property for the construction of wind turbines.

4.4 Hydro

Bangladesh is a riverine country, but most rivers are low tide, a significant problem setting up hydropower plants. The heaviest tidal river is Kaanapali. Bangladesh has set up a capacity hydro plant at Karnafuli at 230 MW. The rest of the rivers are out of consideration due to low tide. Bangladesh has offered Nepal to set up hydropower plants on their river through Bangladeshi investment. The rapid growth of renewable energy in electricity from the above discussion. Generations will change the world shortly. Oil, gas, and coal are traditional fuels that will progressively run out and be replaced by renewable energy sources like solar and wind until they are history. When the rest of the world embraces a bright and clean future for renewable energy, Bangladesh is left with little alternative but to remain alone. Although there may be many obstacles in the way of developing renewable energy, the government should reach out and assist in its early growth. Let's say the Bangladeshi government genuinely decides to spearhead and advocate for renewable energy in Bangladesh. In such circumstance, developing and implementing sustainable practices are not challenging. All technical and non-technical obstacles are addressed in Bangladesh by its renewable energy-friendly energy policy.

4.5 Biomass

High-humidity organic matter is not an appropriate feedstock for traditional thermochemical conversion processes like gasification and pyrolysis. High humidity might make the conversion process less effective. Because fuel made from these components may contain moisture, moisture in raw organic matter is likewise undesirable. Fuels with a high relative humidity do not burn well. Water that is contained in the fuel is evaporated using some of its energy. The organic matter's humidity should be lower than 20% to enhance the heating value of fuels produced from these components. Drying materials is not preferred in the conversion process due to the high expense. On the other hand, certain biomass conversion procedures profit from the presence of plenty of organic molecules. For instance, biological processes like biomass hydrolysis and fermentation may be used to treat high-moisture organic matter without the requirement to dry the alcohol from carbohydrates, as can the hydrothermal conversion process, which employs supercritical and subcritical water as a reaction medium. Moisture is crucial to these processes because it helps turn organic matter into the reaction or reaction environment that is required. High levels of humidity in organic matter lead to the loss of organic matter (such as carbohydrates) via organic breakdown, the growth of mold, and storage, which lowers the yield of fuels made from these substances. Preserving organic matter at <10% can extend the storage time of materials and significantly reduce the loss of organic matter (sugars) during preservation. Humans can solve the defects of high humidity content by compressing the organic material mainly for more uniform properties. This process is called concentration. By increasing the bulk percentage of biomass resources, transportation expenses and storage volume are reduced. However, the finished product's price rises as a result of this procedure.

4.6 Biogas

Biogas is a product produced by various microorganisms' degradation of the surface. These microorganisms can exist in various shapes, sizes, and stages of growth (Jyotsna and Srivastava, 2007). In biogas production, the bacterial population is supplied as an inoculum. A biologically active liquid full of microorganisms is called an inoculum (Dennis, 2015). Additionally, in anaerobic digesters, an inoculum serves as a source of micronutrients and maintains the population of microorganisms (Assad). Jehan, 2019; and. In rare circumstances, the absence of inoculum may also lead to reactor failure (Asante-Sackey et al., 2018). Using an inoculum to produce biogas has a number of benefits. The first microbial population is first provided by it (Senes-Guerrero et al., 2018). It is then digested together with the substrate. will accelerate the formation of inoculum and your ability to perform aerobic digestion (Dennis, 2015). Additionally, it aids in reducing the inoculum, or the initial microbial community. stabilizes the digestor (U et al., 2014). possesses the necessary buffering capacity and the process (Horvath et al., 2016). (U et al., 2014). Its enzymatic activity and nutrition are the inoculum's most crucial features (U et Al., 2014). Microorganisms influence the enzymatic activity throughout the digestion process because they create enzymes (U et al., 2014). The chosen inoculum must be fresh, homogenous, and include a wide variety of microorganisms to provide appropriate microbial activity (Vrieze at al., 2015). A high biogas production may result from increased enzymatic activity. The most common inoculum utilized in the generation of biogas is often animal manure and wastewater sludge (Senses et al., 2019). Sludge is frequently brought on by an inoculum's homogeneity and availability (Raposo et al., 2006). However, when using animal manure as an inoculum Waste sludge, biogas output is high and steady (Assad and Zeeshan, 2019). The effectiveness of microorganic enzymes in degrading organic materials may be the cause of varying biogas production from various inoculums. (U et al., 2014). One element that influences the activity of bacteria is their adaption to layers (U et al.,2014). The microbe may adapt to the substrate more quickly the more active it is. Secondly, the population's origin affects how well the microbes adapt to the substrate (Vrieze et al., 2015). Its richness in micro- and macronutrients is another crucial aspect of inoculum that boosts biogas generation (NREL, 2017). For instance, inoculum aids in the provision of nutrients similar to nitrogen in strata with low nutritional content.

4.7 Geothermal Energy

Geothermal power is a renewable, long-term energy source, but it presents its own set of challenges. These challenges include limited resources, limited suitable geographical area, transmission loss, and the potential for depletion of steam resources from underground wells. Geothermal energy resides below the surface of the surface, but humans cannot use all the energy. Only a tiny percent of the land is above suitable water and steam pockets that can heat a house or a power plant, limiting the possibility of setting up a power plant. Many ideas to supply large amounts of geothermal energy humans can convert to electricity are in exceptionally tectonically active areas. Corporations are reluctant to set up large-scale power generation facilities when there is a constant risk of earthquakes or volcanic activity.

4.8 Atomic Energy

Occasionally, the general public perceives commercial nuclear power as unstable or hazardous. This impression is frequently centered on the three worldwide nuclear mishaps, its erroneous association with nuclear weapons, and how it is depicted in well-liked television programs and motion pictures. The DOE and its national labs are collaborating with business to develop new reactors and fuels that will expand the sector as a whole. The effectiveness and volume of nuclear waste created are decreased by these methods. The DOE also aims to give reliable, factual content about nuclear energy through its social networking sites other STEM outreach initiatives in order to inform the public about the significance of nuclear energy.

4.9 Future of Renewable Energy

Renewable energy (RE) consists of (direct) energy from the sun, commonly called solar, biomass, wind, tides, geothermal and hydro. The donation of these resources will determine how much of each renewable energy source can be used in a country. Bangladesh, for example, has no geothermal potential, and its hydropower potential, primarily based on altitude, is small. The tide is a new energy source that has yet to achieve commercialization. Thus it leaves solar, wind, and biomass as the only current alternatives. Regards g biomass, the main problem is the high demand for agricultural and animal waste for cooking in rural areas.

Furthermore, the extraction of non-sustainable excessive organic matter can lead to soil erosion. However, there is significant potential through the bio-gasification route, but it requires careful planning and management of biological resources. In the case of Bangladesh, the main barriers to organic matter are; That price is high, and hard to collect in large quantities, so expensive. Air has always been a problematic resource to evaluate in the context of Bangladesh. A group of experts thinks the potential poster country, mainly on the coast, is limited. From the aforementioned discussion of the current domestic and global energy situation, biomass may draw the conclusion that Bangladesh's power sector faces a significant challenge to meet its future energy demand, particularly given the potential decline in fossil fuel reserves over the next ten years. Additionally, the nation's self-sufficiency rating is lower than 0.2, showing reliance on outside resources. Bangladesh must thus take a more comprehensive approach in order to satisfy its future energy demands, taking into account factors such as the locally accessible energy resources, geological position, and political ties with neighbors. In instance, hydropower production and solar energy gathering have lower Leveled Costs of Electricity (LCOE) than other traditional energy sources, making them more appealing to Bangladesh. Solar panel costs have decreased dramatically in fact today. Therefore, the energy nation should amend the current energy policy tariff (FIT) scheme. In order to draw investors and encourage the construction of large-scale solar power facilities in Bangladesh, the government should also offer incentives for solar energy companies. In addition to making the most of its hydroelectric resources, Bangladesh might work with its neighbors (India, Nepal, Bhutan, and Myanmar) to increase hydropower imports to fulfill local demand at reduced costs. Through the Bheramera-Bahrampur grid link, Bangladesh currently imports 660 MW of energy from India. Bangladesh also plans to negotiate with Myanmar to purchase an additional 500 MW of hydropower. However, it is important to make the most of local resources. Bangladesh has to hold multilateral discussions with its neighbors over hydropower. Bangladesh may use imported LNG and coal as alternative fuels in addition to renewable energy to lower the cost of electricity generation.

4.10 Solar Energy

The most prominent renewable energy source in Bangladesh is solar energy, which has an average of 4.5 KW / m2 solar radiation. But the challenge is the lack of land in this densely populated country due to agriculture, industry, and long-term land use. For example, outlines of 100% electricity access are at risk to man. Due to the contrast between the nature of the land and the cost, remote areas are inaccessible to grid expansion. In this situation, the introduction of a solar home system gives hope. Already 248 MW has been installed from 5.8 million solar-home units across Bangladesh. People in remote areas are encouraged to take advantage of this as costs gradually decrease. IDCOL and SREDA mainly support solar home systems in rural areas. In addition to solar home systems, solar energy use initiatives and opportunities include solar parks, solar rooftop PV pans with and without net metering, solar mini, micro, and nano grid, solar water heating systems, solar irrigation, and solar water

pumps. Solar roof PV panels can also be a triggering way to increase RE usage in land scarcity. PV panels have been asked to be installed on the roofs of commercial and residential buildings and open spaces in industrial areasPower consumption. It has been enacted as a law to install PV panels on the roof with at least 20% of the total approval. Load when you get a new connection. Net metering has been introduced in recent years to facilitate this initiative. In this system,m customers can supply surplus power to them. The grid pays for the generation of solar rooftop panels and the distribution utility at the bulk rate, which is settled at the end of the year. Net imports are taken as usage Consumers, and net exports are carried in favor of consumption next month. Consumers get a salary if net electricity is exported at the end of the financial year. This Inceptive encourages commercial and industrial areas much more than ever before and increases the likelihood of using more solar radiation. Thus, consumers are now considered producers, a mixture of consumer and producer. One hundred and nine units of 39.5 MW rooftop solar PV panel without net metering and 129 MW, 878 units with a net Metering, are currently contributing to the mix of generations in the country. Further implementation will contribute to sustainable growth in this system. Solar rooftop system is effective in municipal areas. The theme of the power supply directly to the grid without using a battery backup. The solar panel is a solar park. This initiative can be traced back to the unused open spaces of government and non-government organizations, which are inaccessible for agricultural Use. This initiative will ensure efficient land use and

contribute to green energy production. Four solar parks supplying 36.4 MW of power have been set up at Cox's Bazar, Rangamati, Panchagarh, and Jamalpur. More than 11 units are under construction with 14 planned units. Irrigation pumps draw significant electricity from the grid, limiting this cost to seasonal Use. Since agriculture is the leading and most necessary sector, We need to ensure this Use in our country, but use this kind of season The burden of the grid. In addition, remote areas need to be covered by grids for such access. Solar Ground breaking option for an irrigation pump. 43% of total expenditure on agriculture is due to diesel or electric-driven irrigation pumps. Installing solar irrigation pumps must be considered a one-time capital investment, although production will reduce such costs. It will also contribute to the reduction of CO2 emissions percentage. Moreover, it is expected. This will reduce the demand for about 150 MW from the grid. CSolarirrigation pumps supply 1271 units to 35 MW of off-grid electricity across the country. More Upcoming projects will further contribute to this initiative. IDCOL financially supports these. Solar mini-grids, micro-grids, and nano-grids are new solar-use concepts. Radiation These grids are isolated from the solar park. In that sense, National grids have been installed to support electricity access in remote areas. The cost of national grid construction will not be cost-effective. Smaller areas are selected Under a particular mini or micro grid, and energy is generated and distributed to Habitat in that area. This installation brings efficient and significant change to the Lifestyle and development of remote areas. There are currently 21 solar mini-grids and two nano-grids, a Contribution of 4.5 MW of power. 650 kWp solar mini-grid in Shula, Sunamganj, is the largest mini-grid in South Asia. IDCOL maintains this grid. A further 1.1 MW from 6 units is under implantation shortly.

4.11 Wind

As of 2014, all studies conducted in Bangladesh have concluded that we do not have good prospects for wind power. But more recently, a study by the National Renewable Energy Laboratory (NREL), supported by the Department of Power, Bangladesh, has changed that perspective. This is because research has been done at an average altitude of 20-30 meters above sea level. But a recent study has been done at an altitude of 80 meters. They have noticed that the wind speed here increases with altitude.

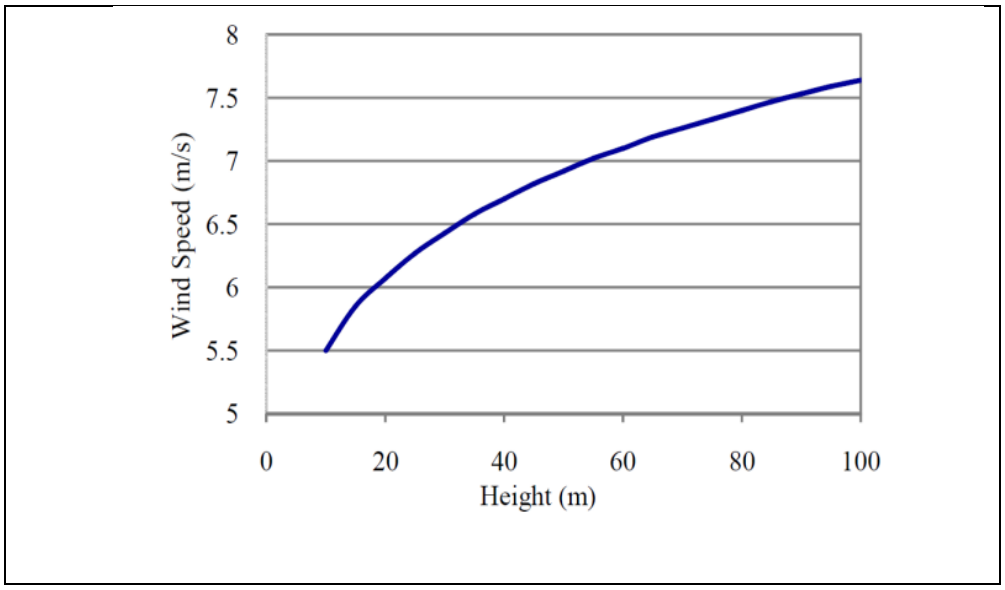


Figure 4.1: Variation of Wind Speed with Height [Hossain, M.A., and Ahmed, M.R., 2013. Present energy scenario and potentiality of wind energy in Bangladesh. World Academy of Science, Engineering and Technology, 7(11), pp.1001-1005]

Moreover, the most important reason to think about wind power is that technology has improved tremendously in the last ten years. Therefore, a wind speed is required to produce that 28 Electricity was not technically efficient then, but new technologies can generate electricity. The government has generated 1360 MW of electricity from wind resources. The government has already completed the mapping of wind resources and launched some mega projects to implement this initiative. The figure above shows the mapping of recent wind resources in Bangladesh operated by USAID at an altitude of 120 meters.

4.12 Hydropower

Hydropower is the most naturally accessible renewable energy. About 26% of global energy comes from hydropower plants. But it is a pity that we haveLittle chance for this source. We have already installed 230 MW of hydropower in Kaptai. Suitable sites for dam construction and water conservation have not yet been found. Robust surveys have not yet been conducted and due to the tribal areas are cunning Safety concerns and transportation. There is no shortage of hilly rivers in Bangladesh, which are fading. Opportunity for hydropower system. Five sites along the Sango River have been identified as potential for a tun-off-river hydro plant. But the cost of building a grid to relocate residents makes such alternatives ineffective. There are opportunities to cooperate with countries like Nepal and Myanmar, which have river water suitable for hydro plants, mutual investment, and Importing electricity from these countries. This will require foreign policy and bureaucrats to come to action, political well-being, and engagement. That's what the Bangladeshi people demand from their government since it is in their country's best interests.

4.13 Biomass Power

As the population grows, so does our food demand, new technologies are being introduced in the agricultural sector to meet this growing demand. This initiative is also making fertile lands fertile. Thus food production is increasing, increasing the number of agricultural residues [9]. On the other hand, the number of farms is also increasing to meet the increasing demand for meat, eggs, fish, etc., which will create a tremendous amount of animal waste. With proper planning, we can generate electricity using this extra waste. The Government of Bangladesh is also seriously considering this opportunity. The Ministry of Fisheries and Livestock has adopted a plan to develop and utilize this opportunity under the "Livestock and Poultry Research, Development and Expansion Plan-2021" under Bangladesh Livestock.

Research Institute.

4.14 Biogas Power

The large volume and variety of projects registered on this energy in the most recent quarter, as compiled in the OEPM Biomass Technology Watch Bulletin, indicate that this is good energy with the potential for commercial and industrial growth. Among the businesses featured in the last Biogas Patent Bulletin were Air Liquide (FR), Abengoa Bioenerg, IA and CIC Nanogune (ES), Saipem (IT), Ecolab (US), Praj Industries and Atmos Power. (IN), Liquor Labs (CA), Song Zhijuan (CN), King Faisal University (SA), or Kawasaki Heavy (JP). Anaerobic digestion reactors, recycling and storage systems, fermenters, oxidation and liquefaction plants, biogas liquefaction facilities, ways of producing ethanol from dates or milk, microorganisms to enhance nitrogen utilization in ethanol production and gasification.

4.15 Geothermal Energy

Unpredictability in countries is one of the biggest hurdles to geothermal energy Exploration. Active volcanoes are still not credible, mainly because the extremely capital intensive and risky search stage is probably why neighboring countries noises. The world prefers a more established renewable subject .ray currently, resources like solar, wind, and hydropower. But many are interested in geothermal energy Co countries have gained momentum in the last few years Technology has improved tremendously over the decad.es. Introduce improved binary cycle plants Geothermal system (EG; S) Howe. Ever ethereal are no better alternatives for Bangladesh than coal, nuclear and solar energy. Power generation can use geothermal energy. This will help the country's energy sector in the long run provide as a virtually inexhaustible source of energy, Available all year round. But for him Occurs, interdisciplinary research and development the country has to implement the project. Distinguished University and institutes should be encouraged and funded for research, not just geological aspects. Engineering aspects of geothermal energy Fo,r example, generate electricity through exhaust t Ex, tended conversion efficiency external resources to ensure small size use and durability Production from geothermal resources.

4.16 Atomic energy

In collaboration with the Russian nuclear energy corporation Rosatom, the Bangladesh government has started generating nuclear power within a few months. The journey started in 1961 and is now in the final stages of starting at Rooppur in Pabna district. While the country's endeavor is admirable, there are some severe issues, as nuclear power generating is a particular threat. With the constant threat of natural disasters throughout the year, the country's economic potential and dense population can be positively managed as neighboring countries like India and Pakistan operate 22 and 4 reactors respectively. Nonetheless, a successful nuclear program is highly desirable for a comprehensive structure involving a wide range of structures, including the provision of nuclear facilities, a pool of capable human resources, facilities, investigative agencies, and administrative facilities, government departments with nuclear capabilities, and directive agencies to implement disaster response programs Bangladesh. A strong legal framework with the experience of nuclear superpowers such as the United States, Russia, China and Japan can ensure the success of such a program. There is no authentic and reliable information about this initiative in the public domain. Bangladesh Nuclear Power Company was established under the Nuclear Power Plants Act 2015. Although some general provisions regarding risks and security under the Bangladesh Atomic Energy Control Act, 2012, there is still no comprehensive law to deal with risks, security, and so on. Potential liabilities arising from nuclear power plants have been accepted. With these hazards and security issues in mind, Bangladesh must also examine the prospect of terrorist groups hacking nuclear power plant cyber systems and attempting cyber-attacks on nuclear power plants in order to get atomic weapons.

CHAPTER 5

Conclusion

For the next 20 years, Bangladesh's proven natural gas reserves of 34 TCF will power the nation, and 82 percent of natural gas is now utilized in the power industry. Renewable energy sources produce just 3% of the world's power. However, the Bangladeshi government has already unveiled a master plan for future power generation in response to the sharp rise in electricity consumption. In order to further grow the power industry and restructure renewable energy supplies, this plan places a strong emphasis on exploring and discovering the nation's natural resources. Bangladesh, however, need more modern research facilities. Renewable energy is a possible replacement for conventional energy produced from fossil fuels. Due to financial and environmental factors, using renewable energy sources like solar, biofuels, geothermal, and wind is becoming more popular. The Bangladeshi government has made considerable efforts and ambitions to establish a number of renewable energy projects, which it also finances. The results' conclusion takes into account the following factors:

Installing a solar power system has a number of drawbacks, the most significant of which is the high cost of the semiconductor materials needed in its construction.

Compared to non-renewable energy sources, solar energy is more expensive. Solar energy is becoming more affordable as energy shortages grow more prevalent.

For solar panels to operate at a respectable efficiency level, a sizable installation area is necessary. The location of the sun also affects how well the system works, however this issue may be fixed by installing particular components. Pollution in the air or clouds has an impact on solar energy generation. That evening, no solar electricity will be produced; however, a battery backup system will address this issue. During the wet season, there will be less sun energy. Solar power generation has, however, undergone a stealthy revolution similar to other renewable energy sources. Bangladesh. As a sustainable energy source, solar PV electricity is now employed for residential lights. However, it began in Bangladesh's metropolitan regions off the grid 40 years ago with primitive illumination. Applications using grid hybrid systems are growing daily. Bangladesh offers great potential for the solar energy industry. The Bangladeshi government should take the required actions to inspire consumers and business attractors.

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