



**2<sup>nd</sup> Foundation Training Course**  
**Bangladesh Power Management Institute**

**Research on:**

**Prospects and Challenges of Renewable Energy  
Development in Bangladesh**

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## **Summary**

Energy prerequisite is obstructing the socio-economic and industrial improvement of Bangladesh. Global energy demand has risen sharply over the years with developing countries recording the greatest share in this trend. Hurry of acquiring sustainable development and holding climate change has put renewable energy into sharp focus globally. Acceptance of the United Nation's 2030 Agenda for Sustainable Development, and in particular Sustainable Development Goal –No. Seven has led to a global consensus that the share of renewable energy in the global energy mix need to be significantly increased. As per the Paris Agreement, Keeping global temperature rise below two degree centigrade and increasing the share of renewable energy in the energy mix as renewable energy emits also calls for no greenhouse gas on a net basis.

Considering recent times, the uses of renewable energy has risen immensely. Renewable Energy Policy of Bangladesh targets to achieve 10 % of electricity from renewable resources by 2020. To date, total installed capacity of renewable power in Bangladesh stands at around 631 MW comprising less than 3% share of total electricity generation, which falls far short of its target of two thousand MW. This paper summarises the current renewable energy situation of Bangladesh power sector and examines the available renewable energy resources and their future prospect and the challenges. Finally, some suggestions have been made to tackle the ongoing energy crisis in the country, in addition to the renewable energy & how we can overcome these challenges.

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# **CHAPTER 1**

## Introduction

## **1. Introduction:**

Today's energy requirement increasing in trend due to population growth, economic and technological advancement. The act of making various modern technology would result in significant energy security and economic benefits in Bangladesh. It creates a broad aspect for deploying Renewable Energy. Renewable energy in Bangladesh refers to the use of renewable energy to generate electricity in Bangladesh. The current renewable energy comes from biogas that is originated from biomass, hydro power, solar and wind. Also these renewable energy resources are free from environmental pollution. Wind, solar, bio-mass, geothermal, tidal, hydro energy have taken on a greater sense of urgency, especially in developing countries.

Bangladesh has a long legacy in the field of Renewable energy, which started back in 1957 with the start of construction of Country's first Hydroelectric project on Karnaphully river at Kaptai, Chittagong. In October 1988 the fourth and fifth generating units, both 50 MW Kaplan-type turbines, were installed which raised the total generation capacity to 230 MW. In the mid of 80's initiative of private sector played an instrumental role to install the 1st Solar Home System (SHS) with the single installation of a home system at Sylhet. Since the introduction of SHS in 1996, it has become now the biggest renewable energy program in the world, so far installed 4.5 million units and ever increasing its number due to an integrated program undertaken by the government through its financial institution IDCOL.

This Solar Home System (SHS) is a robust and reliable system and it owes much of its success to a unique rural credit and 'cost buy down' system that it employs to improve access by rural households.

Several fiscal incentives have been extended by the government to Renewable Energy project developers and investors. Dedicated funding support has also been extended through government financial institutions like Bangladesh Bank and IDCOL, as well as through private commercial banks. Moreover, government has extended fiscal incentives including duty exemption on certain renewable energy products, e.g. solar panel, solar panel manufacturing accessories, Charge Controller, Inverter, LED light, solar operated light and wind power plant.

Encouraged by the success of SHS, government has initiated number of programs like, Solar Irrigation, Solar Mini/Micro-grid, Solar Park, Solar Roof-top and so on. The main focus of RE is to provide electricity to the rural areas and to reduce the dependency on diesel, so as to reduce the carbon emission.



**Fig 1. Installing PV cell at a house in a rural area.**

The government of Bangladesh has also created Sustainable and Renewable Energy Development Authority (SREDA) to implement and disseminate the idea and efficient technology including utilization of RE at rural and urban areas of Bangladesh through scores of programs. The power division has published programs, action plans and subsequent master plan in this regard to promote the adoption of Green Energy and energy efficiency programs for demand side management. The government, however, is committed to provide electricity to all citizens by 2021 at a reasonable and affordable price. So, this program is placing as priority on developing Renewable Energy resources considering the development of off grid electrification program at all level as forty percent of the people of the country live in remote areas which are far away from existing grid line and sometime isolated from the main land. Under the above circumstance, the government has undertaken five hundred Mega-Watt Solar mission and prospects of wind and hydro which are also under pipeline program. In addition, the government has planned to save fifteen percent of energy by 2020 through implementation of action plan for energy efficiency and conservation and subsequently twenty percent by 2030 at different sectors of power consumption. As solar is the most dispersed form of energy offering wide range of applications using commercially available technologies, the government has taken proper steps to include solar home system, solar irrigation, solar mini grid, rooftop solar. Floating Solar is also a burning issue for developing country like Bangladesh. Rooftop solar opens up opportunities for industrial as well as residential consumer to utilize their idle roof spaces for sizable solar power generation at ease with minimum maintenance. By Introducing green energy we may draw attention much foreign investors.

## **CHAPTER 2**

### **Methodology**

Due to Covid-19 situation and time constraints, we can't go outside for data collection. Basically, we have studied several research paper on renewable energy and tried to extract main essence from it. We also studied many contents regarding renewable energy prospect from Wikipedia, SREDA website, IRENA website and we collected data as well as information from these source. Our honourable supervisor also provided us some valuable research findings and govt. initiative to promote RE in Bangladesh. So this paper is based on study outcome.

## **CHAPTER 3**

### Renewable Energy Overview: Bangladesh

### 3. Renewable Energy Scenario in Bangladesh:

The looming energy crisis, heightened by the continuing depletion of fossil fuels, accentuates the need for deployment of renewable energy resources in Bangladesh, now more than ever before. Though hydrocarbon resources in the country are limited, the substantial availability of renewable energy sources in the form of solar, biomass, hydropower and wind energy offers opportunities of sustainable energy based development.. Previously the renewable energy sources in Bangladesh are only a Hydro Power Station in Kaptai, Rangamati and stand-alone Solar Home System (SHS) in rural areas. But in the last few years, a number of projects to produce electricity from renewable energy have been successfully completed and a lot of projects are ongoing.

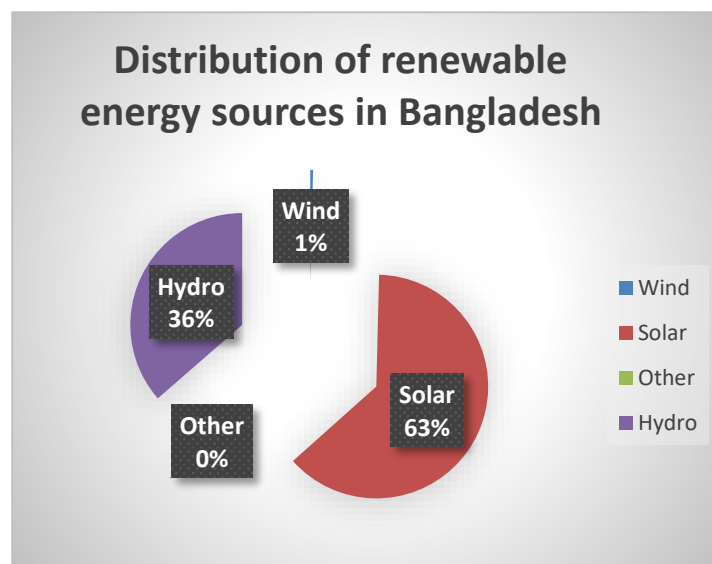


Fig 3.1: present renewable energy condition in Bangladesh. (source: sreda.gov.bd)

#### 3.1.Solar:

In Bangladesh major portion of the renewable energy comes from solar. The long term average sunshine data indicates that the period of bright sunshine hours in the coastal regions of Bangladesh varies from 3 to 11 hours daily. [Mohammad Aslam Uqaili; KhanjiHarijan (2011). Energy, Environment and Sustainable Development. Springer. p. 19]. The insolation in Bangladesh varies from 3.8 kWh/m<sup>2</sup>/day to 6.4 kWh/m<sup>2</sup>/day at an average of 5 kWh/m<sup>2</sup>/day. These indicate that there are good prospects for solar thermal and photovoltaic application in the country.[ Tom P. Hough (2006). Solar Energy: New Research. Nova Publishers. p. 309.]In Bangladesh, solar energy turned into electricity using mainly from SHS, grid tied Solar PV power Plant, Solar Mini-grid etc. The total generated electricity from Solar energy is 397.03MW from which On-grid portion is 80.93 MW and the rest 316.1 MW is Off grid. (<http://www.renewableenergy.gov.bd>)

### **3.1.1.Solar Home System:**

With an estimated 40% of the population in Bangladesh having no access to electricity, the government introduced a scheme known as solar home systems (SHS) to provide electricity to households with no grid access.[Wikipedia]

Dissemination of solar home systems (SHSs) is being promoted mainly by IDCOL, private sector companies and NGOs based on the direct-sale approach and provision of refinancing funds for micro-financing of SHSs to participating organizations (mostly NGOs) through IDCOL.(<https://www.energypedia.info>)

Up to January 2019, about 4.13 million SHSs have been installed under the program in the remote areas where electrification through grid expansion is challenging and costly. Thus the program has ensured supply of solar electricity to 18 million people i.e. 12% of the country's total population who previously used kerosene lamps for lighting purpose. IDCOL has a target to finance 6 million SHS by 2021 with an estimated generation capacity of 220 MW of electricity. At present, 56 Partner Organizations (PO) are implementing the program. IDCOL provides grant and soft loans as well as necessary technical assistance to the POs. POs select customers, extend loan, install the systems, and provide after sale service. IDCOL's total investment under the program is BDT 52,240 million (USD 696 million) out of which loan USD 600 million and grant USD 96 million. The program has so far saved consumption of 1.14 million tons of kerosene worth USD 411 million approx. In addition, in the next 15 years already installed 4.1 million SHS will save consumption of another 3.6 million tons of kerosene worth USD 1,300 million. Moreover, around 75,000 people are directly or indirectly involved with the program. ([www.idcol.org](http://www.idcol.org)). The World Bank has called it "the fastest growing solar home system program in the world.[ Xinhua News Agency (5 November 2014)]

### **3.1.2.Grid Tied Solar PV plant:**

For generating large scale electricity from solar energy, multiple solar panels are wired together to form array. This array of a photovoltaic or PV system, produces direct current (DC) power which fluctuates with the sunlight's intensity. For practical use this usually requires conversion to certain desired voltages or alternating current (AC) through the use of inverters. An inverter tied to this PV system, ensures supplying the power at desired voltage, desired frequency and phase angle. The whole arrangement is commonly known as Solar PV plant or Solar Park. At present there are 4 Grid tied Solar PV plant in operation and a couple of projects are ongoing. (<http://www.sreda.gov.bd>). 3 MW Grid-connected PV Power Plant at Sharishabari, Jamalpur is the first grid connected solar park of Bangladesh. It is in operation since 14<sup>th</sup> July 2017. 20MW (AC) Solar Park by Joules Power Limited (JPL) is the largest one, which is situated in tekna, Cox's bazar. ([www.renewableenergy.gov.bd](http://www.renewableenergy.gov.bd))

### 3.1.3.Solar Mini grid:

Solar PV based mini-grid projects are installed in remote areas of the country where possibility of grid expansion is remote in near future. These projects provide grid quality electricity to households and small commercial users and thereby encourage commercial activities in the project areas. A joint initiative of the United Nations Development Programme (UNDP), the Global Environment Facility (GEF) and the Sustainable and Renewable Energy Development Authority (SREDA) at the Ministry of Power, Energy and Mineral Resource has been successful in bringing electricity to 1,199 households in Monpura island in Bangladesh through two solar power mini-grids. In addition, the 684 shops and 41 institutions on the island are now able to generate new opportunities for jobs and livelihoods. The island's only source of electricity used to be generators which ran for six hours a day. Expanding the national grid to the remote island located in the estuary of the Meghna river was an exceptionally challenging and expensive option. [([www.undp.org](http://www.undp.org) posted on 28<sup>th</sup> may 2020)]. So far IDCOL financed installation of 26 solar mini-grids with cumulative generation capacity of 5 MW. The mini-grid projects have successfully created access to low-emission electricity for approximately 16,000 beneficiaries in rural Bangladesh. They are also contributing an estimated CO2 reduction of 29,300 tons during the project lifetime. The World Bank, KfW, GPOBA, JICA, USAID, ADB and DFID are financially supporting IDCOL's Solar Mini Grid Project. ([www.idcol.org](http://www.idcol.org))

### 3.1.4. Rooftop Solar:

Being a good recipient of solar irradiation, Bangladesh expects to largely harness solar energy source in order to achieve this target. However, installation one MW of solar power plant requires approximately 3.5~4 acres of land. Therefore, land constraint seems to be a challenge for a densely populated country like Bangladesh. Availability of plenty open rooftops may address the space constraint issue for installing solar panels. The Government of Bangladesh has enacted Net Metering Guideline on August 2018 to encourage the use of vacant spaces and rooftops in solar power generation. Up to July 2019, IDCOL has approved 11 Rooftop Solar Projects of which 4 are already in operation with a cumulative capacity of about 3.07 MW. IDCOL has a target to finance a total capacity of 300 MW by 2022. The remaining projects are expected to come into operation shortly. IDCOL offered a financial scheme for rooftop solar system, which is as below-

Facility	Term Loan
Loan amount	80% of the project cost
Tenor	10 years
Grace period	1 year (principal only)
Repayment	Quarterly
Interest rate	6% p.a. (Fixed for Loan Tenor)

**Table 3.1: Financial scheme for rooftop solar system in Bangladesh .(source: [www.idcol.org](http://www.idcol.org)).**

Dhaka-based renewables developer Joules Power Limited will install Bangladesh's largest industrial solar rooftop – a 3.1 MW system in the Narayanganj district near the capital. The 33,000m<sup>2</sup> array will cover multiple buildings owned by textile company Robintex Group, which will buy the electricity generated by the system from Joules Power under a 20-year rooftop leasing arrangement. Robintex is expected to procure around a third of its power needs from the \$1.7 million solar rooftop, for \$0.077/kWh. The system will be grid connected and eligible for net metering for excess power exported to the grid. Indian company Mahindra Susten will undertake its first PV project in Bangladesh by providing engineering, procurement and construction services on the project.[Pv magazine, published on 17<sup>th</sup> march 2020].

### **3.1.5. Solar Irrigation System:**

Solar based irrigation systems are innovative and environment friendly solution for the agro-based economy of Bangladesh. The program intends to provide irrigation facility to rural off-grid areas. Solar irrigation systems reduce dependency on fossil fuel and demand for electricity from national grid in irrigation seasons. The program also reduces carbon emission and at the same time saves millions in foreign currency. Given the immense potential the program aims to install solar PV-based irrigation systems in areas where there are possibilities to produce three types of crops throughout the year, all the while staying safe from flooding, arsenic contamination and saline water. To work towards this end, IDCOL has now set a target of installing 50,000 solar irrigation pumps by 2025. Up to October 2019, IDCOL has approved 1,630 solar irrigation pumps of which 1,323 are already in operation with a cumulative capacity of about 32 MWp. The remaining pumps are expected to come into operation shortly. The World Bank, KfW, GPOBA, JICA, USAID, ADB and BCCRF are supporting this initiative. ([www.idcol.org](http://www.idcol.org)).

### **3.1.6. Solar street light:**

The Government of Bangladesh has requested the Asian Development Bank and the Islamic Development Bank for co-financing of up to \$300 Million for the implementation of the Bangladesh Power Systems Efficiency Improvement Project (the Project). The project aim is to assist the Government of Bangladesh (GOB) in combating this energy crisis through appropriate candidate subprojects under a loan program. Four Subprojects were selected to be financed under this Loan, some which will improve power supply to the general National power grid network in Bangladesh and public utilities and one sub-project providing “off-grid” or direct sources of power to specific communities. One of these is the proposed “Sub-project 2: Solar LED Street Lighting”, designed to replace 1,000 km of streetlights across the 6 Bangladesh City Corporations (the subproject) (Refer to Map – Figures 1). The subproject cost is estimated to be at approximately USD 37.03 million financing. The Executing Agency

(EA) is the Bangladesh Power Development Board (BPDB), with each City Corporation being Implementing Agencies (IAs). Although land acquisition or resettlement is not expected, there may still be minimal damages to crops/gardens that may result in compensation liabilities. This Land Acquisition and Resettlement Plan for the subproject are associated with the relevant land acquisition and compensation impacts ascribing to the construction of the Solar LED street lights under the Power Efficiency Improvement Project. The Land Acquisition and Resettlement Plan (RP) has been prepared for this subproject in accordance with the provisions set out by the ADB policy on Involuntary Resettlement as embedded in the Safeguards Policy Statement (2009) and the Operations Manuals F1 (2010) and the laws of Bangladesh. The RP is based upon information gathered through field observations conducted in October 2010 and February 2011 and field surveys conducted in February 2011, in consultation with the stakeholders, especially community leaders and affected householders in the alignment zone of influence. [[www.adb.org](http://www.adb.org)]

Dhaka South City Corporation has installed solar panels on 61 street lamp posts from Kakrail to Notre Dame College via Fakirapool to reduce the large dependency on the power grid, under "Solar Photovoltaic-powered LED Street Lighting" project.[ Recent progress on the sustainable energy systems in smart cities, Rehnuma Rifat Chowdhury, 2013]

### **3.2. Wind Power:**

The long term wind flow, especially in the islands and the southern coastal belt of Bangladesh indicate that the average wind speed remains between 3 and 4.5 m/s for the months of March to September and 1.7 to 2.3 for remaining period of the year.[9] There is a good opportunity in island and coastal areas for the application of wind mills for pumping and electrification. But during the summer and monsoon seasons (March to October) there can be very low pressure areas and storm wind speeds 200 to 300 km/h can be expected. Wind turbines have to be strong enough to withstand these high wind speeds.[ CAJ Paulson (2001). Greenhouse Gas Control Technologies: Proceedings of the 5th International Conference on Greenhouse Gas Control Technologies.] In Bangladesh firstever generation of electricity from wind is at Muhuri Dam, Feni having a capacity of 0.9 MW (225 KW, 4 Turbines) and another one at Kutubia Island (20 KW, 50 turbines) with a capacity of 1MW. [[http://www.thewindpower.net/country\\_windfarms\\_en\\_90\\_bangladesh.php](http://www.thewindpower.net/country_windfarms_en_90_bangladesh.php)]. The 2 MW Wind Park in Sirajganj district went into commercial operation on 16 February, 2018. ([www.renewableenergy.gov.bd](http://www.renewableenergy.gov.bd)). Vesta Company of Denmark will invest 100 MW wind power plant which will be made in Patuakhali. This will be the largest wind power plant of Bangladesh [<http://energybangla.com/denmark-will-invest-in-wind-power-plant/>]

### **3.3. Hydro:**

Kaptai Dam is on the Karnaphuli River at Kaptai, 65 kilometres (40 mi) upstream from Chittagong in Rangamati District, Bangladesh. It is an earth-fill embankment dam with a reservoir (known as Kaptai Lake) water storage capacity of 6,477 million cubic metres (5,251,000 acre·ft). The primary purpose of the dam and reservoir was to generate hydroelectric power. Construction was completed in 1962. The generators in the 230 megawatts (310,000 hp) Karnafuli Hydroelectric Power Station were commissioned between 1962 and 1988.[Bari, M Fazlul (2012). "Dam". In Islam, Sirajul; Jamal, Ahmed A. (eds.). Banglapedia: National Encyclopedia of Bangladesh (Second ed.). Asiatic Society of Bangladesh.] It is the only hydroelectric power station in Bangladesh.

### **3.4. Biogas:**

There mainly two types of biogas plants used in Bangladesh, floating dome type and fixed dome type. Bag type plants are also used in the country but rarely.[ Bangladesh Sangbad Sangstha (BSS)". Archived from the original on 2014-01-09. Retrieved 2014-08-23.]

Cattle dung available from 22 million cows and buffaloes is nearly 0.22 million tons. One ton of dung can produce 37 m<sup>3</sup> of biogas. Available cattle dung can produce 2.97 x 10<sup>9</sup> m<sup>3</sup> of gas which is equivalent to 1.52 x 10<sup>6</sup> tons of kerosene or 3.04 x 10<sup>6</sup> tons of coal. Besides, a substantial amount of biogas can be produced from human and other animal excreta, garbage and water hyacinth.([www.energypedia.info](http://www.energypedia.info))

## **CHAPTER 4**

### Renewable Energy Overview: Worldwide

## 4. Worldwide overview of Renewable Energy:

United Nations SDGs acts as guidelines and framework for countries to achieve a sustainable and better environment for everyone on the planet. The SDGs accelerate the steps to be addressed to overcome critical challenges and interconnects every goal for a better future and the UN has fixed the deadline for every member nation to accomplish the goals by 2030 [1]. Goal 12 [2] of the SDGs emphasizes the motto “doing more and better with less,” energy efficiency, sustainable infrastructure, consumption, and production are the key areas that need to be addressed. While goal 7 [3] stresses affordable and clean energy for all, but global nations are facing various blocks in executing this practically. More progress needs to be made and more public and private investments should be made. Moreover, innovative models and regulatory frameworks need to address to achieve this goal.



Fig 4.1 :The 2030 Agenda for Sustainable Development

About 17.5% of total final energy consumption [3] comes from renewable energy while remaining came from conventional sources. This indicates that fossil fuels comprise a major part of energy production which leads to a chain reaction of GHG emissions, global warming, and climate change effects. One of the primary objectives of the Paris agreement is to keep the global temperature rise less than 2 degrees Celsius [3]. It also aims to improve and aid nations in dealing with global climate change. The Agreement was different from its predecessors with its bottom-up approach; INDCs (Intended nationally determined contributions) for making it even more successful [4]. With about 197 countries signed the

Paris agreement as of November 2019, many of them have committed themselves towards the net-zero emission target. The Paris agreement acts as a catalyst in driving.

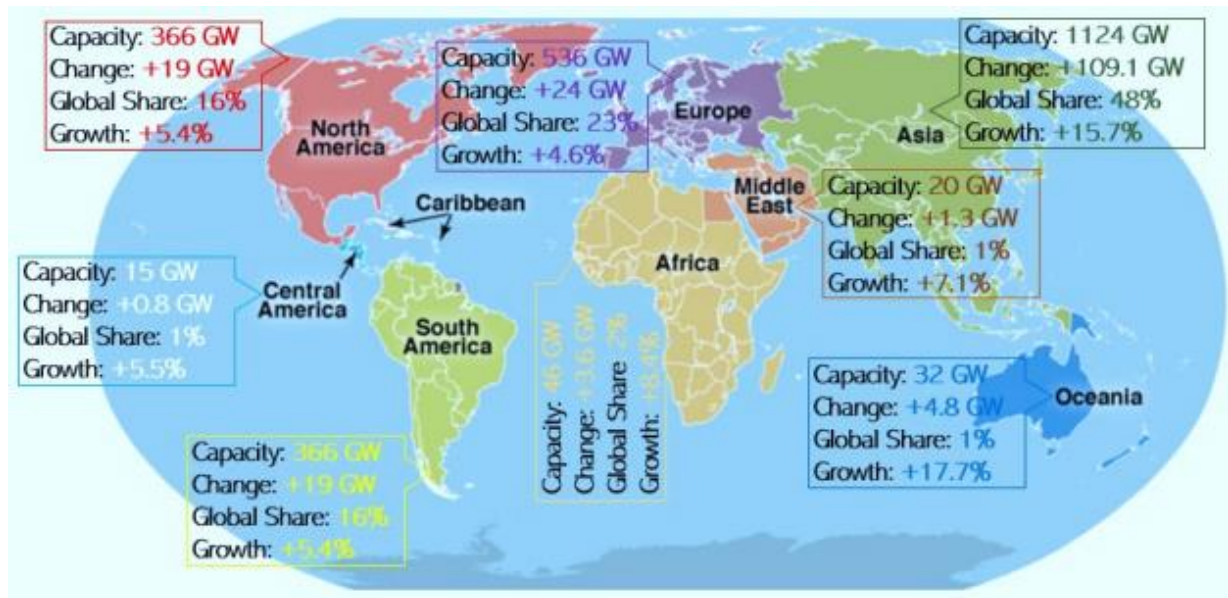


Fig 4.2: Renewable energy generation capacity at the regional level

investments into cleaner energy and economy. India has also committed to reaching 40% of no-fossil fuel electricity by 2030 [4]. With 185 countries ratified the agreement; still, some are pending to ratify it. While the US intends to exit the accord by 2020, China has achieved its 2020 target in 2017 and countries like Sweden, Portugal, France had made the most progress with 77%, 66%, 65% respectively [5].

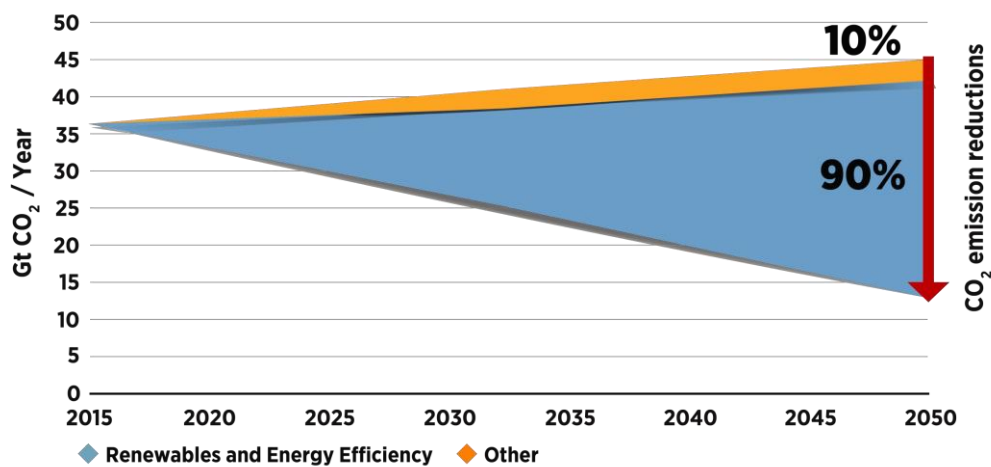
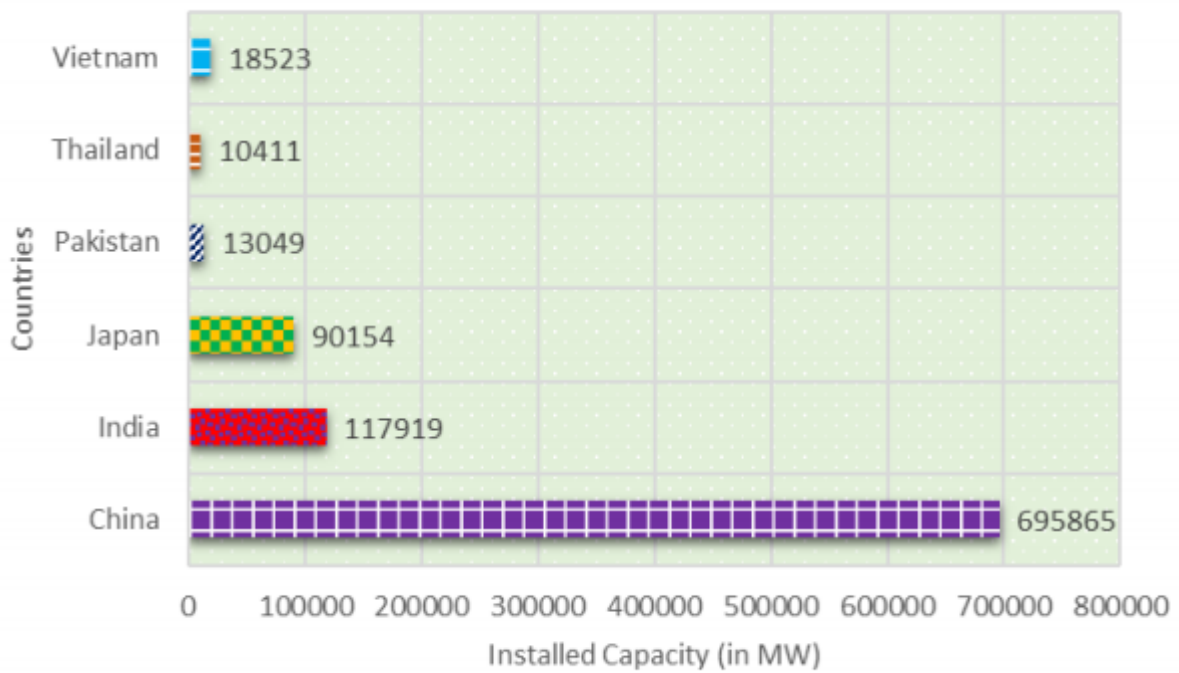


Fig 4.3 : CO<sub>2</sub> Emissions Reduction Potential (Source: IRENA 2019)

Therefore, the emerging interest today is to increase the share of renewables in global energy production to meet the ever-rising demand, reduce global warming and energy costs. Hence, significant initiatives are being taken to develop policies to increase renewable energy penetration into the energy mix, and over time, many countries have developed individual frameworks and policies [5, 6]. In recent years, many policies have been adopted throughout the world in supporting renewable energy integration in the electricity sector such as 61 countries introducing a feed-in tariff (FIT) and the introduction of green certificates or auction systems with Europe leading implementation [5]. By 2017, policies for renewable power had spread to 121 countries.



**Fig 4.4: Total Installed Capacity of Leading RE producing Asian**

Global production of renewable energy is increasing day by day and in 2018; 171 GW renewable energy is integrated into the energy mix with an annual increase of 7.9 per cent by new additions from solar and wind energy [6]. Total RE installed capacity continent wise is shown in Figure 1 in which it is evident that Asia is the leading continent with a global share of 44%.

Among the Asian countries, China leads in renewable energy production followed by India and Japan. Figure 2 shows the Total RE Installed Capacities (in MW) of some of the leading Asian countries. From Figure 5, it is evident that China, the world’s most populous nation and one of the largest renewable energy-producing nations achieving through its enormous potential in solar

## Total Installed capacity (in MW)

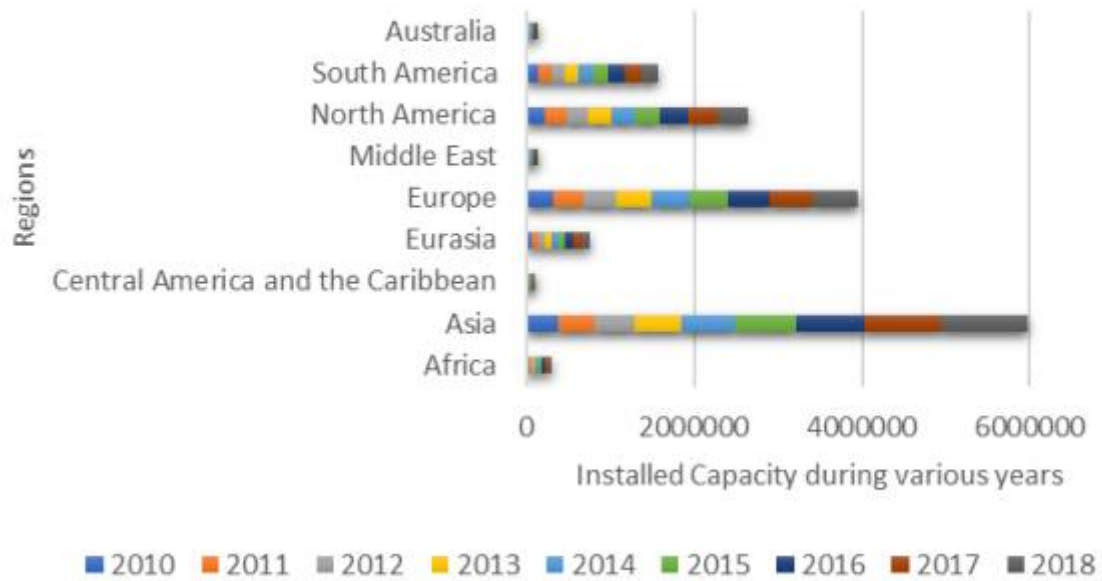


Fig 4.5: Total Renewable Energy Installed Capacity [7]

[8] and installed capacity in hydroelectric and wind energy. As of 2018, it has a RE installed capacity of 695.86 GW which was six times greater than India's total installed RE capacity [9].

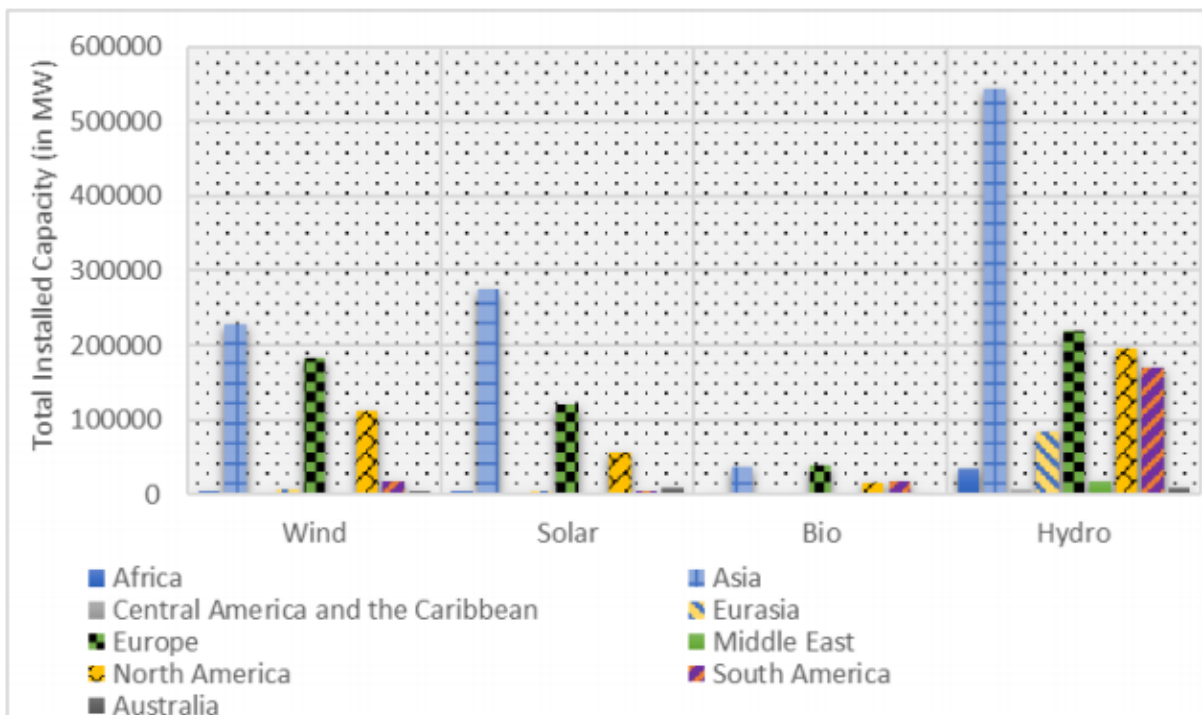
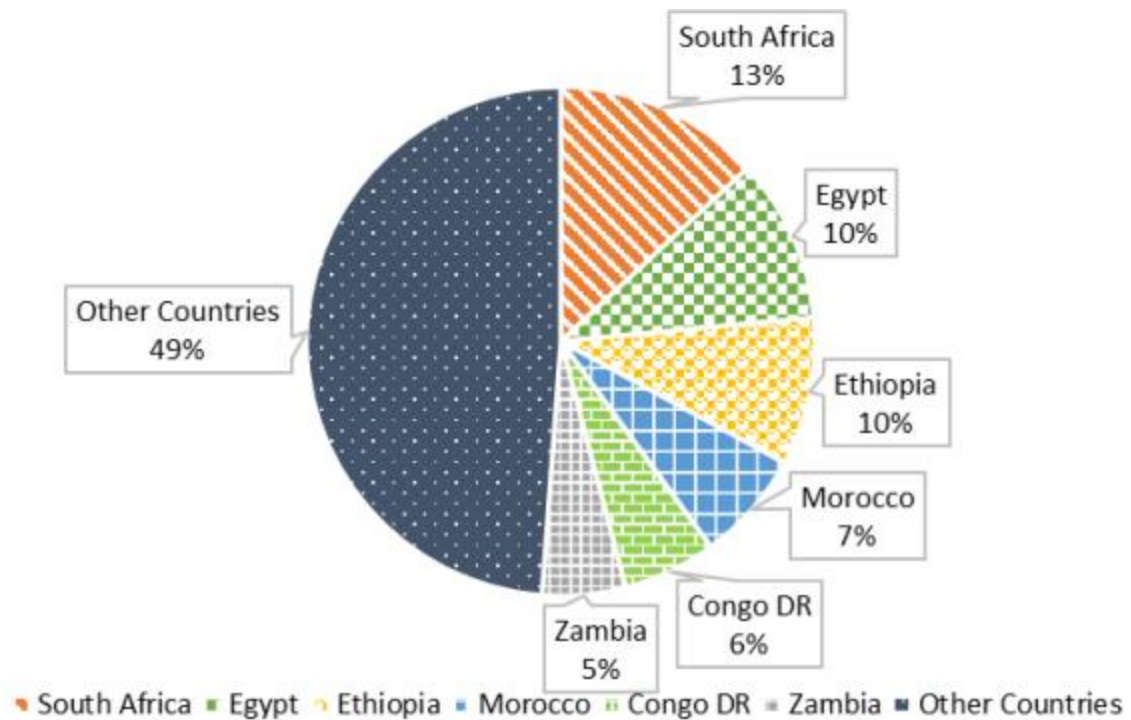


Fig 4.6: Resource-Wise Installed Capacity as of 2018 [7]

In the 13th Renewable energy five-year plan, China had set a target to achieve 680 GW of power generation from renewable energy sources by 2020, with wind energy accounting up to 210 GW [9]. But China at the end of 2018, achieved a total installed capacity of 728 GW, which is a 12% year on year increase in all forms of renewable [10]. The Chinese government is also giving many incentives for local companies to support this development to reduce dependency on other countries [10]. Biomass capacity has been considerably increased in recent years with total installed biomass capacity accounting for about 17.8 GW. Thus, China's new energy policy on self-security for energy takes proactive steps in developing cutting-edge technology in improving the efficiency of plants and delivering quality renewable energy and expansion of its various facilities across the nation. Renewable energy growth in the region from 2010-2018 is shown in Figure 3. Various sources of RE generation in these regions as of 2018 are shown in Figure 4

In the North American Continent, countries like the United States, Canada, Mexico lead in renewable energy production, with the United States pioneering in all fronts with an installed RE capacity of about 245.24 GW as of 2018 [9]. The United States of America stands as the second-highest polluter in the world, with 14.6 % [11] of overall carbon emissions in the world, but it also manages to lead in RE production in the world only behind China. The United States of America has abundant resources and mainly has a greater potential of wind energy and the government is likely to invest resources to increase its total capacity of wind energy to 314 GW [11]. In recent years, interest in solar energy adoption in small scale production has been in rising with the initiative of many private players like Solar City Corporation who tends to play a key role in the wide-scale adoption of solar energy in US households. The share of renewable energy production through the solar, wind, geothermal and hydroelectric are projected to increase considerably in the next decades, with solar PV is projected to constitute about 48% of total renewable energy production followed by wind at 28% and hydroelectric at 18% by the end of 2050 [11]. The hydropower limited since there is a minor possibility of adding new structures. Renewable energy could also become the largest energy source contributing to about 50% by 2030. In Europe, among various countries like Sweden, Finland, Portugal, Denmark, Germany, and France leads the renewable energy production in the continent. Sweden is considered for discussion as it is one of the pioneering countries which lead towards a low-carbon economy with nearly 60% of energy coming from RE sources [12]. It has an installed capacity of about 29.06 GW, according to a report by IRENA(International Renewable Energy Agency) [9]. It is a part of IEA (International Energy Agency) since 1974 and currently, the country has the second-lowest CO<sub>2</sub> emissions in the world [41] and which is about 1/4th of the United States of America [12]. The country was able to achieve this feat only because most of its energy comes from nuclear and hydroelectric power, which is nearly emission-free. Its energy sector underwent huge changes in the production of energy in the last 30 years. Though nuclear and conventional sources make a large part of the country's energy production, hydropower contributes a considerable amount of about 68.6 TWh [13]. It enjoys a huge amount of water resources but still, hydropower expansion remains narrow as part of safeguarding the remaining large rivers. The country has already achieved 50% RE in total energy production way back in 2012 and now it is on track to achieve 100% RE production by 2040 [13].



**Fig 4.7: Total RE Installed Capacity of African countries in 2018**

The total renewable energy installed capacity of the African continent stands at 46269 MW at the end of 2018 [14]. African countries like Ethiopia, Egypt, Morocco, South Africa leads the renewable energy production. RE installed capacities in some of the African countries are shown in Figure 5. South Africa is the pioneer regarding renewable energy production among the African countries, and the National Development Plan 2030 aims to make a decent investment in renewable energy capacity and generation [14]. The White paper on renewable energy (2003) was key in stressing the needs of RE and the need for diverse energy generation mix in the country [14]. The nation has witnessed a rapid increase in recent years from a baseline zero RE capacity in 2010. South Africa Department of Energy (SADOE) has decided based on the new Integrated Resource Plan (IRP) focusing on increasing PV solar panels to reduce coal-fired plants and also not to install new nuclear power plants. Under the Renewable Energy Independent Power Producer Procurement Program (REIPPP), 27 new renewable energy projects have signed which will add about 19400 MW of new generation capacity by 2030 [15]. Many parts in South Africa on average, receives about 2500 hours of clear sunshine throughout the year. The average solar radiation South Africa receives is about 4.5 and 6.5 kWh/m<sup>2</sup> [15]. Currently, Rooftop solar PV installed capacity is about 250 MW [50]. Wind energy generation is also considered from several wind farms like Metrowin Van Stadens (27 MW), Jeffreys Bay (138 MW), Kouga wind farms. It also has a higher potential for biogas production with an estimation potential of 2500 MW of power. Though renewable energy production is acute, the government aims to adopt various RE sources and to gradually reduce coal consumption with an ambitious target of 21.5 GW of RE capacities by 2030. It includes 9200 MW Wind, 8400 MW Solar PV, and 1200 MW of solar CSP(Concentrating Solar Power) capacity.

Bangladesh has fast-tracked its approach in adopting renewable energy, gaining necessary experience from global countries regarding how to accommodate feed-in tariffs, net metering, attracting stakeholders to promote renewable energy, and have adopted national policies. Many states in India have also drafted separate policies for both grid connected and off-grid renewable energy, which will be discussed in later sections.

## **CHAPTER 5**

### Prospects of Renewable Energy in Bangladesh

## 5. Prospects of Renewable Energy in Bangladesh

The energy demand is ever increasing day by day with the increasing population. At present, approximately 97 percent of the total energy demand in Bangladesh is fulfilled by fossil fuel and these conventional energy sources are limited as well as harmful for environment. So for sustainable power generation, utilizing renewable energy source has become mandatory today. Its energy sector suffers from power shortages, increasing demand, decreasing domestic natural gas reserves, and inadequate transmission infrastructure. To meet the current energy demand there is no alternative to renewable energies such as solar, wind, biomass etc besides other existing sources.

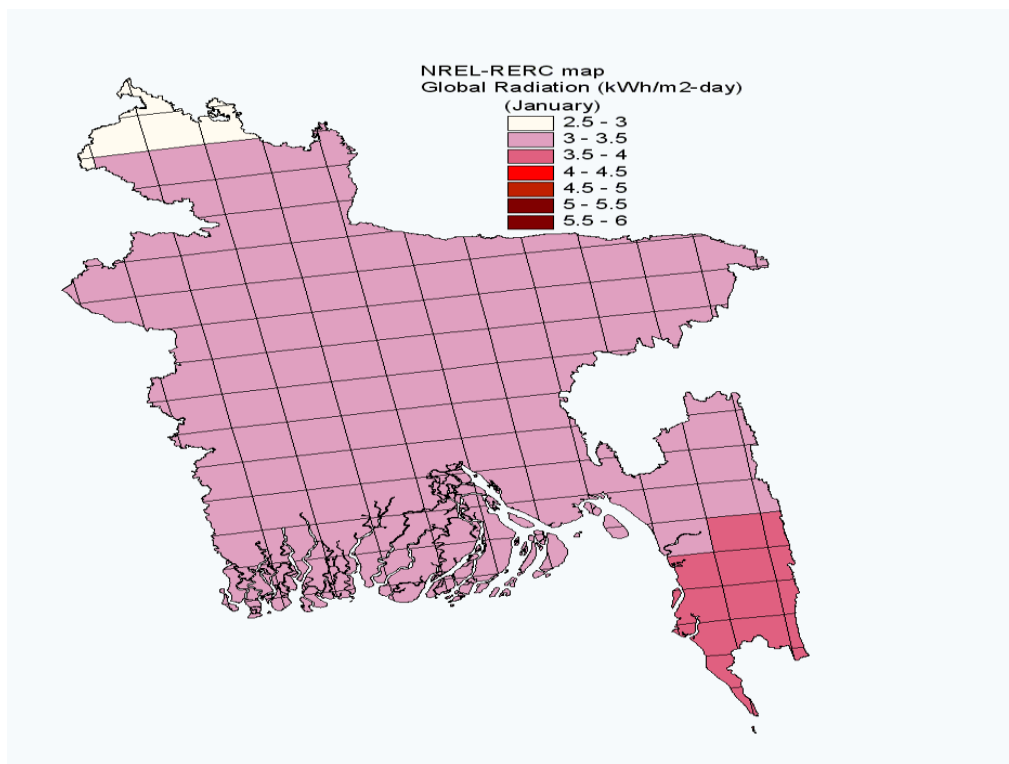
As part of a comprehensive plan to overcome these challenges, Bangladesh has committed that 10% of the total generation capacity will be renewable energy by 2021 (Power Division 2016). The adoption of the United Nation's 2030 Agenda for Sustainable Development, and in particular Sustainable Development Goal 7 (SDG 7) has led to a global consensus that the share of renewable energy in the global energy mix need to be substantially increased. Keeping global temperature rise below 2°C as per the Paris Agreement also calls for increasing the share of renewable energy in the energy mix as renewable energy emits no greenhouse gas on a net basis. SREDA targets to generate 10% of power (that is about 2000 MW) from renewable sources within 2020. Due to covid-19 pandemic, it is anticipated to accomplish less than prospect (around 2177 MW) from renewable technology within 2021 (sourced by [sreda.gov.bd](http://sreda.gov.bd)). However Commendable progression has been compiled in the renewable energy sector in the last few years. At present, 632MW is being generated from renewable energy sources. Solar home system is a success story in Bangladesh and day by day its popularity is increasing in the rural areas, especially in the off-grid regions. Table 3 below shows the progression complied so far in the renewable energy sector in Bangladesh [16].

<b>Technol ogy</b>	<b>On-grid (MW)</b>	<b>Off-grid (MW)</b>	<b>Total (MW)</b>
<b>Solar</b>	80.93	317.01	397.94
<b>Hydro</b>	230	0	230
<b>Wind</b>	0.9	2	2.9
<b>Biomass</b>	0	0.4	0.4
<b>Biogas</b>	0	0.63	0.63
<b>Total</b>	<b>311.83</b>	<b>320.04</b>	<b>631.87</b>

**Table 5.1: Current Renewable Energy Power Generation (2020) (source: [sreda.gov.bd](http://sreda.gov.bd))**

## 5.1. Solar :

Bangladesh is a south Asian country located in between latitudes 20°34' and 26°39' north and longitudes 80°00' and 90°41' east. Therefore, it is an ideal location for solar energy utilization. Also, as it is a subtropical country, 70% of the year sunlight is plentiful [17]. This makes the use of solar panels very effective in Bangladesh. Daily solar radiation is 4-6.5 kWh/m<sup>2</sup> and maximum radiation is generally received in the months of March-April and minimum in December-January. Hence, solar energy can be a viable solution for the power crisis in Bangladesh [18].



**Fig 5.1 : Solar potential map for Bangladesh ( Source- SREDA)**

Also solar energy offers some key qualities like having no waste and emission, resulting no adverse effects on the environment and ideally suited for distributed resource applications [19]. The government has recently taken many steps to address this fact. Concurrently, some Non-government Organization (NGO) is working to provide solar panels to consumers and the price of these panels, at present, is very affordable. As of 2017, Bangladesh has the world's largest Solar Home System (SHS), with about 5 million SHS in the country. The organization leading the charge in developing this technology is Infrastructure Development Company Limited (IDCOL), which has been developing SHS technology for Bangladesh since 2003.

The organization has been producing an estimated 65,000 SHSs per month. Since Bangladesh adopted SHS in 1996, over 30 million people have directly benefited from solar energy, resulting in 100,000 new jobs being created. Bangladesh has over 300 days of sunlight a year, making it a prime destination for solar technology.

Bangladesh has also been investing in solar irrigation pumps. The country plans on replacing the 1.3 million irrigation pumps currently running on diesel with solar, with 631 already been installed as of 2019. It is estimated that replacing all of the diesel water pumps will generate 10,000 megawatts of solar energy. [20]

## 5.2. Hydro-Energy :

Hydroelectricity is a natural renewable source of power and water is utilized for the production of electricity by converting water head into kinetic energy in which the turbine propeller rotated using water flow [21]. In comparison to the world hydroelectricity production rate, Bangladesh has lower sources of hydroelectricity [22] and total hydroelectricity production at the end of 2014 were 879.0 MTOE which is 2.0% increment and lower than the last two years; below the 10 years average of 3.3%. Total consumption of hydroelectricity around the world in 2014 was 406.83% and China was the highest (27.4% of global share) [23]. Whereas in Bangladesh the production capacity of hydroelectricity in 2014 was 230MW and global sharing is very negligible.

Name of the River	Potential of Electrical Energy in MW
Kaptai	100
Shangu	100
Matamuhuri	100
Mohamaya	23-65
Lohajari	4.5

**Table 5.2: Prospect of future hydro-electricity projects in Bangladesh [23]**

## 5.3 Tidal power :

Tidal power is a form of hydropower that converts the energy of tides into electrical power. As tides are more predictable than wind and sunlight, tidal energy can easily be generated from the changing sea levels. Dams or barrages with water turbines can be placed diagonally in a river's mouth or inlets to generate electricity from the motion of tides. The coast of Bangladesh has a tidal rise and fall from 2 to 5 meters. Among these coastal areas, Sandwip, which experiences 5-meter tidal waves, has the best prospect in generating tidal energy. Moreover, according to existing literature, Bangladesh can generate tidal power from these coastal tidal resources by applying low head tidal movements and medium head tidal movements. Low head tidal movements use tides of height from 2 m to 5 m in areas like Khulna, Barisal, Bagerhat, Satkhira and Cox's Bazar regions. In contrast, medium height tidal movements use more than 5 m high tides which are available in Sandwip [20]. So, geothermal can be a great source of energy for electricity generation in Bangladesh.

## **5.4 Ocean wave energy :**

Ocean wave energy is generated directly from waves in oceans. It is another viable type of renewable energy which helps to decrease the harmful emissions of greenhouse gases associated with the generation of power. It has the potential of being a significant source of electricity in Bangladesh. Though the main purpose of ocean wave energy plants is to generate electricity, they can also be used for pumping water, water desalination etc. The oscillating water column method is technically feasible and is becoming economically attractive for this purpose in many countries. This type of wave energy harnessing device is being commissioned by several countries such as the U.K (500 kW), Ireland (3.5 MW), Norway (100 kW) and India (150 kW) etc. Bangladesh has the potential for harnessing ocean wave energy from the Bay of Bengal.

## **5.5. Wind Energy:**

The world is going on fast in the sector of wind renewable energy and a turbine is used to convert wind energy into electricity [24]. Bangladesh produced 900 KW wind power at Muhuri Dam area of Sonagazi in Feni and 1000 KW Wind Battery Hybrid Power Plant at Kutubdia Island; Grameen Shakti, Bangladesh Center for Advanced Studies (BCAS), BRAC, Bangladesh Army, IFRD, Installed total 19.2 KW at different coastal regions of Bangladesh [25]. However, Bangladesh has a world longest coastal belt of around 724 km in the line of Bay of Bengal and electrification from wind turbines in Bangladesh need more techno-economic assessment. However BPDB recently identified 22 sites for wind power generation and onshore Wind Power Plants along the coastline of coastal regions of Bangladesh, moreover BPDB has planned a 50-200 MW wind generations plants Anawara in Chittagong area, 15 MW Wind Power Plant in Muhuri Dam Area of Feni, Mognamaghat of Cox's Bazar, Parky Beach of Anwara in Chittagong, Kepupara of Borguna and Kuakata of Patuakhali [25].

Wind energy is proportional to the cubic velocity of air. Bangladesh has large coastal area ( 47201 sq km covering 19 district) where wind velocity is greater than 2.4 m/s .

$$P_{in} = \frac{1}{2} \rho A V^3$$

Power in the wind,  **$P_{in}$** ,  
 Air density,  **$\rho$**   
 Blade swept area,  **$A$**   
 Wind Speed,  **$V$** .

Wind Power Curve

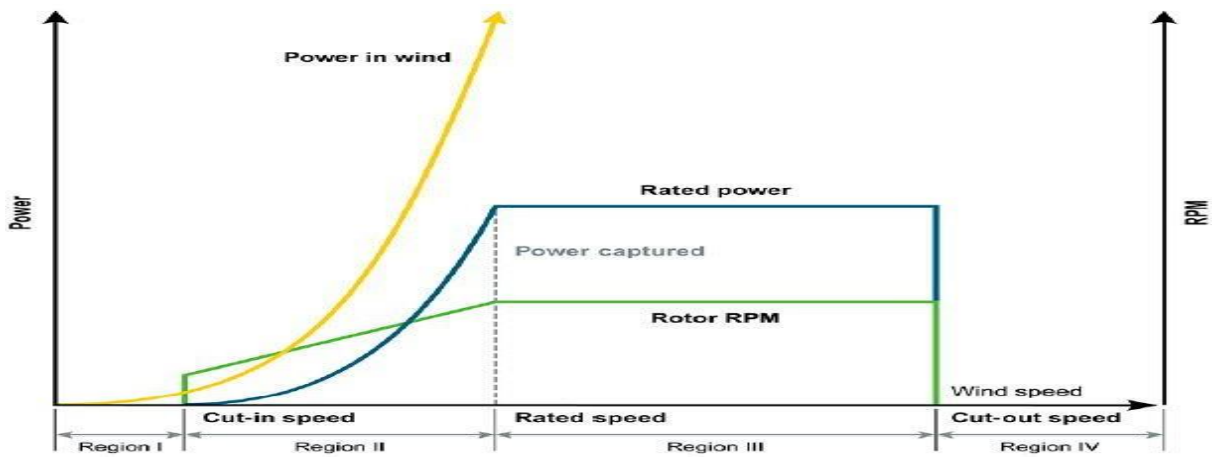
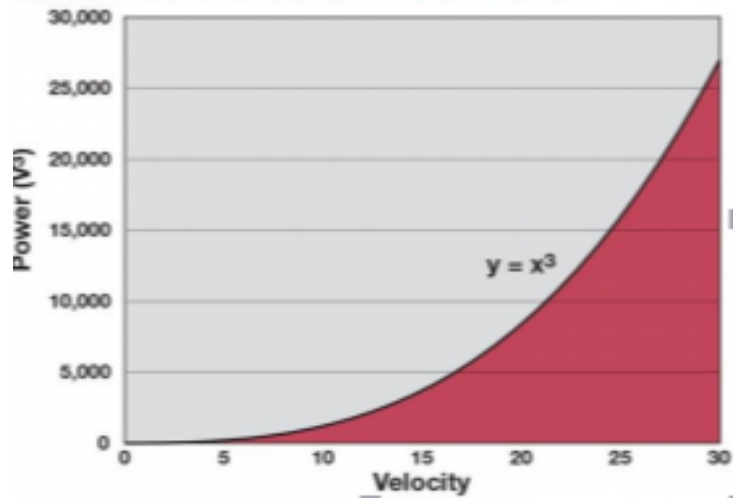


Fig 5.2: Wind Power Generation Basics

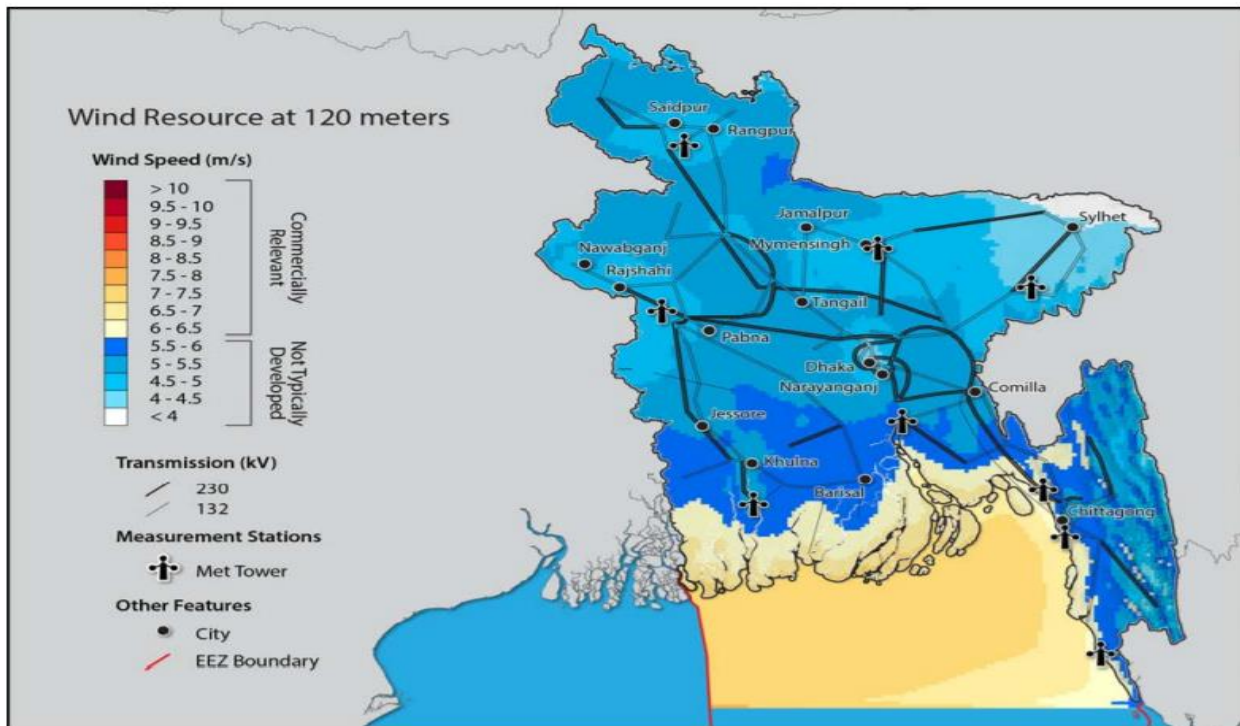
USAID Bangladesh and the U.S. Department of Energy’s National Renewable Energy Laboratory partnered with the Government of Bangladesh to develop a national wind resource assessment.

Site	Reference Height (m)	Annual-Average wind speed (m/s)
Cox’s Bazar	10	2.42
Sandip Island	5	2.16
Teknaf	5	2.16
Patenga Airport	5	2.45
Comilla Airport	6	2.21
Khepupara	10	2.36
Kutubdia Island	6	2.09
Bhola Island	7	2.44
Hatia Island	6	2.08

**Table 5.3 shows the wind speed w.r.t height in Bangladesh.**

<b>Potential of Wind Power in Bangladesh</b>		
<b>Wind Speed Range (m/s)</b>	<b>Square Kilometer under the Wind Speed Range</b>	<b>Potential Electricity Generation in MW (based on 0.6 km<sup>2</sup>/MW)</b>
4.00-4.75	14769	Producing electricity will be technically viable but not be economically viable in this speed.
4.75-5.25	51966	
5.25-5.75	37728	
5.75-6.25	12276	20214
6.25-6.75	6093	10033
6.75-7.25	2196	3616
7.25-7.75	162	267
<b>Total</b>	<b>20727</b>	

**Table 5.4 shows the wind energy potential in Bangladesh.**  
(Source: WRMP Report Executive Summary, Presented at SREDA on 24 May 2018.)



**Fig 5.3: Wind resource map of Bangladesh and measurement locations.**

Government has taken the initiative to produce 1370 MW electricity from wind resource. To materialize this initiative, Government has already completed the wind resource mapping and launched some mega projects. Above figure shows the Recent Wind Resource mapping of Bangladesh at 120 m height conducted by USAID.

## 5.6. Biogas and Biomass Energy:

The biofuel produced for bio-product, bio-energy and bio-power [26]. Biofuel creates environment-friendly alternative renewable fuel oil specially produced from (tallow, lard, white or yellow grease, poultry fats, or fish oils) and mostly produced from natural plant oils. The process of gaseous and liquids extraction from biomass referred to as biofuel production and oil derived from crops [27]. Biogas and biomass are more popular in Bangladesh. Bangladesh has more than 350 potential oil-bearing crops which produce biodiesel such as J. curcas, sunflower, sesame, castor, cottonseed and groundnut oils are considered as alternative sources of fuel in Bangladesh. The first biogas plant in Bangladesh was constructed in 1972. Till April 2014, IDCOL has financed construction of over 33,000 biogas plants all over the country. In case of biogas, feasibility studies have been conducted in six municipal areas and it was found that major cities including Dhaka generates about 20000 tons/day. So, it is possible to build biogas plants that can generate of 26666 MWh electricity each day. German Development Agency (GIZ) found that, by using the waste of Keraniganj, 4-5 MW Power plant can be installed.

There are 7 Biogas Projects and 1 Biomass Project which are running in Electricity Production which can produce around 1.09 MW electricity. One of them having generation capacity of 1 MW is anticipated to be accomplished by December 2020 .

Project Name	Capacity	RE Technology	Agency	Finance	Tentative Completion Date
1 MW Grid Connected Power Plant Based on Municipal Solid Waste at Keraniganj on Turnkey Basis.	1 MW	Biogas to Electricity (On-Grid)	BPDB	IPP (Unsolicited)	31 <sup>st</sup> December, 2020

**Table 5.5: Project details on power plant based on municipal waste in Bangladesh.**

## 5.7 Initiative of Bangladesh Govt. in RE sector :

Bangladesh Govt. has taken several effective initiative to flourish in renewable energy sector. Some of them are as follows (source [1] sreda.gov.bd) :

Policy landscape taken by govt.	Aims
Private Sector Power Generation Policy, 1996	Incentivizes private power companies including renewable power producers
Remote Area Power Supply System [RAPSS] Guidelines, 2007	To promote private sector investment for power supply in remote areas
Bangladesh National Building Code [BNBC]	RE & EE options are included in the revised BNBC
Renewable Energy Policy of Bangladesh, 2008	Mandates 10 % of electricity to come from renewables by 2020
Bangladesh Climate Change Strategy & Action Plan [BCCSAP], 2009	Mitigation & low carbon development- one of the six thematic areas
Quick Enhancement of Electricity and Energy Supply (Special Provisions) Act, 2010	Provides for negotiating tariff of RETs on a case-by-case basis thereby overcoming inconvenience of a single tariff for a specific technology
7 <sup>th</sup> Five Year Plan, FY 2016-FY 2020	Scalable power generation from solar & wind is emphasized

Power System Master Plan, 2016	Detailed roadmap of the power sector development upto 2041 with one of the objectives to maximise green energy. At least 10% generation from RE is emphasised.
Net Metering Guidelines, 2018	Up to 3 MW may be exported to the grid.
International Cooperation	<ul style="list-style-type: none"> <li>▪ Member of International Renewable Energy Agency (IRENA)</li> <li>▪ Founding Member of International Solar Alliance (ISA)</li> <li>▪ Joint Crediting Mechanism (JCM) with Japan in 2013</li> </ul>
Dedicated Financing	<ul style="list-style-type: none"> <li>▪ BB's revolving fund of Taka 4 (Four) Billion</li> <li>▪ Bangladesh Climate Change Trust Fund (BCCTF) has allocated Tk.3500 Crore during FY10-FY 19.</li> <li>▪ Bangladesh Climate Change Resilience Fund (BCCRF)</li> <li>▪ Infrastructure Development Company Limited (IDCOL)</li> <li>▪ Bangladesh Infrastructure Finance Fund Limited (BIFFL)</li> </ul>

**Table 5.6: Bangladesh Gov. Initiative at a glance.**

Overall the prospect of renewable energy in Bangladesh is very promising, especially in the case of solar and wind energy. However, for the near future, renewable energy will remain annexed to the current energy genesis by non-renewable conventional means. Still, renewable energy will play an important role reaching consumers outside the national grid or in places where grid connection is delayed.

## **CHAPTER 6**

### Challenges of Renewable Energy in Bangladesh

## 6. Challenges Of Renewable Energy :

The Renewable Energy Policy of Bangladesh mandates sourcing of 10 % of electricity from renewables by 2020. In reality, Bangladesh is heavily reliant on fossil fuel-based power plants with a little contribution from renewable energy sources.

Fossil fuels are going to eventually end globally one day, but the solar energy, the wind energy, and the sea will remain so long as Earth exists. The sunlight striking the earth's surface in just one hour delivers enough energy to meet the global energy need for an entire year. Hence, solar energy is by far the largest energy source on Earth.

One-third of the earth is beset with water. At the same time earth surface is surrounded by the unlimited wind. So, the sources of renewable energy are beyond the end.

But unfortunately, the deployment of renewable energy in Bangladesh is being hampered due to geographical reasons and the mindset of the people.

There is a misinterpretation from certain interest groups in Bangladesh that the electricity from renewable energy is expensive. Some of the glaring reasons are discussed below in solar, wind, hydro extents.

We have already seen that solar, wind and hydro are three major sources of renewable energy in Bangladesh.

### 6.1 Uphill battle in the overall sector:

In a nutshell, the challenges of establishing renewable energy sources can be summarized as the following-

- 1. Capacity lack:** There exists a considerable gap in the dissemination of information about project viability, risk, and return for private investors. Because of this, there is a lack of incentive that slows down renewable generation growth. Credit ratings for such projects are not as high as those in India, for example. Domestic financial institutions and commercial banks are not sufficiently equipped for large scale infrastructure financing.

**2. Land Requirements:** As Bangladesh already faces the prevalent problem of overpopulation, there is a considerable lack of viable land required for large scale solar projects. Most of the viable land is government-owned and this further discourages private investors. SREDA's current renewable energy development plan states that solar parks are to only be built on non-agricultural, government-owned land. In addition to this, viable land also is under risk of environmental shocks due to Bangladesh's vulnerability to natural disasters and flooding.

**3. Deficiencies in Grid Infrastructure:** Despite having generation capacity, actual generation and distribution are often hindered by process-loss and underdeveloped grid infrastructure.

## **6.2. Challenges in the respective sectors:**

### **6.2.1. Solar sector:**

Realistically, several reasons are restricting the expected growth of utility-scale power. One of the major challenges is the difficulty of acquiring land.

- *As per the government rule, no agricultural land can be used for a solar power project. Bangladesh is a densely populated fertile agricultural land and non-agricultural unused land is not easily available.*

A 100MW solar park for example would require about 300 acres of land. It is expected that the efficiency of the solar panel will increase in the future through new technological advances thus requiring lesser areas for generating per unit of power. But until that happens, acquiring land will be a major problem for the rapid expansion of utility-scale solar power in Bangladesh.

- *Another drawback of developing utility-scale solar power in Bangladesh is an insufficient governmental incentive. The companies which are engaged in negotiations and implementation of solar park opine that the solar industry in Bangladesh is still in an immature and infant stage and requires incentives from the local authorities.*

A major point in this is fixing the tariff of the produced power. The organizations engaged in building solar power plants in Bangladesh opine that unless incentive in solar power tariff is given, their effort to develop the solar industry would not be economically feasible.

- *It appears that the companies consider 9 US cents per unit tariff offered by the government too low a price to build a solar plant and make a profit.*

Ideally, the government negotiators should be good at offering tariff which is biased towards the people and not towards the companies. But the solar power industry in Bangladesh is yet

to stand on its feet and at this initial stage, it needs the incentive to grow to a reasonable strength. Tariff incentive is perhaps a vital area that makes a company decide its future in Bangladesh.

Another problem regarding solar and wind is the intermittency problem since the sun doesn't shine at night and the wind doesn't blow all the time. So, it will be uphill to manage the uninterrupted electricity.

### **6.2.2. Wind Sector:**

Bangladesh belongs to a moderate to low wind regime. So, the scope of the massive expansion of onshore wind is limited in Bangladesh.

- *The Bangladesh Power Development Board (BPDB) implemented a pilot project in 2005, for the first time in Bangladesh, to generate electricity from wind energy at the Muhuri Dam area in Feni district with an installed capacity of 0.9 MW.*

However, any utility-scale commercial wind power plant is yet to be installed in the country. Wind power must still compete with conventional generation sources on a cost basis. Even though the cost of wind power has decreased dramatically in the past several decades, wind projects must be able to compete economically with the lowest-cost source of electricity, and some locations may not be windy enough to cost-competitive.

1. Good land-based wind sites are often located in remote locations, far from cities where the electricity is needed.
2. Transmission lines must be built to bring the electricity from the wind farm to the city. However, building just a few transmission lines could significantly reduce the costs of expanding wind energy.

Wind resource development might not be the most profitable use of the land. Land suitable for wind-turbine installation must compete with alternative uses for the land, which might be more highly valued than electricity generation.

### **6.2.3. Hydro Sector:**

Bangladesh is a riverine country but most of the rivers are low tidal, which is the glaring issue in installing hydro power plants.

- *The heaviest tidal river is Karnaphuli. Bangladesh has set up a hydro plant in Karnaphuli with an installed capacity of 230MW.*
- *The rest of the rivers are out of consideration due to low tidal velocity. What is more interesting is that Bangladesh proposed Nepal for setting up hydropower plants on their rivers by Bangladesh's investment.*

From the above discussion, it appears that the rapid growth of renewable energy in power generation will change the world for the better in a not so distant future. The use of traditional fuels oil gas and coal will gradually decrease to be replaced by renewable solar winds etc till a time when the formers will find their place in a history book.

- Bangladesh does not have an option to remain isolated when the rest of the world embraces a future with smarter and cleaner renewable energy for its power.
- The challenges in developing renewables may be high, but it is the government which should extend its hand to help it grow in the initial stage

If the Government of Bangladesh takes a genuine initiative to lead and promote renewable energy in Bangladesh, it is not that difficult to formulate and implement a sustainable renewable energy-friendly energy policy in Bangladesh, overcoming all the technical as well as non-technical challenges. This is what the people of Bangladesh expect from the government as it is for the greater interest of their country.

## **CHAPTER 7**

### **Conclusion and Recommendations**

## 7.1. Conclusion

Electricity is the major source of power for most of the country's economic activities. Natural gas is the main fuel for producing power in Bangladesh. The reserve of natural gas is 34 TCF which will lead the country next 20 years. Other resources for producing power are also very rare in Bangladesh. Renewable energy can be considered as potential energy sources. Although only 3% of the total electricity come from renewable energy sources at now. Bangladesh government has announced a master plan for overall power sector of Bangladesh in 2016. Therefore, this strategy emphasizes the countries natural resource exploration and discoveries for further improvement of the power sector and reconstruct the renewable energy resources. Bangladesh needs more sophisticated research facilities and skilled manpower for exploration activities both inland and offshore areas to meet future demand. Bangladesh government must work with national expert group for exploration of natural resources. Renewable energy can be best alternative to conventional fossil fuel . Due to environmental and economic concern there is an immense interest in the use of renewable energy like solar, bio fuel, geothermal, wind etc. The government of Bangladesh gave notable importance to establish different renewable energy projects. Following points are considered to conclude the findings:

- The main problem of installing a solar energy system is the high cost of solar system materials.
- Solar panels require quite a large area for installation to achieve a good level of efficiency.
- The efficiency of the system also relies on the location of the sun, although this problem can be overcome with the installation of certain components.
- The cost of solar energy is high compared to non-renewable utility supplied electricity.
- Solar system are unable to work at night.
- Solar panels have temperature problems, it becomes fade when temperature is excessively high.
- Solar system can be damaged by air pollution.
- Installation solar panels need large area which maybe not always possible for in country.
- During rainy season solar powers can not be harnessed.
- Extracting wind power depends on environment also.
- Wind turbines has a very low efficiency.
- Hydro power facilities can affect land use, homes and natural habitats in the damn area.

## 7.2. Recommendations:

Globally use of renewable energy is rising. Government of Bangladesh has vision to provide electricity to its entire citizen within 2020. To fulfill this vision the government plan to produce 2000 MW power from renewable energy. But this plan will not success without proper plan, so some recommendations are given below so that government could be successful.

- Government should reduce VAT and other supplementary taxes on solar accessories.
- Government should arrange proper training system for proper uses of various renewable technology.
- Reducing cost of installation of solar panel as much as possible.
- Solar energy is not available at night, at rainy day. So, priority must be given to energy storage.
- Bangladesh has a huge opportunity to extract wind and ocean current power as it has a coastal area of 47201 square km which is almost 32% of the total area.
- Biogas generation facilities should be made available for the farmers as they can get a lot bio waste from their cattle.
- Government should fund more on renewable energy research so that efficiency can be increased.
- Universities should include more courses on renewable energy for grad students.
- Private organizations should come forward with a view to increasing producing more power from renewable energy.

## References:

1. United Nations Sustainable Development Goals (SDGs). Available online:<https://www.un.org/sustainabledevelopment/sustainabledevelopment-goals/> (accessed on 28 May 2019).
2. SDG Goal-12 Ensure sustainable consumption and production patterns. Available online: <https://www.un.org/sustainabledevelopment/sustainable-consumptionproduction/> (accessed on 23 August 2019).
3. SDG Goal-7 Ensure access to affordable, reliable, sustainable and modern energy. Available online: <https://www.un.org/sustainabledevelopment/energy/> (accessed on 23 August 2019).
4. Press Information Bureau Report- Ministry of New and Renewable Energy (MNRE). Available online: <http://pib.nic.in/newsite/PrintRelease.aspx?relid=186228>(accessed on 30 May 2019).
5. Paris Agreement. Available online : <https://www.britannica.com/topic/Paris-Agreement-2015/Negotiationsand-agreement> (accessed on 26 November 2019)
6. Progress in Global Energy Scenario. Available online: <https://www.irena.org/newsroom/pressreleases/2019/Apr/RenewableEnergy-Now-Accounts-for-a-Third-of-Global-Power-Capacity> (accessed on 1 November 2019).
7. Renewable energy installed capacity continent wise and its growth from 2010 to 2018. Available online: <https://www.irena.org/publications/2019/Mar/Renewable-CapacityStatistics-2019> (accessed on 21 February 2020 )
8. A.Durusu, A.Erduman, "An Improved Methodology to Design LargeScale Photovoltaic Power Plant", Journal of Solar Energy Engineering, vol.1, pp.140, 2017.
9. International renewable energy agency (IRENA) renewable energy report. Available online: [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Mar/IRENA\\_RE\\_Capacity\\_Statistics\\_2019.pdf](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Mar/IRENA_RE_Capacity_Statistics_2019.pdf) (accessed on 2 June 2019).
10. International energy agency-CHINA's 13th renewable energy development 5-year plan. Available online: China 13th Renewable Energy Development Five Year Plan (2016-2020) (accessed on 9 June 2019).
11. All the world's carbon emissions in one chart - Visual capitalist. Available online: <https://www.visualcapitalist.com/all-the-worlds-carbon-emissions-in-one-chart/> (accessed on 21 August 2019).
12. International Energy Agency-About Sweden. Available online: <https://www.iea.org/countries/Sweden/> (accessed on 3 June 2019).
13. Energy usage-Sweden. Available online: <https://sweden.se/society/energy-use-in-sweden/> (accessed on 3 June 2019).
14. RE installed capacity in African countries. Available online: [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Mar/IRENA\\_RE\\_Capacity\\_Statistics\\_2019.pdf](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Mar/IRENA_RE_Capacity_Statistics_2019.pdf) (accessed on 3 November 2019 )
15. Solar irradiation on South Africa. Available online: [https://energypedia.info/wiki/South\\_Africa\\_Energy\\_Situation#Hydropower](https://energypedia.info/wiki/South_Africa_Energy_Situation#Hydropower) (accessed on 4 November 2019)

16. Md Niaz Murshed Chowdhury. 2015. "Present Scenario of Renewable Energy and Non Renewable Energy Sources in Bangladesh: A Compact Analysis" Business and Economics Journal.
17. M. Hussain. 1987. "Bangladesh Energy Resources and Renewable Energy Prospects".
18. Md. Abu Bakr Siddique and S. M. Rezaul Karim. 2017. "Modeling of Double Diode Solar Photovoltaic Module using Matlab" International Journal of Computer Applications 179(7): 4-10
19. Md. Habib Ullah, T. Haque & Md. M. Hasib. "Current Status of Renewable Energy Sector in Bangladesh and a Proposed Grid Connected Hybrid Renewable Energy System".
20. P. Halder, N. Paul, M. Joardder, M.J.R. Sarker, S.E. Reviews, Energy scarcity and potential of renewable energy in Bangladesh, 51 (2015) 1636-1649.
21. M.A.H. Mondal, M. Denich, T.J.E.S.R. Mezher, Deployment of renewable energy technologies in Bangladesh: Long-term policy implications in power sector, 2 (2014) 307-312.
22. B.J.B. Petroleum, London, Statistical review of world energy 2007, (2009).
23. S. Jacobsson, A.J.E.p. Johnson, The diffusion of renewable energy technology: an analytical framework and key issues for research, 28 (2000) 625-640.
24. S. Baek, E. Park, M.-G. Kim, S.J. Kwon, K.J. Kim, J.Y. Ohm, A.P.J.R.E. del Pobil, Optimal renewable power generation systems for Busan metropolitan city in South Korea, 88 (2016) 517-525.
25. M.T. Islam, S. Shahir, T.I. Uddin, A.J.R. Saifullah, S.E. Reviews, Current energy scenario and future prospect of renewable energy in Bangladesh, 39 (2014) 1074-1088.
26. M. Uddin, K. Techato, J. Taweekun, M. Rahman, M. Rasul, T. Mahlia, S. Ashrafur, An Overview of Recent Developments in Biomass Pyrolysis Technologies, Energies, 11 (2018) 3115.
27. SREDA- Sustainable and Renewable Energy Development Authority. 2015 ([www.sreda.gov.bd](http://www.sreda.gov.bd))
28. P. Bhowmik, S. Barua, Prospect of Nuclear Power Plant in Bangladesh, Gas, 70 90.