1st Foundation Training Course

BANGLADESH POWER MANAGEMENT INSTITUTE

Research on:

Prospects of Renewable Energy in Bangladesh

Supervised By:

Mohammad Alauddin

Chairman, Sustainable and Renewable Energy Development Authority (SREDA) & Additional Secretary

Submitted by:

1. Engr. Raquibul Islam, AE, DESCO, ID No: 1953
2. Engr. Mostafa Hasan Siam, AE, DESCO, ID No: 1933
3. Engr. Chenmoy Sarker, AE, DESCO, ID No: 1932
4. Engr. Mikal Ahmad Ulubbi, AE, DESCO, ID No: 1917
5. Engr. Rakibul Islam, AE, DESCO, ID No: 1906
6. Engr. Md. Sazzad Hossain, AE, DESCO, ID No: 1962
7. Engr. M. Shahriare Azad, AE, DESCO, ID No: 1910
8. Engr. Nirupom Das Dipto, AE, DESCO, ID No: 1907

Abstract:

Urgency of achieving sustainable development and tackling climate change has put renewable energy into sharp focus globally. With 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.

Globally the use of renewable energy has risen considerably in recent times. Renewable Energy Policy of Bangladesh mandates the sourcing of 10 % electricity from renewables 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 2000 MW. This paper takes stock of the renewable energy resources of Bangladesh upon desk review of available literature. On an analysis of current renewable energy scenario, it endeavours to identify the barriers in the deployment of renewable energy and sheds light on the prospects of renewable energy in Bangladesh. This paper recommends to extend more government support for scalable power generation from renewables and build capacity of key stakeholder both public and private sector.

INDEX

CHAPTER I

Introduction

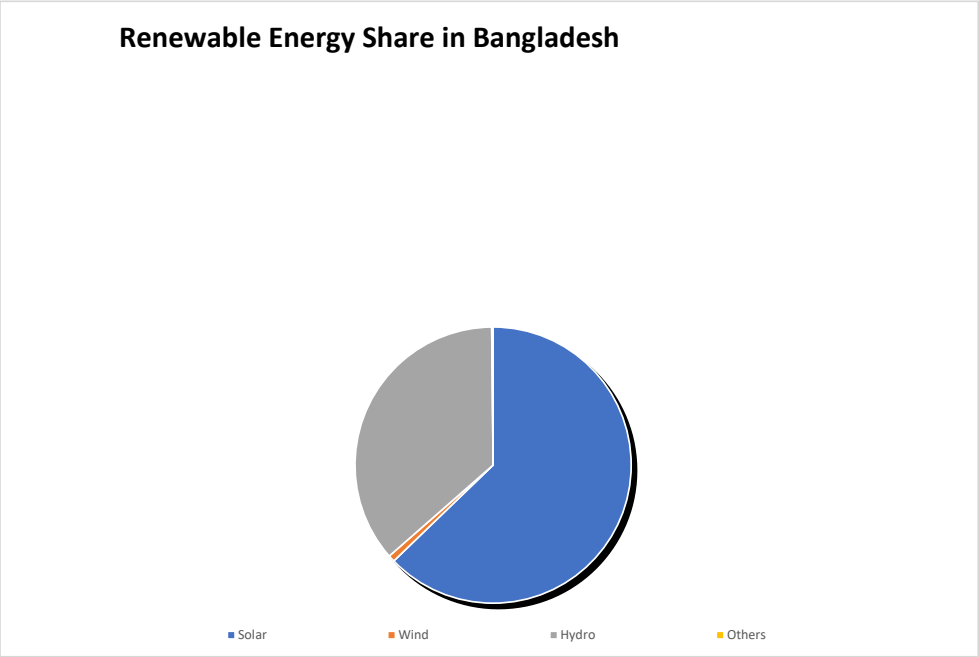
1.Introduction: Diversification of modern technology would result in significant energy security and economic benefits in Bangladesh. It creates a broad aspect for deploying Renewable Energy. The use of renewable energy free from environmental pollution such as wind, solar, bio-mass, geothermal, tidal, hydro energy have taken on a greater sense of urgency, especially in developing countries. In this regard the government of Bangladesh has planned to generate 20% of total generation by nuclear, renewable and cross border by 2030 out of 40,000 MW total expected generations. Renewable Energy (RE) technologies will result in reducing dependency on fossil fuel to a sustainable level and it will ultimately minimize load shed, further expansion of national grid at remote rural areas in Bangladesh. In this regard the Government of Bangladesh has planned to generate 10% of generation (i.e., 2000 MW) by 2020. The average cost of power generation in Bangladesh is approximately Tk 6.02/kWh and diesel-based generation is Tk 15.80/kWh, the cost of renewable energy ~~is~~ appears to be pricey with comparison to conventional energy but the difference between conventional and RE is gradually decreasing due to availability of efficient RE technologies (Power Division, 2013). Gradual expansion of RE in rural Bangladesh is getting popularity as the natural resources e.g. gas is depleting with an approximate projection of declining time around 2017 as indicated in Power System Master Plan 2010 (PSMP 2010). With a projection to gradual depletion of fossil fuel resources the developed countries e.g., UK and USA also started exploring alternate energies particularly RE for their sustainable development. The UK has published UK2050 calculator and US State Department also started a program as SE4ALL prior to depletion of their fossil fuel resources. 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 RE 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 RE resources considering the development of off grid electrification program at all level as 40% 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 500 MW Solar mission and prospects of wind and hydro which are also under pipeline program. In addition, the government has planned to save 15% of energy by 2020 through implementation of action plan for energy efficiency and conservation and subsequently 20% 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. 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. Floating Solar is also a burning issue for developing country like Bangladesh. Introducing Renewable Energy draws attention of the foreign investors, as they are more likely to invest on green energy.

CHAPTER II

Renewable Energy Scenario in Bangladesh

2.Renewable Energy Scenario in Bangladesh:

For generating electricity, Bangladesh is embracing both conventional and renewable source of energy. Currently, the available renewable energy sources in Bangladesh are Solar, Wind, Hydro, Biomass and Biogas. Keeping pace with the global trend, Bangladesh is now laying emphasis on the development of Renewable Energy. 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. The present renewable energy condition is shown in the following pie chart-



In this chapter, we will discuss the renewable energy scenario in Bangladesh.

2.1.Solar:

In Bangladesh, Solar energy is the major contributor of the renewable energy. The long-term average sunshine data indicates that the period of bright sunshine persists in the coastal regions of Bangladesh varies from 3 to 11 hours daily [*Mohammad Aslam Uqaili; Khanji Harijan (2011). Energy, Environment and Sustainable Development. Springer. p. 19*]. Bangladesh receives an average daily solar radiation in the range of 4-5 kWh/m^2. In Bangladesh, solar energy turned into electricity using mainly from SHS, grid tied Solar PV power Plant, Solar Minigrid 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*)

2.2.Solar Home System:

Solar photovoltaic (PV) are gaining acceptance for providing electricity to households and small businesses in rural areas. In 1988, Bangladesh Atomic Energy Commission (BAEC) installed several pilot PV systems. The first significant PV-based rural electrification program was the project in Narsingdi district initiated with financial support from France. Three Battery charging stations with a total capacity of 29.4 kWp and a number of stand-alone solar home systems (SHS) with a total capacity of 32.586 kWp were installed. Rural electrification Board (REB) owned the systems and the users paid a monthly fee for the services. Since 1996, penetration of SHSs increased rapidly which is now the biggest renewable energy program in Bangladesh. 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. Several other NGOs such ASA, CMES and BRAC are also engaged in promoting PV technology. PV modules are generally imported, while there are a few private companies manufacturing PV accessories (*www.shakti.org.bd*)

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 (*http://www.sreda.gov.bd*)

More than 5.8 million SHSs have already been installed through BREB, IDCOL, GIZ, MoDMR in the off-grid rural areas of Bangladesh and about 13 million beneficiaries are getting solar electricity. SHS have aggregated capacity of about 248.29MW. (*http://www.renewableenergy.gov.bd*) The program has been acclaimed as one of the largest and the fastest growing off-grid renewable energy program in the world. (*http://www.sreda.gov.bd*)

2.3.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*).

The 3 MWp Grid Connected Solar PV Power Plant at Sharishabari, Jamalpur is the first grid connected plant that went into commercial operation in August 2017. (*https://www.newagebd.net/article/42618/growth-of-grid-solar-power-in-bangladesh-*

published on June 02,2018 | Updated: 23:06, Jun 01,2018). The 2nd solar PV power plant is 20 MWp at Teknaf Upazilla of Cox's Bazar has started its operation on 1 November, 2018.

7.4 MWp Solar Park at Kaptai, Rangamati is another Solar Park which has started its operation on September, 2019. The project, costing Tk 111.2 crore, was implemented with the assistance of Asian Development Bank on a 22-acre plot of Bangladesh Power Development Board. Works on the project started in October 2017. The EPC of this project was Chinese firm ZTE which will provide technical assistance for the next two years after its inauguration. (*https://www.thedailynewsline.net/7458/kaptai-solar-power-plant-to-be-inaugurated-today*).

The latest Solar Park that went into operation on 13 November, 2019 is an 8 MW Solar Park at Tetulia, Panchagarh. The project was implemented by Sympa Solar Power Limited, a joint-venture company of Thailand based solar PV developer, Symbior Solar, and leading agro based firm in Bangladesh, Paragon Group.

2.4.Solar Mini grid:

A **mini-grid** is an off-grid electricity distribution network involving small-scale electricity generation (wiki). Solar PV based mini-grid projects are installed in remote areas of Bangladesh where possibility of grid expansion is less in near future. These projects provide grid quality electricity to households and small commercial users and thereby encourage commercial activities in the project areas.

So far IDCOL financed installation of 27 solar mini-grids with cumulative generation capacity of 5.656 MW. (*http://www.renewableenergy.gov.bd*) The mini-grid projects have successfully created access to low-emission electricity for approximately 16,000 beneficiaries in rural Bangladesh (IDCOL).

2.5. Rooftop Solar:

Bangladesh enjoys good amount of sunshine and the use of solar energy continues to grow while the cost of solar technology continues to decline. Incentivizing grid-connected customers is of utmost importance to promote RE-based distributed generation. Net metering is one of the tools to popularize the RE based electricity generation in the country. Net metering is a policy approach designed to encourage distributed renewable energy development by allowing utility customers to generate their own electricity from solar or any other renewable sources and use the electricity produced to offset the amount of energy they draw from the utility grid (sometimes called the distribution grid) and any access generation can feed into the grid. Customers are only billed for their "net" energy use and receive credit usually in the form of kilowatt-hour (kWh) during a given period. A net balance in favor of the customer is carried forward to the next month, while a balance in favor of the utility is settled at the end of the month as usual. Net-metering system has gained popularity very quickly because at present nearly 13 MW power has already been added to National Grid through Net-metering Rooftop Solar system. (*http://www.renewableenergy.gov.bd*)

2.6.Wind Power:

Wind Energy has also made some inroads but its potential is mainly in coastal areas, and offshore islands with strong wind regimes. These coastal settings offer good opportunities for wind-powered pumping and electricity generation. Until now, there are only three Wind Farms in Bangladesh with an aggregated capacity of 4.9 MW. (*http://www.renewableenergy.gov.bd*) Of them Wind Parks in Sonagazi Upazilla, Feni and in Kutubdia coastal area have been in operation for the last couple of years while the 2 MW Wind Park in Sirajganj district went into commercial operation on 16 February, 2018.

2.7.Hydro:

There is one hydro power plant at Kaptai established in the 1962s with present installed capacity of 230 MW. Micro hydro and Mini hydro have limited potential in Bangladesh, with the exception of Chittagong and the Chittagong Hill tracts. Hydropower assessments have identified some possible sites from 10 kW to 5 MW but no appreciable capacity has yet been installed.

2.8.Biomass:

Bangladesh has strong potential for biomass gasification based electricity. Since agriculture is the main source of income for the Bangladeshi rural areas' inhabitants, agricultural waste provides significant amounts of biomass resources, in addition to animal waste and household waste, hence the great potential of biomass in the country. Biomass is considered –along with natural gas- as the main energy sources in the country -consumption wise-, with biomass accounting for 70% of the country's total energy consumption.

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Capacity	1	1	2	3	3	4	5	5	5	5

Table: Bangladesh's Total Bioenergy Capacity (MW) 2009-2018
(https://energypedia.info/)

The main agricultural residues, from which Bangladeshi biomass is extracted are rice, maize, wheat, coconut, groundnut, bean, vegetables, jute and sugarcane. Agricultural crop residues, of which about 46% of Bangladesh's biomass energy come from are: rice, rice straw, husk, jute stick, and sugarcane. Generating power from biomass gasification is common and favored technology in Bangladesh. Until now 400 KW electricity is generated through Biomass. (*http://www.renewableenergy.gov.bd*)

2.9.Biogas:

Biogas is the mixture of different gases produced by the breakdown of organic matter and typically is produced from animal and municipal wastes may be one of the promising renewable energy resources for Bangladesh. About 70 per cent of this gas is methane which is better as fuel than firewood while the remaining gas is carbon dioxide and some other gases. Presently there are tens of thousands of households and village-level biogas plants in place throughout the country. It is a potential source to harness basic biogas technology for cooking, and rural and peri-urban electrification to provide electricity during periods of power shortfalls.

Cattle dung available from 22 million cows and buffaloes is nearly 0.22 million tons. One ton of dung can produce 37 m^3 of biogas. Available cattle dung can produce 2.97 x 10^9 m^3 of gas which is equivalent to 1.52 x 10^6 tons of kerosene or 3.04 x 10^6 tons of coal.

Besides, a substantial amount of biogas can be produced from human and other animal excreta, garbage and water hyacinth.

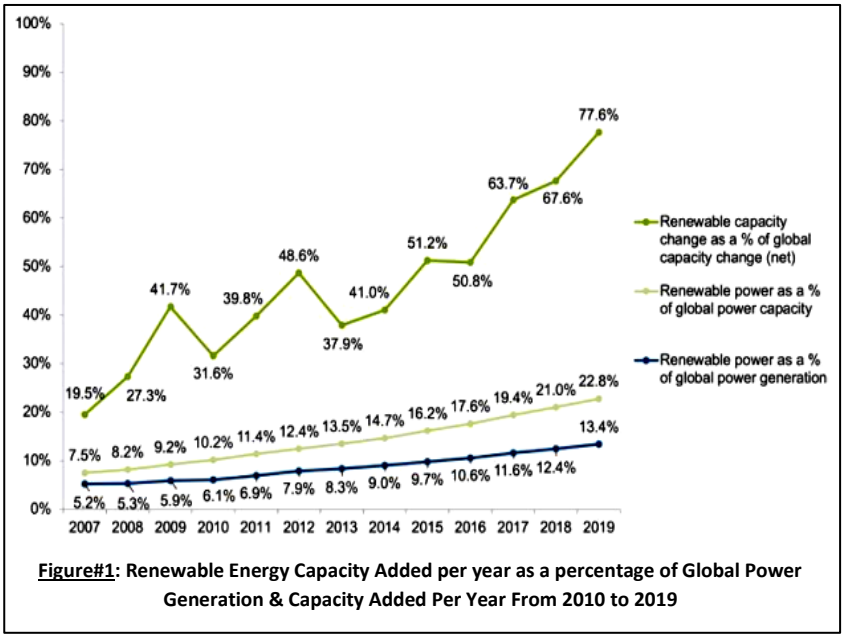
The first biogas plant (floating dome type) was constructed in 1972. At present, 630 KW electricity is generated through Biogas. (*http://www.renewableenergy.gov.bd*)

CHAPTER III

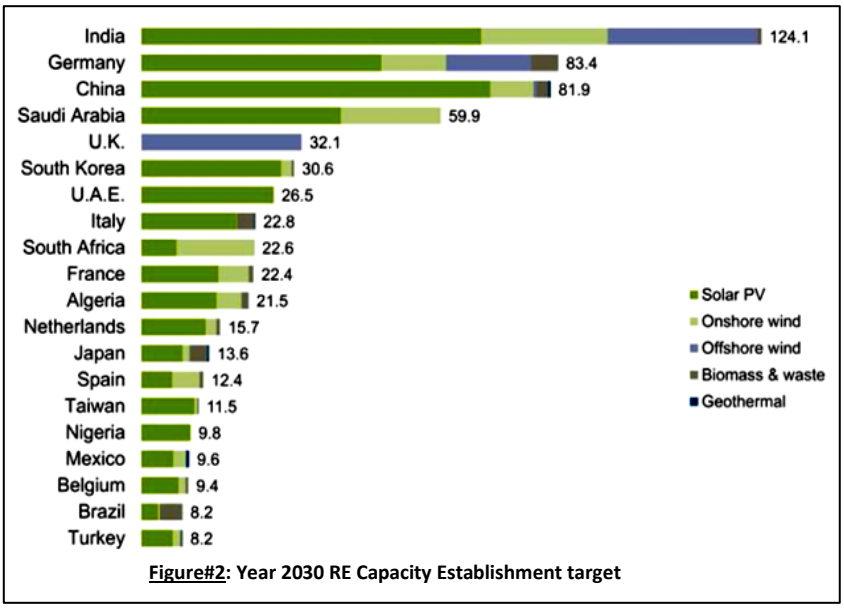
Global Scenario of Renewable Energy

3.Global Scenario of Renewable Energy

3.1. Increase in Dependence on Renewable Energy: Renewable energy saw a record-breaking year in 2019 in terms of increase in installed capacity and capacity investment, mainly by the developed nations all over the world. The world invested $282 million in new renewable energy capacity (excluding large hydro), which is 1% higher than the total for the previous year. The amount of new renewable power added in 2019 was the highest ever, at 184 GW, a full 20 GW more than in 2018. As of total installed capacity, renewable energy holds 22.8% share of total global generation capacity in 2019 (figure#1). Wind energy and biomass energy saw a rise in terms of investment than the previous year, which is 6% and 9% respectively, whereas solar energy saw a fall of 3% in capacity investment as a result of decreasing solar panel cost. So, recent energy trend focuses mainly on solar, wind, biomass energy. While developed and developing countries are focusing mainly on renewable energy over existing fossil fuel energy and investing more and more towards achieving year 2030 renewable energy capacity installation goal (figure#2), Bangladesh can be seen nowhere near them in terms of investing in RE.

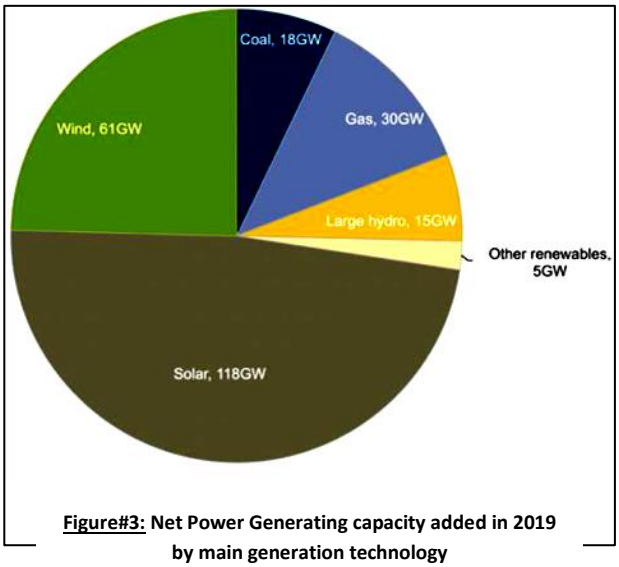


Figure#1: Renewable Energy Capacity Added per year as a percentage of Global Power Generation & Capacity Added Per Year From 2010 to 2019



Figure#2: Year 2030 RE Capacity Establishment target

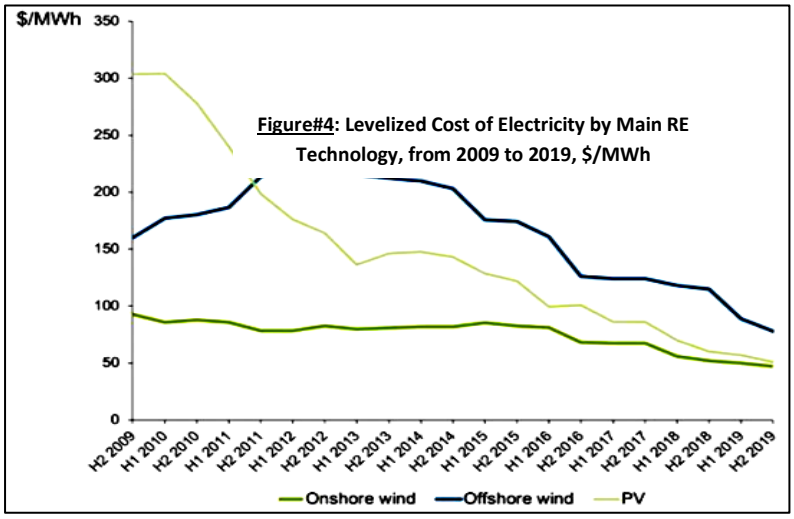
Developed economies tended to be the early adopters of renewable energy technologies such as wind, solar and biomass – although this was not the case with biofuels, where Brazil was one of the main centers of activity. Increasingly during the 2010s, however, and particularly once costs fell toward parity with fossil fuel alternatives, developing economies picked up the



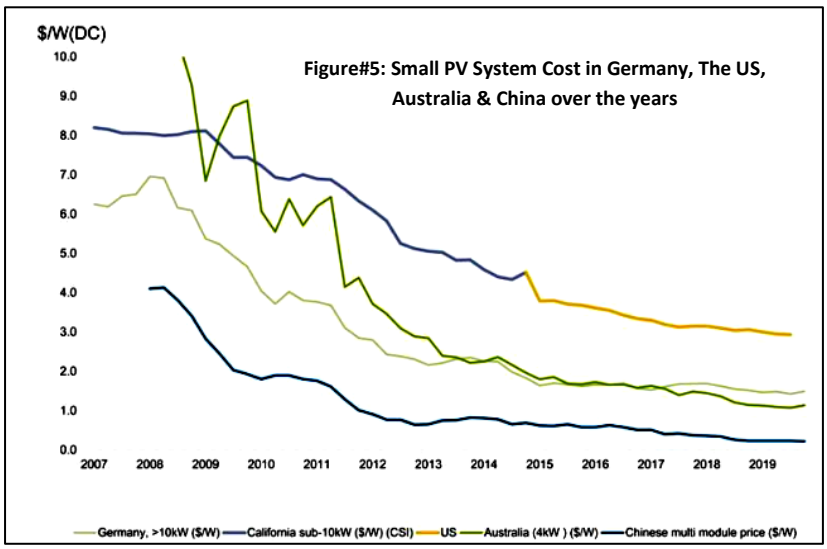
Figure#3: Net Power Generating capacity added in 2019 by main generation technology

baton. They have usually been looking to build additional generating capacity to meet rising electricity demand, while for many developed countries it has been more about replacing existing coal, gas or nuclear generation. (figure#3)

3.2. Cost of PU Renewable Energy Continues to Decrease: The lifetime cost of generating electricity from wind and solar continued to decline. The levelized cost, which includes just the expense of buying the equipment and constructing the plant but also developing it through permitting stage, financing it and operating and maintaining it, have evolved as shown in figure 4. The global benchmark levelized cost of electricity, or LCOE, from onshore wind was $47 per MWh in the second half of last year, according to Bloomberg analysis. This was down 10% on the same period in 2018, and 49% lower than in the second half of 2009. For offshore wind, the global benchmark LCOE in the second half of 2019 was $78 per MWh, down 32% on a year earlier, and 51% on the second half of 2009. The biggest reductions in LCOE have come in solar photovoltaics. Their benchmark levelized cost stood at an average of $51 per MWh in the second half of 2019, down 15% on the year and a remarkable 83% lower than their figure of $304 in second half 2009, when solar generation was still an immature technology and heavily reliant on subsidy. The latest



Figure#4: Levelized Cost of Electricity by Main RE Technology, from 2009 to 2019, $/MWh



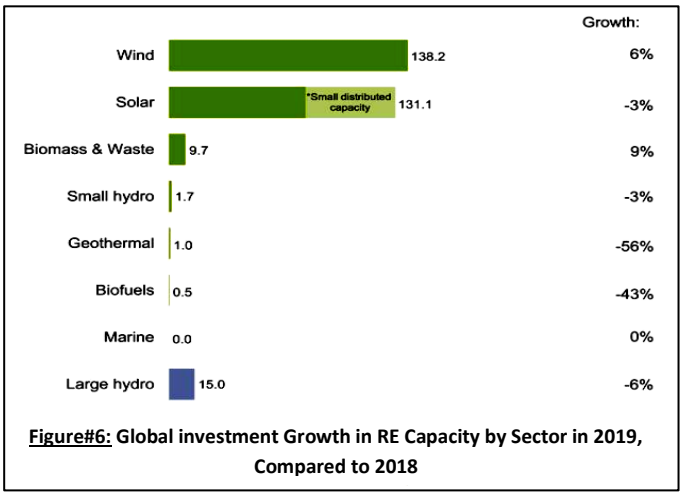
Figure#5: Small PV System Cost in Germany, The US, Australia & China over the years

reductions in LCOE have meant that an estimated two-thirds of the world's population now live in countries where either solar or wind, or both, is the cheapest option for new electricity capacity.

3.3. Increase In Investment & Achievement In Solar Power: The biggest asset financing of the year came in solar thermal, in the shape of a $3.9 billion equity and debt package for the 700MW Al Maktoum IV trough and tower complex in Dubai. The project also has a 250MW photovoltaic component. Together, the two represented the largest ever non-hydro renewable energy project financing. This investment was made possible because of definitive increase in the ratio of efficiency of solar panel vs cost. The chart shows the cost reductions respectively for a German small PV system of less than 10kW – down from $6.25 per Watt in early 2007, to $4.04 per Watt in early 2010, to an average of $1.59 per Watt during 2018, and $1.47 per Watt in 2019. In the U.S., the typical cost reduction has been from $7 per Watt in 2010 to $2.96 per Watt in 2019 (figure#5). Installation and balance of-plant costs have fallen during the decade, but the most dramatic reduction has been in the modules themselves, with the Chinese multi-module price tumbling from $1.85 per Watt, to just 23 cents per Watt. Also, some innovative ideas have appeared to be implementable, like:

1. Bi-facial solar module,
2. Thin film solar technology,
3. Light sensitive Nanoparticle,
4. Transparent solar window,
5. Nano tube fabric solar panel,
6. Hydrelio floating solar PV system.

3.4. Decrease Of Investment In Large Hydro Plants, stalled investment in tidal energy:
Final investment decisions for large hydro-electric dams of more than 50MW are estimated to have been worth $15 billion in 2019, down 6% from the previous year (figure#6). Investment in both 2018 and 2019 was far below the $40 billion plus annual totals recorded several times during the preceding decade. A major reason for the lower large hydro investment totals recently has been the absence of mega projects reaching financial close, or the start of full scale construction. The most recent such project to reach that stage was the 16GW, $28 billion Baihetan dam in China in 2017. More fundamentally, some big projects in Africa and South East Asia have been delayed by environmental or political concerns.



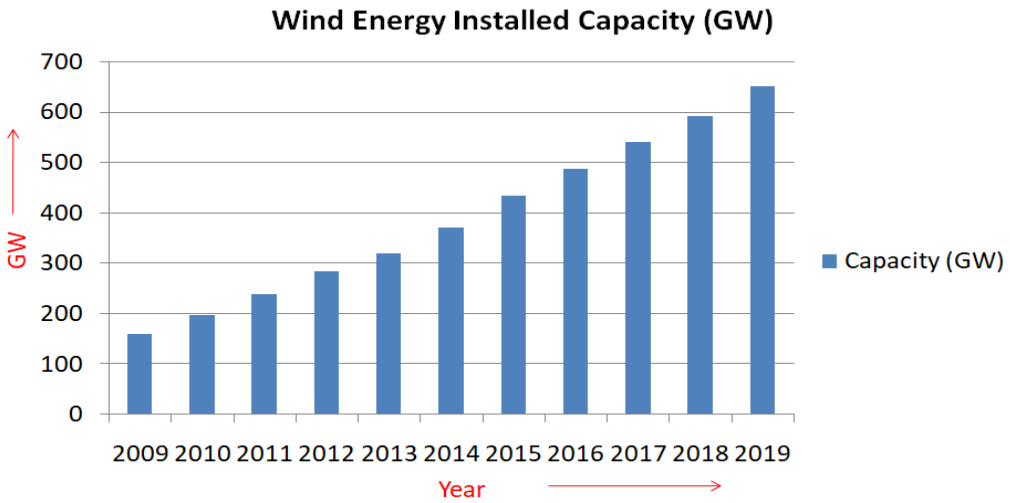
Figure#6: Global investment Growth in RE Capacity by Sector in 2019, Compared to 2018

Tidal Energy is not showing development growth like development in solar PV or biomass/waste energy technology. As of today, global tidal energy market is estimated to be worth of 76 billion euro. A project named NEMMO (Next Evolution in Materials and Modelling for Ocean energy) started to work on producing an optimized tidal blade design using advanced computer modelling, innovative materials and new testing procedures. This

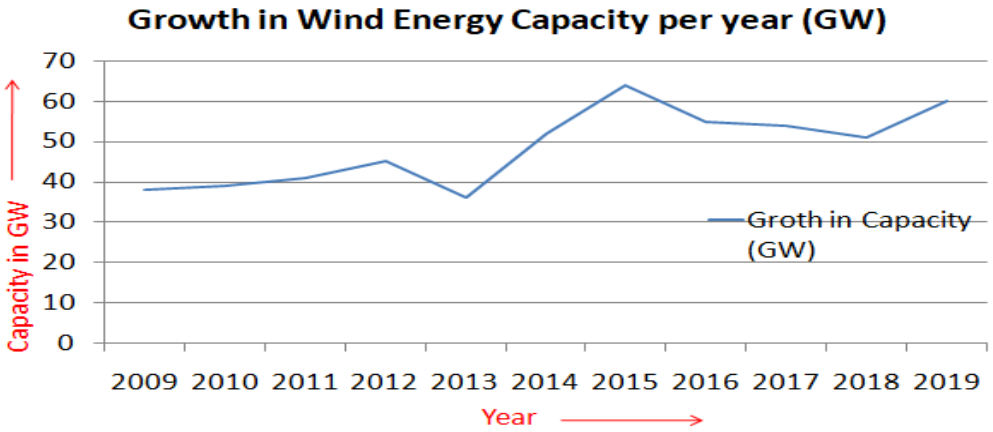
next generation of larger, lighter and more durable composite blades will enable devices to reach capacities of over 2 MW. Green Ocean Energy Ltd (an Aberdeen based renewable energy company of Scotland) is set to create and innovate in the field of clean and green energy after receiving £100,000 of funding from the Scottish Enterprise Seed Fund & £150,000 of private investment. They has produced two innovative devices, namely –

1. Ocean Treader: It is a floating device. It will be tied up 1 – 2 miles offshore in ocean wave systems. It will not pose any obstruction on the shoreline. The theory has been put to test in wave tank.
2. Wave Treader: Wave Treader uses its Sponsons and Arms and are mounted on the base of a static offshore structure. That structure can be a Wind Turbine or Tidal Turbine

3.5. Wind Power is showing significant promise: Wind power is holding very significant portion in current renewable energy generation in the world. Total installed capacity of wind power up to 2019 is 651GW which has seen a steady growth over the years.



Around 60GW (19% growth) of installed capacity of wind power is added in 2019 which is the second best year in terms of installation so far although USA and China accounted for 60% of the new instalment. 102 countries around the world is currently using commercial wind power.



The cost of per kilowatt-hour of wind energy has reduced so much that in many cases it is competing with fossil fuel based generation even without subsidies. In terms of wind's participation of total electricity generation Denmark (57%), Ireland (32%), Portugal (26.4%) is doing significantly well. Although, the onshore wind installation is currently holding 95% share, offshore installation has shown significant promise by rising at 10% in 2019.

3.6. Geothermal Energy sector is dominated by direct use: The current total generation capacity of geothermal energy is 13.9GW. USA, Indonesia, Philippines, Turkey and New Zealand are the top five geothermal producing countries. In 2019 only 0.7 GW new geothermal power generating capacity is added around the world. Turkey, Indonesia and Kenya showed a significant increase in geothermal generating capacity. On the other hand, 2.2 GW of installed capacity is increased for direct use of geothermal energy which is around 8% of the total installed capacity in this sector. China is the largest user of direct geothermal energy and it's market is being growing more than 20% from year to year. Direct geothermal energy is being used in various applications like bathing and swimming, space heating, greenhouse heating, industrial heating, aquaculture, snow melting etc. Space heating is the fastest growing use of direct geothermal energy which is growing at 13% per annum. The direct use of the geothermal is not distributed around the globe as only the top 10 countries use 75% of the energy in this sector.

3.7. Biomass Energy using is shifting from traditional use to bioenergy: Biomass energy is a very important sector in renewable energy field with a lot of areas for improvement. The biomass energy can be divided into two sectors i.e. traditional use of biomass and modern bioenergy. Traditional use of biomass consists of cooking and heating applications which is not very efficient. The traditional biomass sector has seen a steady slight decline in use from 27.2EJ (2010) to 26 EJ (2018). The sector is expected to decline further as it can negatively impact the local air quality. On the other hand, modern bioenergy is more efficient and

cleaner for household and industry. The bio-energy used to generate electricity is called bio-power. The installed capacity of bio-power in 2019 is 139 GW which is 6% more from that of 2018. China is the leading producer of bio-power in the end of 2019. The country has managed to increase 26% growth in this sector in 2019. The growth is based on solid biomass and municipal solid waste. Other major producer of bio-power is Brazil, India, Germany and UK.

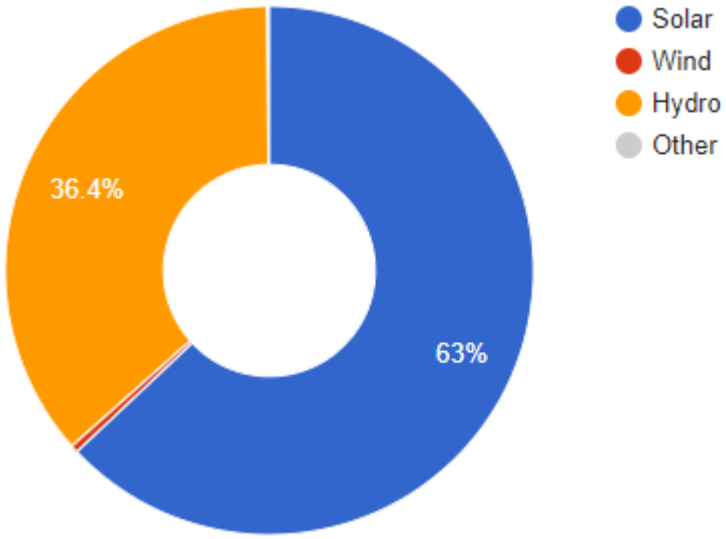
CHAPTER IV

Challenges of Renewable Energy in Bangladesh

4.Challenges of Renewable Energy

The Renewable Energy Policy of Bangladesh mandates sourcing of 10 % 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 unlimited wind. So, the sources of renewable energy are beyond the end. But unfortunately, deployment of renewable energy in Bangladesh is being hampered due to geographical reasons and mind set 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.



From the above picture, it is clear that solar, wind and hydro are three major sources of renewable energy in Bangladesh.

4.1.Solar :

Realistically, there are a number of reasons that are restricting 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 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 future through new technological advances thus requiring lesser area for generating per unit of power. But until that happens, acquiring land will be a major problem for rapid expansion of utility-scale solar power in Bangladesh.

Another drawback in developing on utility-scale solar power in Bangladesh is the insufficient governmental incentive. The companies which are engaged in negotiations and implementation of solar park opine that 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 organisations engaged in building solar power plants in Bangladesh opine that unless incentive in solar power tariff is given, their effort to develop solar industry would not be economically feasible. It appears that the companies consider 9 US cent 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 solar power industry in Bangladesh is yet to stand on its feet and at this initial stage it needs incentive to grow to a reasonable strength. Tariff incentive is perhaps a vital area which 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.

4.2.Wind:

Bangladesh belongs to moderate to low wind regime. So, scope of 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 Muhuri Dam area in Feni district with an installed capacity of 0.9 MW. However, any utility-scale commercial wind power plat 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 be cost competitive. Good land-based wind sites are often located in remote locations, far from cities where the electricity is needed. 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.

.

4.3.Hydro:

Bangladesh is a riverine country but most of the rivers are low tidal, which is the glaring issue in installing hydro power plant. 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 plant 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 better in 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 history book. Bangladesh does not have an option to remain isolated when rest of the world embraces a future with smarter and cleaner renewable energy for their 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 V

Prospects of Renewable Energy in Bangladesh

5. Prospects of Renewable Energy in Bangladesh

Bangladesh is observing a sheer advancement towards development for which sustainable power generation is becoming a mandatory thing. The profile of power demand and supply has been broadly discussed in PSPM 2016. For energy security fuel mix plays a vital role. Bangladesh is largely depended on natural gas for power generation of which reserve is ceasing. Future power generation plan is based on coal and furnace oil. But for sustainability and environment friendliness in the long run, use of renewable energy is nothing but a must. 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. Achieving these goals have accelerated the implementation of utilization of renewable energy to a great extent. Bangladesh is intending to produce at least 10% of total power generation from renewable energy as per the proclamation of PSMP 2016.Bangladesh is producing only 2.85% of total electricity from renewable sources of which hydro and solar occupies the major portion. SREDA targets to generate 10% of power (that is about 2000 MW) from renewable sources within 2020 but in contrast to current pandemic situation this claim seems now mere a dream according to the available data. SREDA is looking forward to gradual increase in using renewable resources for which government of Bangladesh has taken initiatives to ensure substantial use of renewable technology. It is anticipated to accomplish around 2177 MW from renewable technology within 2021 (sourced by sreda.gov.bd).

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**	

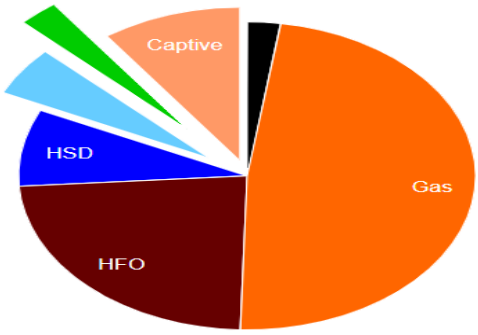


Fig: Current Generation Mix (2020) (source: sreda.gov.bd)

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**

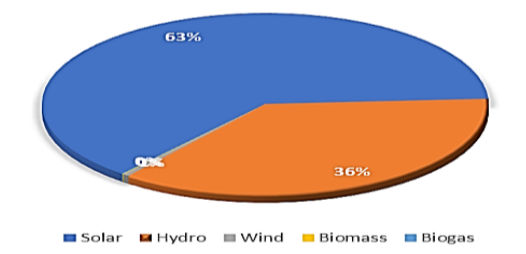


Fig: Current Renewable Energy Power Generation (2020) (source: sreda.gov.bd)

5.1.Solar Energy: Most prominent source of renewable energy in Bangladesh is solar energy as it receives 4.5 KW/m^2 solar radiation on average. But the challenge is the scarcity of land due to agricultural, industrial and habitual usage of land in this densely populated country. The outline of 100% access to electricity for such instance comes at a stake since many remote areas are inaccessible for grid expansion due to nature of land and cost contradictions. In this circumstances, introduction of solar home system gives a hope. Already 248 MW from 5.8 Million solar home units have been set up all over Bangladesh till date and people in remote areas are encouraged to take advantages of it as costs are gradually reducing. Solar home systems are mostly financially supported by IDCOL and SREDA in rural areas. Apart from solar home systems, initiatives and opportunities of solar energy usage are solar park, solar rooftop PV panes with and without net metering, solar mini, micro and nano grids, solar water heating system, solar irrigation pumps, solar water pumps.

Solar rooftop PV panels can be also a triggering way to increase RE usage in the scarcity of land. The rooftops of commercial and residential buildings and the open spaces of industrial zones are asked to install PV panels to reduce their electricity expenses. It has been implemented as law to set up rooftop PV panels comprising at least 20% of total sanctioned load during getting a new connection. Net metering has been introduced in the recent years to facilitate this initiative. In this system, consumers can provide surplus electricity from their solar rooftop panels to the grid and eventually paid for the export of generation at the bulk rate of distribution utility which is settled at the year end. The net import is taken as usage of consumer and net export is carried away in favour of consumes for the next month. Consumers are getting paid if there is a net export of power at the end of fiscal year. This inceptive encourages the commercial and industrial zones much more than before and as well as increases the possibility of more solar irradiation usage. Thus, consumers are now considered as prosumers, the mix of consumer and producer. 109 units totalling 39.5 MW rooftop solar PV panels without net-metering and 878 units totalling 129 MW with net metering are currently contributing to generation mix in the country. More implementation of this will aid to sustainable growth in this system. Solar rooftop systems are effective in the municipal areas.

The theme of supplying electricity directly to the grid instead of using a battery backup from solar panels is known as solar park. This initiative can be implied in the unused open spaces of governmental and non-governmental organizations which are inaccessible to agricultural usage. This initiative will ensure the efficient use of land and contribute to green energy generation. At present, 4 solar parks providing total 38.4 MW have been installed in the area of Cox's Bazar, Rangamati, Panchagarh and Jamalpur and more 11 units are under construction along with 14 units under planning.

Irrigation pumps draw a significant amount of electricity form grid and this consumption is actually limited to seasonal use. As agriculture is the principal and most required sector for our country, this consumption has to be guaranteed, but such seasonal consumption is a burden to the grid. Moreover, remote areas are to be covered by grid for such access. Solar irrigation pumps are ground-breaking alternatives to this. 43% of total expenses in agriculture are due to diesel or electricity driven irrigation pumps. Installation of solar irrigation pumps will reduce such expenses though onetime capital investment has to be considered. It will also contribute to the reduction of CO_2 emission percentage. Moreover, it is anticipated the this will reduce the burden of almost 150 MW demand from the grid. Solar irrigation pumps at present are contributing 35 MW off-grid power from 1271 units all over the country. More upcoming projects will contribute more in this initiative. These are mostly financially supported by IDCOL.

Solar mini-grids, micro-grids and nano-grids are new ideas to the utilization of solar irradiation. These grids are different from solar park in the sense that there are isolated from the national grid and installed to support access to electricity in remote areas where consumptions to national grid construction cost will not be efficient. Small areas are selected under a specified mini or micro grid and power is generated and distributed among the habitats in those areas. This establishment is efficient and bringing significant changes in the lifestyle and development if remote regions. 21 solar mini-grids along with 2 nano-grids are contributing 4.5 MW energy currently. 650 kWp solar mini-grid located at Shulllah, Sunamganj is the largest mini-grid installed in the south Asian region. These grids are maintained by IDCOL. More 1.1 MW from 6 units are under implantations in near future. These solar grids are seemed to be effective option in the tribal regions and islands. Definitions of isolated solar grids by SREDA are:

System type	System Capacity	Conditions
Mini-grid	100 kW ≤ Capacity < 5 MW	• Each system must consist of at least 10 consumers • Isolated from national grid • Commercial or contributory operation among prosumers
Micro-grid	10 kW ≤ Capacity < 100 kW	
Nano-grid	3 kW ≤ Capacity < 10 kW	
Pico grid	500 W ≤ Capacity < 3 kW	

Source by sreda.gov.bd

Solar charging stations are used to charge the batteries used in the electric vehicles and other battery-driven utilities. Currently 13 such units are operational throughout the country. Government has already implemented 120 units of solar based drinking water system by SED project in the southern region of Bangladesh where scarcity of pure drinking water is huge due to salt contamination. These systems can both serve the drinking water to the people as well as utilization of renewable (solar) energy. Telecom BTSs are encouraged to use solar powered system to avoid interruption from grid supply and provide uninterrupted telecom service facility as well cost minimization in the long run. 1933 units of such solar powered BTS are operation till the date. Street lighting in the country is planned to bring under solar

energy utilization instead of grid-powered system so that a significant amount can be saved from such consumption.

5.2. Hydropower: Hydropower is the most naturally accessible renewable energy. Almost 26% of global energy comes from hydro powerplant. But it is matter of regret that we have little opportunity for this source. We have already installed 230 MW hydro power in Kaptai. The suitable places for dam construction and water reserve are yet not founded, especially robust survey has not yet been done and is also quite difficult in the tribal areas due to security concerns and transportation. Bangladesh lacks in hilly rivers which dims the opportunity of hydropower system. Some micro hydro plants may be considered to construct. Five sites along Sango river have seemed feasible for tun-of-river hydro plants. But relocation of the inhabitants are grid construction expenses make such options ineffective. There are chances to build up collaboration with the countries like Nepal and Myanmar which have upstream river water suitable for hydro plants to make mutual investment and import power from these countries. This will require foreign policies and foreign bureaucrats to come in action as well as political wellness and involvement.

5.3. Wind Energy:

Till 2014, all studies conducted in Bangladesh concluded that we do not have good potential in wind energy. But very recently this view has been changed by a study of National Renewable Energy Laboratory (NREL) with the support of Power division, Bangladesh. Because earlier studies have been conducted at average height of 20-30 meter from the sea level. But recent study is done at 80 meter height. They found that, wind speed here increases with height.

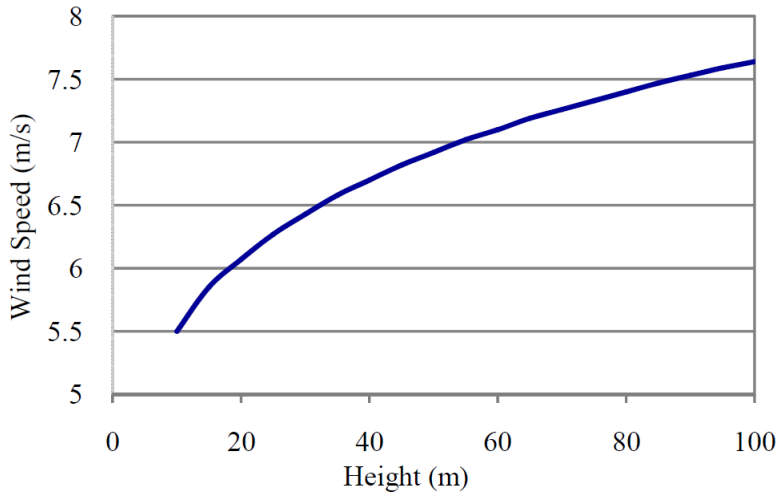


Figure: Variation of Wind Speed with Height [Hossain, M.A. and Ahmed, M.R., 2013. Present energy scenario and potentiality of wind energy in Bangladesh. *World Academy of Science, Engineering and Technology*, *7*(11), pp.1001-1005]

Moreover, most important reason to think about wind energy is that the technology has improved tremendously over last 10 years. Hence, a wind speed which is required to produce

electricity was not technically viable that time, is now capable of producing electricity with the new technology.

Potential of Wind Power in Bangladesh		
Wind Speed Range (m/s)	**Square Kilometer under the Wind Speed Range**	**Potential Electricity Generation in MW (based on 0.6 km^2/MW)**
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
Total	20727	

Source: WRMP Report Executive Summary, Presented at SREDA on 24 May 2018.

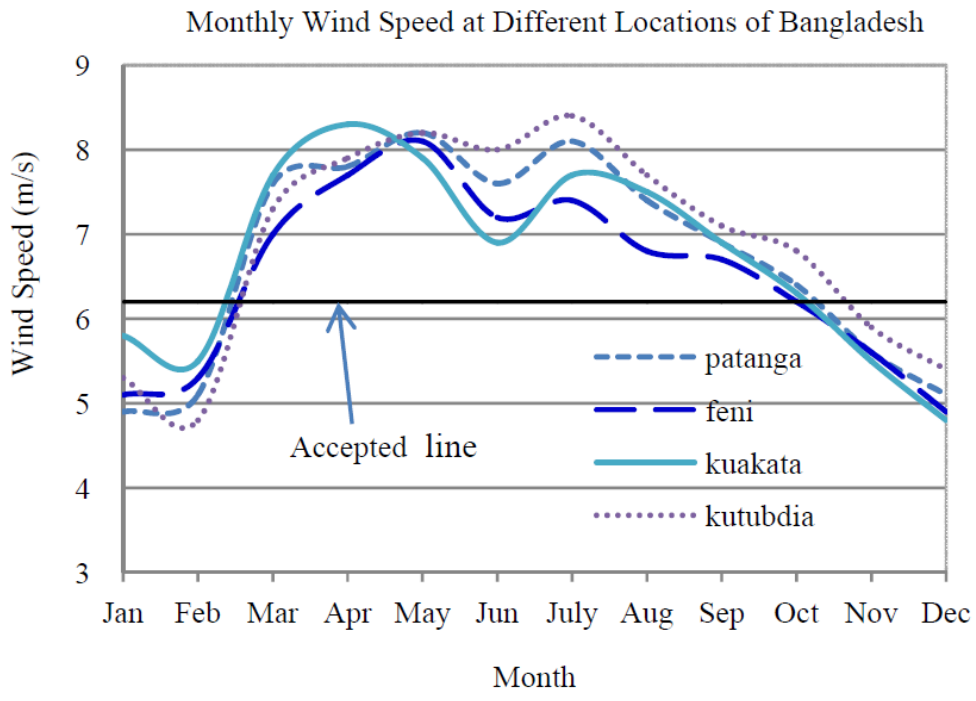


Figure: Wind speed at different locations at 50 meters height conducted by BPDB [Hossain, M.A. and Ahmed, M.R., 2013. Present energy scenario and potentiality of wind energy in Bangladesh. *World Academy of Science, Engineering and Technology*, *7*(11), pp.1001-1005]

At 3 m/s wind speed, Modern Turbines start to produce energy. But at 3 m/s, wind resource may not be economically viable. At present, 5-6 m/s wind speed is considered as the minimum wind speed needed for initiating a wind project. If wind speed of 5.75 m/s is taken as the minimum, the economically viable wind electricity potential of the country stands at 34,130MW using gross land of 20,727 km^2. Exactly how much of this potential can be

realized, will depend on the actual amount of land which can be brought under wind power generation. Unlike solar or hydro, while developing wind power, the country need not worry about losing agricultural land because land used for generating wind power can simultaneously be used for other purposes like agriculture. If even one tenth of the wind power potential is realized, wind power capacity will stand at 3000MW which will be a great achievement for Bangladesh. Although this estimate is not realistic when proper filters are applied to screen out undesirable land for wind development, it suggests that Bangladesh's 10% renewable target by 2021 is achievable.

To meet the target, government has already taken a number of projects. Wind resource mapping is going on in 13 locations and data collection cycle has been completed by 2017. Several wind projects have been initiated after 2017.

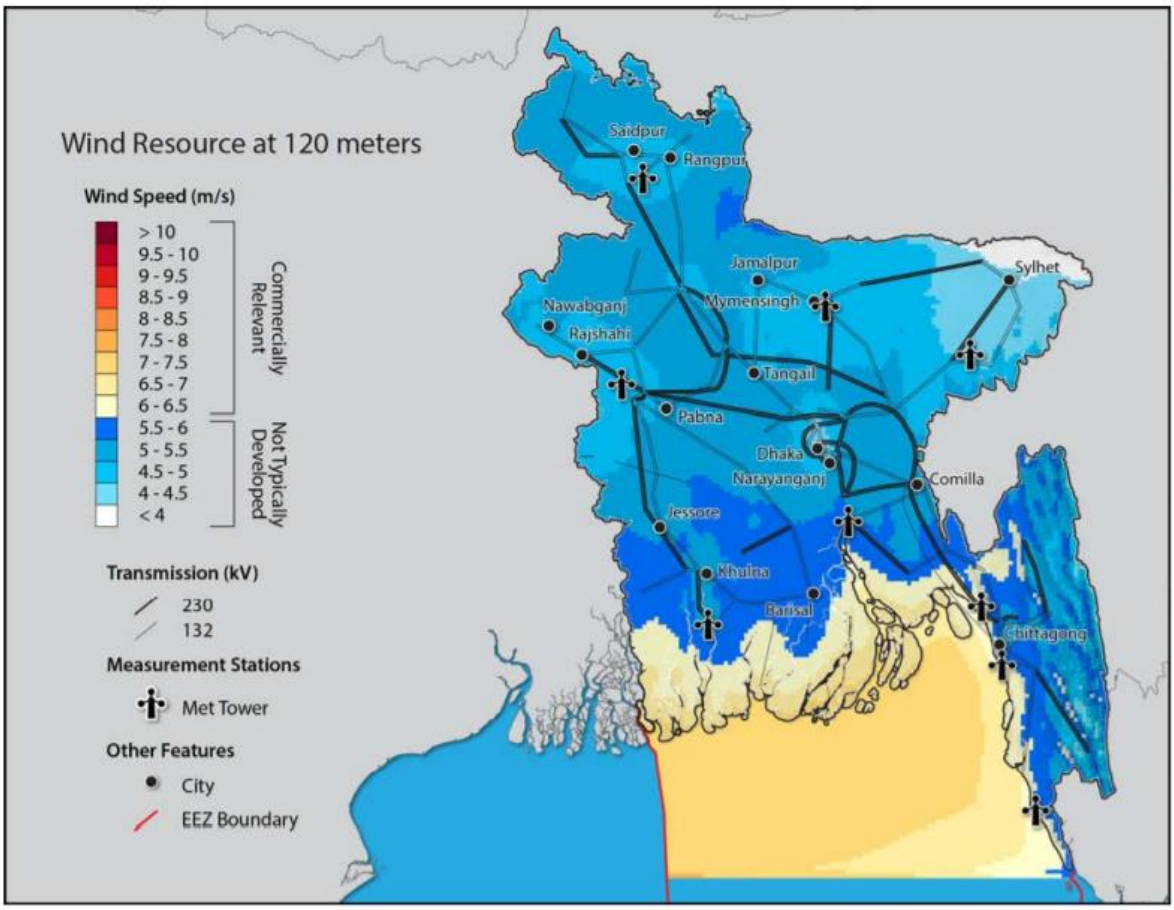


Figure: Wind resource map of Bangladesh and measurement locations

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. The Table showing some ongoing and future projects for Wind energy-to-electricity is given below:

No.	Name of the Project	Capacity	Location	RE Technology	Agency	Finance	Completion Date	Present Status
1	Design, Supply, Installation, Testing and Commissioning of 2 MW Capacity Wind Power Plant on turnkey basis at the bank of the River Jamuna adjacent to the existing Sirajganj 150 MW Power Plant, Sirajganj, Bangladesh	2 MW	Sirajganj Sadar Upazila, Sirajgonj	Wind (On-Grid)	BPDB	Self	2019-01-14	Implementation Ongoing
2	10 MW Wind Power Plant	10 MW	Kalapara Upazila, Patuakhali	Wind (On-Grid)	RPCL	GoB	2022-12-31	Under Planning
3	Feasibility Study for Installation of Wind Firm in Matarbari Island	0 kW	Maheshkhali Upazila, Cox's Bazar	Wind (On-Grid)	CPGCBL	GoB	2019-06-30	Under Planning
4	"60 MW Wind Power Project" at Cox's Bazar by US-DK Green Energy (BD) Ltd	60 MW	Chakaria Upazila, Cox's Bazar	Wind (On-Grid)	BPDB	IPP (Unsolicited)	2017-11-30	Under Planning

5.4. Biogas and Biomass Energy:

Biogas is the mixture of different gases produced by the breakdown of organic matter and typically biogas is produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Biogas plants not only provide gas for cooking purpose but also produce organic fertilizer for the crops and fish pond. 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

There are several active programs and projects to build biogas digesters all over rural Bangladesh. The most successful are those based on poultry waste. Some of these are using the gas to generate electricity. The biogas program started way back in 1975, and thousands of household digesters have been set up, but total working plants will be less than 100,000.

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. Together they can produce around 1.09 MW electricity. But one ongoing Biogas-to-electricity project is considered as the Largest Biogas project in the country and it will be completed at the end of 2020. Details about this project is listed below.

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

In a nutshell, Renewable Energy Year-wise targeted plan can be shown below:

Technology	**Achivement upto 2016 (MW)**	**2017 (MW)**	**2018 (MW)**	**2019 (MW)**	**2020 (MW)**	**2021 (MW)**	**Total (MW)**
Solar	200	120	350	250	300	250	1470
Wind	2.9	50	150	350	300	300	1153
Biomas	0	6	6	6	6	6	30
Biogas	5	0	0.5	0.5	0.5	0.5	7
Hydro	230	-	1	1	2	2	236
Total	**437.9**	**176**	**507.5**	**607.5**	**608.5**	**558.5**	**2896**

5.5.Ocean Wave, Tidal and Geothermal Energy: Ocean wave generated from waves in sea can also be converted to electricity. Same thing goes for tidal surges in the rivers. Though we have not enough survey regarding this, utilization of these sources is quite impossible. Coastal areas of Bangladesh are prone to cyclones which diminishes the security of such infrastructure. We observe 2-5 m tidal rise in the coastal islands like Sandwip and other rivers in Khulna, Satkhira and Barishal etc, but effectiveness of power generation from these sites are still questionable. Geothermal energy is the energy trapped beneath the e4arth surface. Extraction of these energy and conversion into electricity can also be performed. Such infrastructure is environment friendly and can be implemented in small to large scales but we do not have mapping of hot-spots for this. Scarcity of land may also accompany to the failure of such initiative.

5.6. Policy landscape of Renewable Energy in Bangladesh and current statistics

Government has formulated several policies to ensure the increasing use of renewable energy as shown in the following table.

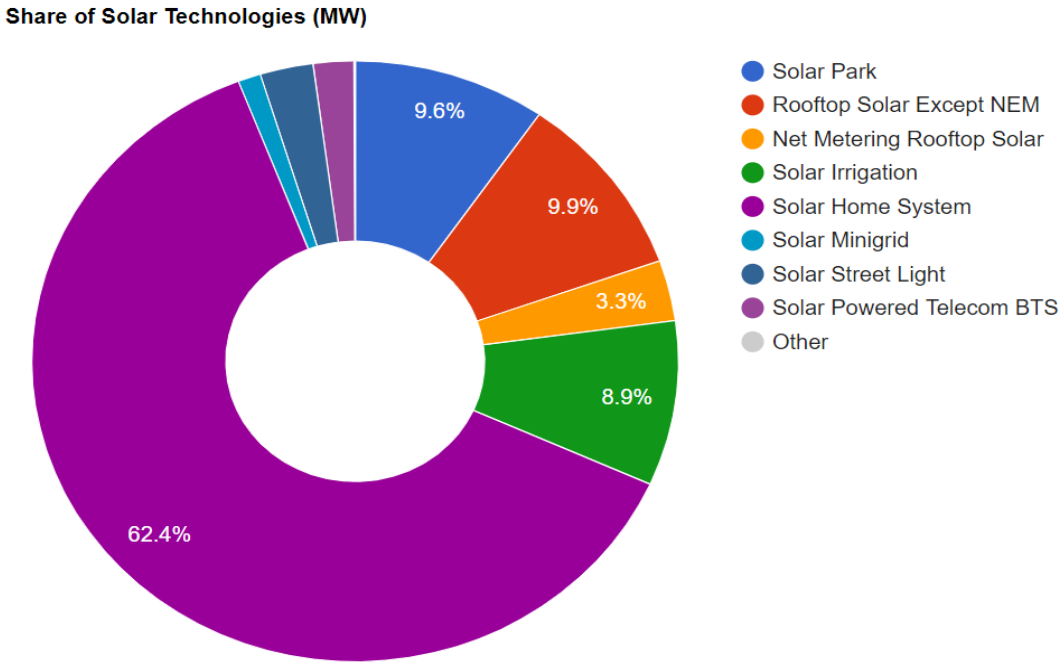
Policy	Aims
Private Sector Power Generation Policy, 1996	Incentivizes private power companies including renewable power producers
Bangladesh Energy Regulatory Commission Act, 2003	Any operator involved in generation, transmission, distribution, marketing, supply or energy storage must operate under a license from the BERC. Electricity tariffs are set by the BERC.
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
7th Five Year Plan, FY 2016-FY 2020	Scalable power generation from solar & wind is emphasized
Power System Master Plan,	Detailed roadmap of the power sector development upto 2041 with one of the objectives to maximise green energy. At least

2016	10% generation from RE is emphasised.
Net Metering Guidelines, 2018	Up to 3 MW may be exported to the grid.
International Cooperation	▪ Member of International Renewable Energy Agency (IRENA) ▪ Founding Member of International Solar Alliance (ISA) ▪ Joint Crediting Mechanism (JCM) with Japan in 2013
Dedicated Financing	▪ BB's revolving fund of Taka 2 (Two) Billion ▪ Bangladesh Climate Change Trust Fund (BCCTF) has allocated Tk.3500 Crore during FY10-FY 19. ▪ Bangladesh Climate Change Resilience Fund (BCCRF) ▪ Infrastructure Development Company Limited (IDCOL) ▪ Bangladesh Infrastructure Finance Fund Limited (BIFFL)

Energy generation summary from renewable sources:

RE Source	Technology	Quantity	Off-grid (MW)	On-grid (MW)	Total (MW)
Solar	Solar Home System	5804222	248.29	0	248.29
	Rooftop Solar except NEM	109	14.477	25.027	39.504
	Net Metering Rooftop Solar	878	0	12.947	12.947
	Solar Park	4	0	38.4	38.4
	Solar Mini-grid	1271	35.337	0	35.337
	Solar Micro-grid	21	0	4.538	4.538
	Solar Nano-grid	0	0	0	0
	Solar Irrigation	2	0	0.001	0.001
	Solar Charging Station	13	0.251	0.016	0.267
	Solar Telecom BTS	1933	8.06	0	8.06
	Solar Street Lights	202017	10.59	0	10.59
	Solar Drinking Water System	120	0	0	0
Hydro	Hydro Projects	1	0	230	230
Wind	Wind Projects	3	2	0.9	2.9
Biomass	Biomass to Electricity	1	0.4	0	0.4
Biogas	Biogas To Electricity	6	0.63	0	0.63
	Biogas Plant	76771	0	0	0
Total		**6087372**	**320.035**	**311.829**	**631.864**

From statistics, it is found that 317 MW among current solar energy utilization are installed off-grid while 80.9 MW are on-grid. Solar Energy utilization is observed maximum by solar home system. Rooftop Net metering system, solar mini grids and solar parks are anticipated to increase in coming years. Prices of solar PV panels and battery devices are decreasing dramatically in the recent years due to technological advancements which will make the way of increasing solar rooftop system.



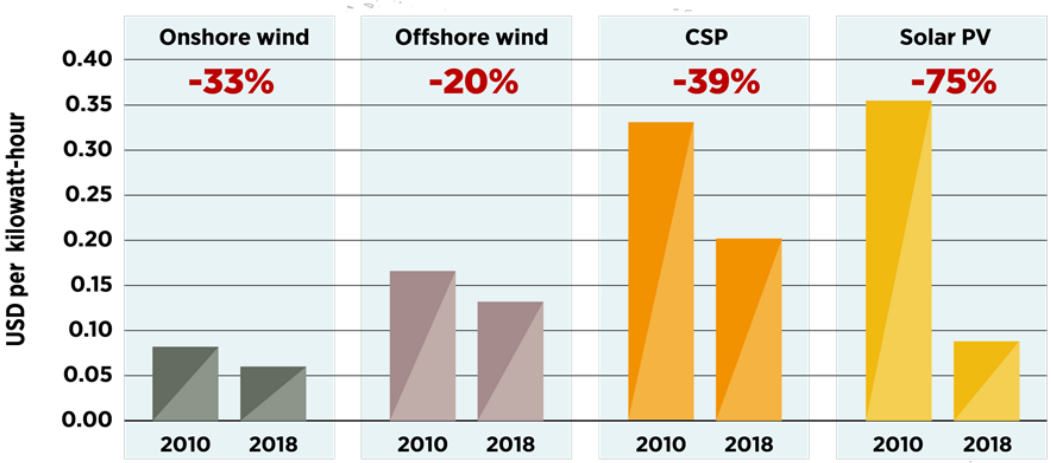
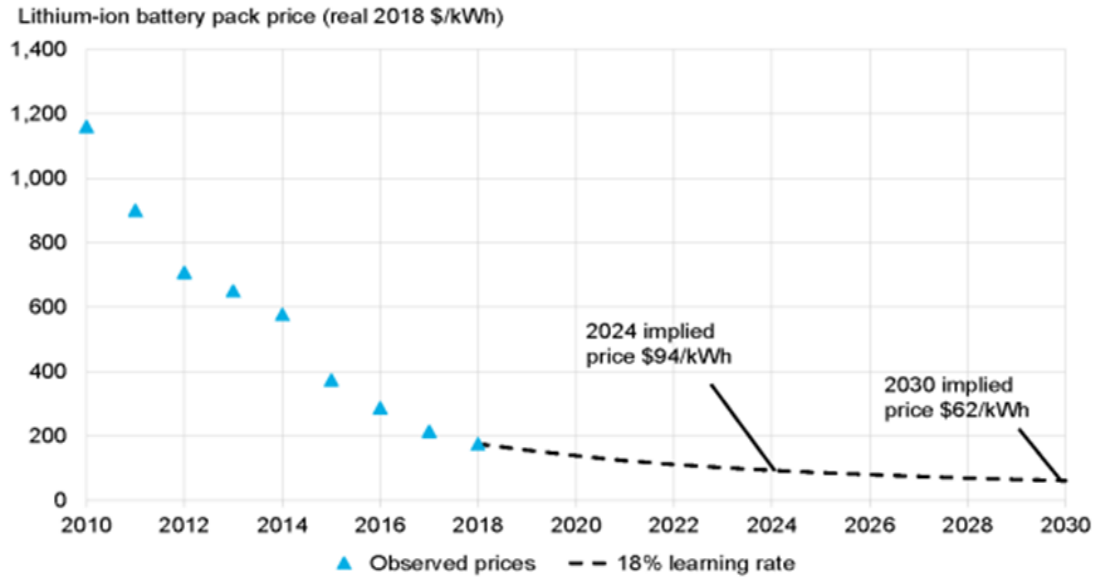


Fig: Price Comparison of Different Technologies (Source: IRENA, 2019)



Source: BloombergNEF.
[Note: This data in this chart has been adjusted to be real in 2018 dollars.]

Future and on-going projects regarding power generation renewable energy:

Under Constructed Projects				
Location	**Generation Capacity (MW)**	**Sector**	**Type**	**Condition**
Sirajganj	7.6	Government	Solar	Under Constructed
Manikganj	35	Private	Solar	Under Constructed
Patgram,Lalmonirhat	5	Private	Solar	Under Constructed
Sutakhali, Mymenshingh	50	Private	Solar	Under Constructed
Gangachar, Rangpur	30	Private	Solar	Under Constructed
Latshal, Gaibandha	200	Private	Solar	Under Constructed
Goynahat, Shylet	5	Private	Solar	Under Constructed
Mongla, Bagherhat	100	Private	Solar	Under Constructed
Teknaf Solar Park	200	Private	Solar	Under Constructed
Dharmapasha, Shunamganj	32	Private	Solar	Under Constructed
Cox's Bazar	60	Private	Wind	Under Constructed
Total	**724.6**			

Public-Private Agreement Projects (LOI & NOA issued)				
Location	**Generation Capacity(MW)**	**Sector**	**Type**	**Condition**
Tetulia, Panchagarh	30	IPP	Solar	LOI issued
Panchagarh Solar Park	50	IPP	Solar	LOI issued
Pabna	100	IPP	Solar	LOI issued
Teesta Barrage, Lalmonirhat	100	IPP	Solar	LOI issued
Dimla, Nilphamari	50	IPP	Solar	LOI issued
Madarganj, Jamalpur	100	IPP	Solar	LOI issued
Sonagazi, Feni	30	IPP	Wind	LOI issued
Debiganj, Panchagarh Solar Park-1	20	IPP	Solar	LOI issued
Total	**527**			

Public-Private Tender Offered Projects				
Location	**Generation Capacity(MW)**	**Sector**	**Type**	**Condition**
Barerhat, Chattogram	50	IPP	Solar	Under Evaluation
Ranguniya, Chattagram	50	IPP	Solar	Under Evaluation
Chuadanga	50	IPP	Solar	Under Evaluation
Netrokona	50	IPP	Solar	Under Evaluation
Inani, Cox's Bazar	50	IPP	Wind	Under Evaluation
Mangla, Bagherhat	50	IPP	Wind	Under Evaluation
Kachua, Chadpur	50	IPP	Wind	Under Evaluation
Total	**350**			

Public & Private under planned projects				
Location	**Generation Capacity(MW)**	**Sector**	**Type**	**Condition**
Sonagazi, Feni	100	Public (BPDB)	Solar	Land Acquisition under process
Gangchara, Rangpur	55	Public (BPDB)	Solar	Land Acquisition under process
Total	**155**			

CHAPTER VI

Conclusion & Recommendations

6.1.Conclusion: In Bangladesh, the proven reserved of natural gas 34 TCF which will lead the country next 20 years and currently82% natural gas consumed in the power sector for power production. Whereas only 3% electricity produced from renewable energy sources. However, Bangladesh government have already announced a master plan for future electricity generation through the demand for power growing faster rate. Therefore, this strategy emphasizes the countries natural resource exploration and discoveries for further improvement of the power sector and reconstruct the renewables energy resource. However, to meet the near future demand Bangladesh needs more sophisticated research facilities and skilled manpower for exploration activities both inland and offshore areas. The government must work with international advanced technology using human intellectuals of the country for energy sustainability. Renewable energy can be considered as a potential alternative to conventional energy that comes from fossil fuel. Currently, there is an immense interest in the use of renewable energy like solar, biofuel, geothermal, wind due to environmental and economic concern. The government of Bangladesh has put significant effort and target to establish different projects on renewable energy which also subsidized by the government. Following points are considered to conclude the findings:

- The high upfront cost is the main disadvantage of installing a solar energy system, largely because of the high cost of the semi-conducting materials used in building it.
- The cost of solar energy is high compared to non-renewable utility supplied electricity. As energy shortages are becoming more common, solar energy is becoming more price-competitive.
- 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 production of solar energy is influenced by the presence of clouds or pollution in the air.
- No solar energy will be produced during night-time although a battery backup system will solve this problem.
- Low solar energy will be produced during rainy season. However, producing electricity with solar system like other renewable energy sources has become a silent revolution in Bangladesh. Solar PV energy is now being successfully used for home lighting as a sustainable source of energy. Though it had started in Bangladesh in the offgrid area for

rural lighting, now urban applications are increasing day by day through hybrid system either through grid. There is a huge possibility of solar energy business in Bangladesh. The Bangladesh government should take necessary steps to motivate the business magnet as well as the consumers.

6.2.Recommendations:

- Government should reduce VAT/taxes on solar accessories and raw materials especially batteries and solar panel and strive to remove the gap between demand and supply.
- Government should provide very low interest loans to rural people for buying the solar system.
- Energy storage should be a priority since solar energy is not available at night, rainy day, and during winter.
- Government must subsidize initial installation costs.
- Government should give more licenses for solar energy business.
- Organization should improve monitoring system on solar system to maintain quality full service.
- Government should set solar energy system in governmental organization to reduce load shedding.
- Organization should give proper training facility to using this system.

References:

[1] BBS (Bangladesh Bureau of Statistics) Statistical Year Book 2011. Government of Bangladesh, Sher-e-Banglanagor, Agargaon, Dhaka, Bangladesh; 2011.

[2] Bahauddin KM, Salahuddin TM. Prospect and trend of renewable energy and its technology towards climate change mitigation and sustainable development in Bangladesh. Int J Adv Renew Energy Res 2012;1:158.

[3] Barua DC. Grameen shakti: pioneering and expanding green energy revolution to rural Bangladesh. In: Proceedings of greening the business and making environment a business opportunity, Jun 5–7, 2007. Bangkok, Thailand; 2007. p2.

[4] Biswas WK. Empowering rural poor through renewable energy technologies in bangladesh, (unpublished Ph.D. thesis). NSW, Sydney, Australia: University of Technology; 2002.

[5] Islam MR, Baksi BK, Momotaz SN. Prospects of renewable energy in Bangladeshfocus on biomass plant. J Bus Res 2002;4:1–18.

[6] Chowdhury ATA, Zaman MH. Uses of alternative forms of sustainable energy: case of solar photovoltaic system in the rural areas of Bangladesh. Int J Bus Manag Tomorrow 2012;2:1–10.

[7] Rasel MAI, Siraj S, Rahman KM. Prospect of renewable energy as the solution of the existing energy crisis of Bangladesh. Int J Sci Eng Res 2012;3:3–5.

[8] Grameen Shakti. One million solar home systems by grameen shakti, solar energy solution. Solar Energy at SolarDaily.com. Mirpur, Dhaka, Bangladesh; 2016.

[9] Uddin SN, Taplin R. Toward sustainable energy development in Bangladesh. J Environ Dev 2008;17:297.

[10] Khan S. An energy saving program for Bangladesh. J Pet Technol Altern Fuels 2011;2(6):87–9. [11] Biswas MM, Das KK, Baqee IA, Sadi MAH, Hossain MSF. Prospects of renewable energy and energy storage systems in Bangladesh and developing economics. Glob J Res Eng: J Gen Eng 2011;11:24–7.

[12] IDCOL. IDCOL biogas and bio-fertilizer program. Present situation of renewable energy in Bangladesh. ⟨http://idcol.org/home/dbiogas⟩; 2016.

[13] Deb A, Bhuiyan MAM, Nasir A. Prospects of solar energy in Bangladesh. IOSR J Electr Electron Eng 2013, [4, 47, 49, 54, 55].

[14] Bahauddi KM, Salahuddin TM. Impact of utilization of solar PV technology among marginalized poor people in rural area of Bangladesh. In: Proceedings of International conference on environmental aspects of Bangladesh (ICEAB 10); 2010. p. 104–5.

[15] 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.

[16] S. Groh, H.J.E.D. Taylor, Microfinance, The role of microfinance in energy access: changing roles, changing paradigms, and future potential, 26 (2015) 307-324.

[17] M. Bazilian, S. Nakhooda, T.J.E.R. Van de Graaf, S. Science, Energy governance and poverty, 1 (2014) 217-225.

[18] A. Islam, E.-S. Chan, Y.H. Taufiq-Yap, M.A.H. Mondal, M. Moniruzzaman, M.J.R. Mridha, S.E. Reviews, Energy security in Bangladesh perspective—An assessment and implication, 32 (2014) 154-171.

[19] P. Action, Poor People's Energy Outlook 2016: National Energy Access Planning from the Bottom Up, Practical Action Publishing, 2016. [6] A.J.E.I.A. Sieminski, International energy outlook, 18 (2014).

[20] B.J.C.S.f.P.o.I. Oil, F.R. Financing Plan for Gas Sector Development, Petrobangla, Dhaka, Gas & Mineral Corporation (Petrobangla), 2012.

[21] S. Groh, S. Pachauri, R.J.E.f.S.D. Narasimha, What are we measuring? An empirical analysis of household electricity access metrics in rural Bangladesh, 30 (2016) 21-31.

[22] I. Habib, Use of digital marketing in brand building efforts, (2015).

[23] B.J.M.P.R. Oil, Gas and Mineral Corporation (Petrobangla), (2007).

[24] M.R. Islam, P.C. Sarker, S.K.J.R. Ghosh, S.E. Reviews, Prospect and advancement of solar irrigation in Bangladesh: A review, 77 (2017) 406- 422.

[25] E.D. Vance, P.C. Brookes, D.S.J.S.b. Jenkinson, Biochemistry, An extraction method for measuring soil microbial biomass C, 19 (1987) 703- 707.

[26] N.G.M.J.G. BPDB, Bangladesh Power Development Board, 88 (2010) 3.76.

[27] B.R. Scanlon, B.L. Ruddell, P.M. Reed, R.I. Hook, C. Zheng, V.C. Tidwell, S.J.W.R.R. Siebert, The food-energy-water nexus: Transforming science for society, 53 (2017) 3550-3556.

[28] A.K. Guha, M.N. Morshed, S. Dey, M.S. Islam, A.J.P. Foisal, Sustainable Eco-Friendly Textile Sludge Management In Bangladesh: Construction And Validation Of Lab Scale Biogas Plant For Generation Of Biogas From Textile Sludge, 37 (2015) 40.17.

[29] G. Plan, Power Division, Ministry of Power, Energy and Mineral Resources, Government of the people‘s republic of Bangladesh, in, 2018. [17] Z. Tan, H. Zhang, J. Xu, J. Wang, C. Yu, J.J.J.o.E.E. Zhang, Photovoltaic power generation in China: Development potential, benefits of energy conservation and emission reduction, 138 (2011) 73-86.

[30] A.S. Islam, M. Islam, T.J.R.E. Rahman, Effective renewable energy activities in Bangladesh, 31 (2006) 677-688. [19] S. Ahmed, M.T. Islam, M.A. Karim, N.M.J.R.E. Karim, Exploitation of renewable energy for sustainable development and overcoming power crisis in Bangladesh, 72 (2014) 223-235. [31] F. Ahmed, A.Q. Al Amin, M. Hasanuzzaman, R.J.R. Saidur, S.E. Reviews, Alternative energy resources in Bangladesh and future prospect, 25 (2013) 698-707.

[32] M. Hossain, Achieving Sustainable Energy Targets in Bangladesh, The Magazine of the United Nations, (2015).

[33] T. Jilani, K. Gomi, Y. Matsuoka, Integration of sustainable and low carbon society towards 2025 in Bangladesh, in: international conference on climate change effects and energy development in Bangladesh, Germany, 2011.

[34] B.K. Sovacool, I.M. Drupady, Energy access, poverty, and development: the governance of small-scale renewable energy in developing Asia, Routledge, 2016.

[35] 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.

[36] 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.

[37] 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.

[38] 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.

[39] 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.

[40] B.J.B. Petroleum, London, Statistical review of world energy 2007, (2009). [30] M. Hassanuzzaman, A. Shahriar, S.T. Faisal, Geothermal energy and its scope in Bangladesh, in: Developments in Renewable Energy Technology (ICDRET), 2014 3rd International Conference on the, IEEE, 2014, pp. 1-5. [31] P. Bhowmik, S. Barua, Prospect of Nuclear Power Plant in Bangladesh, Gas, 70 90.