POSSIBILITY OF RENEWABLE AND SUSTAINABLE ENERGY IN BANGLADESH

Submitted by:

Abdur Rahim

ID: 191-33-906

Mostak Ahmed

ID: 191-33-920

A project and thesis that were submitted in partial completion of the criteria for the award of a degree.

Bachelor of Science in Electrical & Electronic Engineering.

Supervised by:

Professor Dr. Md. Shahid Ullah

Professor

Department of Electrical & Electronic Engineering

Daffodil International University

Co Supervised by:

Jahidul Islam

Lecturer

Department of Electrical & Electronic Engineering

Daffodil International University

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

FACULTY OF ENGINEERING

DAFFODIL INTERNATIONAL UNIVERSITY

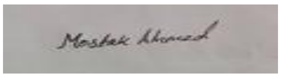
AUGUST –2022

CERTIFICATION

The thesis titled "Possibility of renewable and sustainable Energy in Bangladesh" was completed under the supervision of Professor Dr. Md. Shahid Ullah (Professor), Co supervision Jahidul Islam (Lecturer) of Department of Electrical & Electronic Engineering, Daffodil International University in Dhaka, Bangladesh, approved it as partial fulfillment of the Bachelor of Science in Electrical & Electronic Engineering requirement. To the best of our knowledge and belief, the capstone contains no material previously published or authored by another individual, save when fair mention is given in the capstone itself.

Signature of the candidates

Name: Abdur Rahim
ID #: 191-33-906



Name: Mostak Ahmed
ID #: 191-33-920

Countersigned

Md. Jahidul Islam
(Co-Supervisor)
Lecturer
Department of Electrical & Electronic Engineering
Daffodil International University.
Daffodil Smart City, Ashulia, Dhaka

The title of the project and thesis is “Possibility of Renewable and Sustainable Energy in Bangladesh” submitted by Abdur Rahim, ID No: 191-33-906, Mostak Ahmed, ID No: 191-33-920, Session: Spring 2019 has been acknowledged as satisfactory in substantial fulfillment of the process for the Bachelor of Science in Electrical and Electronic Engineering degree, which will be awarded in August, 2022.

BOARD OF EXAMINERS

Professor Dr. Md. Shahid Ullah

(Supervisor)

Department of Electrical and Electronic Engineering

Daffodil International University

Daffodil Smart City, Ashulia, Dhaka

Md. Jahidul Islam

(Co-Supervisor)

Department of Electrical and Electronic Engineering

Daffodil International University

Daffodil Smart City, Ashulia, Dhaka

Member (Internal)

Department of Electrical and Electronic Engineering

Daffodil International University

Daffodil Smart City, Ashulia, Dhaka

Member (Internal)

Department of Electrical and Electronic Engineering

Daffodil International University

Daffodil Smart City, Ashulia, Dhaka

DEDICATED TO

PARENTS

CONTENTS

TABLE OF CONTENTS

CHAPTER NAME

LIST OF FIGURE

LIST OF TABLE

LIST OF ABBREVIATIONS

HVDC	High voltage direct current
VSC	Voltage Source Converter
CSC	Current source converter
IGBT	insulated gate bipolar transistor
VSC-HVDC	Voltage Source Converter-High voltage direct current
CB	Circuit breaker
LCC	Line Commutated Converter
DCCB	Direct Current Circuit Breaker
SSCB	Solid state circuit breaker
UFD	Ultra-Fast Disconnector
SiC JFET	Silicon Carbide Junction Field Effect Transistor
GCT	Gate Commutated Thyristor
GTO	Gate Turn-Off Thyristor
IGCT	Insulated Gate Commutated Thyristor
WBG	Wide band gap
FET	Field-effect transistor
MOSFET	Metal oxide semiconductor field effect transistor
RCD	Resistor-capacitor diode
MOV	Metal Oxide Varistor

SiO	Silicon oxide
ZnO	Zinc oxide
TVS	Transient Voltage Suppression
MVDC	Medium voltage direct current
LCS	Load Commutation Switch
ARPA–E	Advanced Research Projects Agency–Energy
GaN	Gallium nitride
SiC	Silicon carbide

ACKNOWLEDGEMENT

First of all, we are grateful to the great Creator and to our teachers, who have helped us to do the practical work that has resulted in a Bachelor of Science degree in Electrical and Electronic Engineering. The author to express his sincere appreciation gratitude to his supervisor, Professor Dr. Md. Shahid Ullah, Professor and Co supervisor, Jahidul Islam, Lecturer, Department of Electrical & Electronic Engineering, DIU, for his invaluable suggestions and support, continuous and inspirations, and continued encouragement throughout the progress of the project.

We are grateful to Dr. Md. Rezwanul Ahsan, Associate Professor and Head of the Department of Electrical and Electronic Engineering, for his instruction, guidance, support, and consistent encouragement. We would also like to thank our classmates who helped us with their experience and some tools to make the project a reality.

We'd want to thank our beloved family for their constant support, and also their inspiration and encouragement, throughout our stay at this university.

ABSTRACT

Bangladesh has made questionable economic and environmental decisions in order to provide energy to its 160 million citizens. About 65 percent of its electricity-generating capacity is reliant on gas, which is underutilized. Although natural gas is environmentally favorable, the option to install gas-powered generators is economically dubious because Bangladesh lacks a reliable gas supply and the infrastructure to import it. To fulfill the rising need for electricity, the administration has turned to leasing it from oil-based rental power plants, which are both expensive and environmentally unfriendly. Energy supply that is reliable, economical, and secure is critical for socioeconomic growth. Bangladesh, with a serious power crisis, the country is currently focusing on developing renewable resources in addition to the above-mentioned fossil fuel sources. It has limited nonrenewable energy sources, but renewable energy sources including biomass, biogas, wind, hydro, and solar insulation are plentiful. From the perspective of Bangladesh, the following research paper analyses solar energy potential. Solar technologies such as photovoltaic cells and status of renewable energy are addressed in terms of their ideal capacity, efficiency, storage facility, and cost per unit power. Some cultural, financial, and environmental impediments to solar technology adoption, as well as potential remedies, are highlighted.

CHAPTER-1

INTRODUCTION

1.1 Theme of the Research

Bangladesh as a populous and developing country needs to produce a lot of energy every year, but climate change due to greenhouse gas emissions, and energy constraints are disrupting almost all economies. There is currently no alternative to renewable energy to keep this economy moving, which the developed countries of the world took steps on long ago. Bangladesh is environmentally very fortunate in terms of proper utilization and production of renewable energy, but Bangladesh's long-term only option for harnessing this environment for energy supply is renewable energy sources. Among them, the most important renewable energy sources are - Solar Energy, Wind Energy, Hydro Power, Bio-Gas, Biomass, Photovoltaic Cells (PV), Solar Thermal Energy etc. [1]

At present, Bangladesh is able to produce about 25514 MW of electricity and the generation capacity is about 14423 MW. Through this research, the current source and status of renewable energy in Bangladesh is highlighted. Notable among them are solar and wind power – solar power/solar panels, sometimes called photovoltaic cells (PV), are solid-state electrical devices that convert light into electrical energy. Bangladesh's sunlight plays an essential role in generating solar energy. Bangladesh enjoys about 7.6 hours of bright sunlight during the dry season compared to about 4.7 hours during the monsoon season, which plays a major role in solar thermal energy generation.

Through this study, zone wise annual wind energy, air mass and biogas energy current status and future potential of regions like Dhaka, Chittagong, Comilla, Mymensingh, Sylhet, Khulna, Barisal, Raj Shahi, Rangpur have been highlighted. We are doing various researches for its progress and are ongoing. Solar thermal system or photovoltaic cell (PV), silicon, thin-film photovoltaic, organic photovoltaic can be used to produce renewable energy at low cost. This will save both cost and environment damage.

Above all, through this research, we can get a better idea about the renewable energy of Bangladesh and it will be helpful in building a productive and self-reliant country in the future.

CHAPTER-2

PRESENT POWER SCENARIO OF BANGLADESH

2.1 Present Power Scenario of Bangladesh

Since like March 2022, Bangladesh's capacity for electricity production is estimated to be about 25,556 MW, 3,208 MW are off-grid while 22,348 MW are on the grid (as of 20 June, 2022)

Bangladesh's energy industry is flourishing. The 2.4 GW Rooppur Nuclear Power Plant in Bangladesh has actually started development; it is scheduled to start operating in 2023. In March 2022, the whole population has access to electricity, according to the Bangladesh Power Development Board (BPDB). [2] Bangladesh is thought to have low per capita energy usage, nonetheless. It is indicated by figure 1 below:

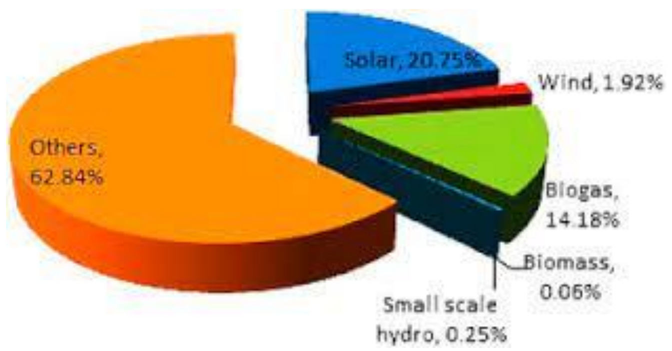


Figure 1 Current energy scenario of Bangladesh

The term power refers to the entire amount of power, which includes controlled electricity from many resources like fossil fuel, wind, biogas, biomass, solar energy, and hydroelectricity. In order to meet the demand predicted by the grand plan 2030, Bangladesh has already been increasing its power production. Table-1 below shows the current power position of Bangladesh.

Table 1Bangladesh Power Sector at a Glance (July 2022)

Sector	2022
Generation Capacity	25,514 MW as of March 2022
Highest Generation	14423 MW on April 12, 2022
Power plants	120 (2022)
Per Capita	433 kWh
Total Consumers	100% Population
Transmission Lines	12835.94
Distribution lines (Km)	50000 Km
System loss (%)	14.032%
Distribution loss (%)	10%
Access Electricity (%)	96.20%

2.2 Generation Capacity (July, 2022)

The power generation capacity of various sectors is shown in the table-2 below: [3]

Table 2 The power generation capacity of various sectors

Public Sector	9996 MW (45%)
Private Sector	9896 MW (44%)
Joint Ventures	1244 MW (6%)
Power Import	1160 MW (5%)
Total	22296 MW (100%)

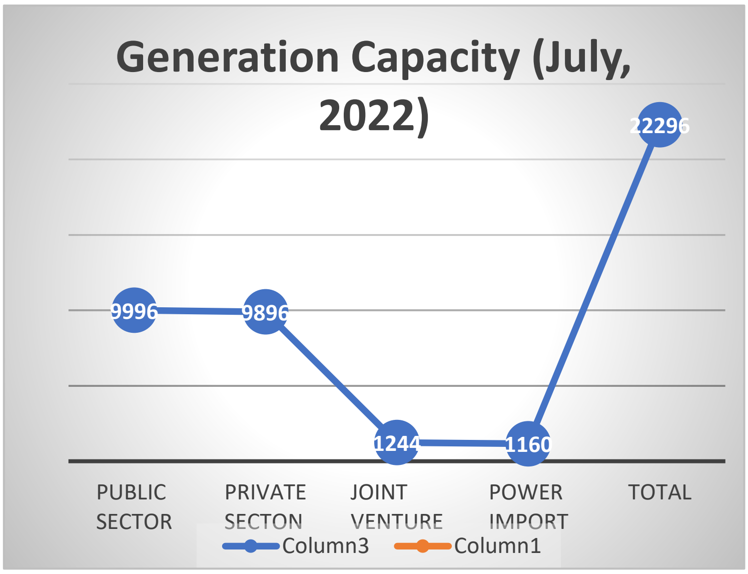


Figure 2 The power generation capacity of various sectors

2.3 Zone Wise Daily Generation Report of 21/07/2022 [4]

Table 3 Zone Wise Daily Generation Report of 21/07/2022

ZONE	Installed Capacity
Dhaka zone	6004
Chittagong zone	2442
Comilla zone	3059
Mymensingh zone	622
Sylhet zone	2522
Khulna zone	2388
Barisal zone	1958
Raj Shahi zone	2124
Rangpur zone	800
Under long term maintenance	800
Total Installed capacity	22348

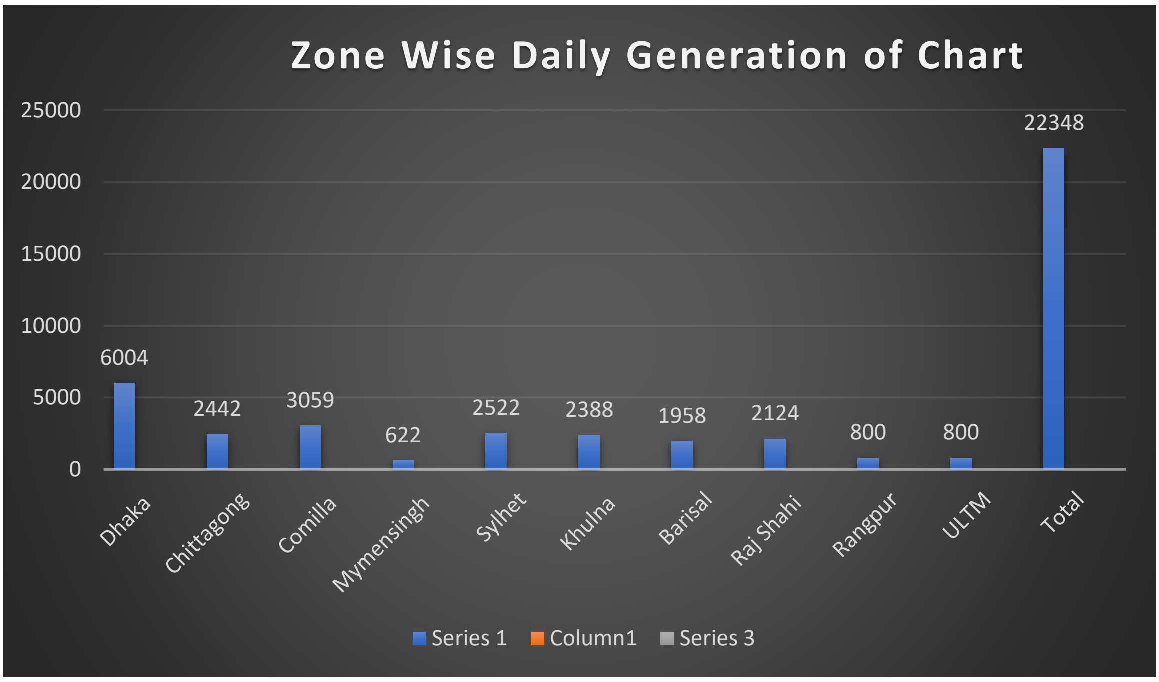


Figure 3 Zone Wise Daily Generation of Chart

2.4 Resources Wise Electricity Generation Mix: [5]

Table 4 Resources Wise Electricity Generation Mix

Resources	Capacity
Coal	1768 MW (6.93%)
Gas	11330 MW (44.38%)
HFO	6238 MW (24.44%)
HSD	1341 MW (5.25%)
Imported	1160 MW (4.54%)
Renewable	891.58 MW (3.49%)
Captive	2800 MW (10.97%)
Total	25529 MW

2.5 Year Wise Commissioning Status of Generation Projects [6]

The consumption prediction for 2030 in the Power System Master Plan was created using a GDP growth rate of 7%. Accelerated power development is necessary to improve access and achieve economic development. A 7 percent annual growth rate in the economy would be ideal. Fiscal year wise commissioning status of generation is presented through table-5

Table 5 Fiscal year wise commissioning status of generation

Fiscal Years	Public Sector (Capacity MW)	Private Sector (Capacity MW)	Total
2010	255	520	775
2011	800	963	1763
2012	607	344	951
2013	587	576	1163
2014	68	567	635
2015	560	793	1357
2016	775	370	1145
2017	967	220	1187
2018	1349	2914	4381
2019	814	1590	2404
2020	709	438	1771
2021	749	575	1324

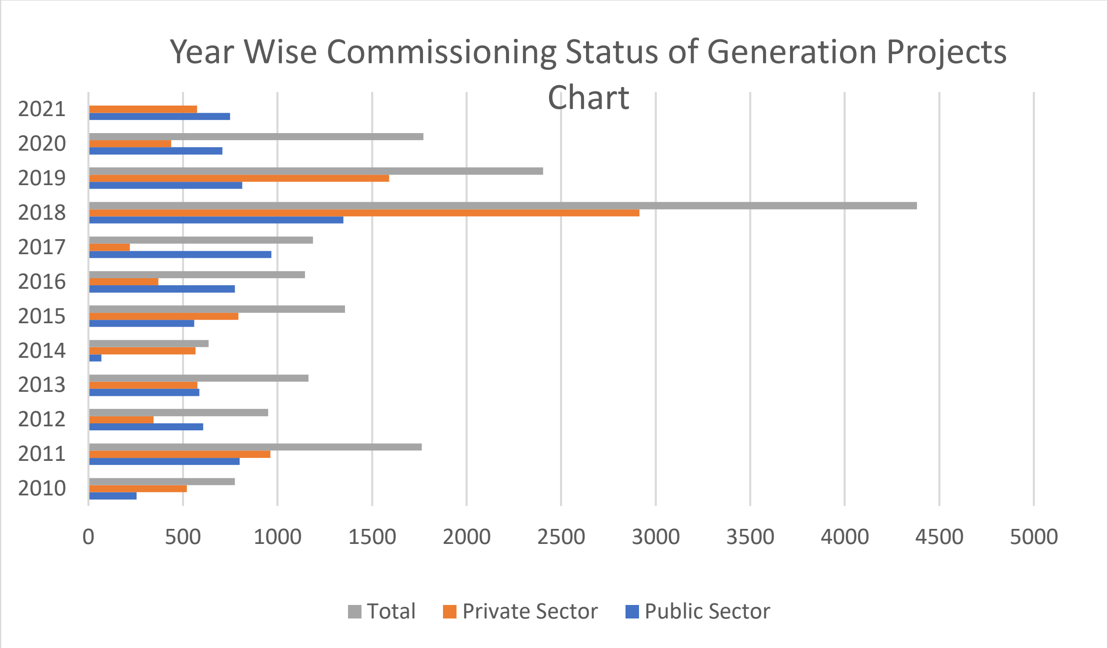


Figure 4 Year Wise Commissioning Status of Generation Projects Chart

2.6 System Loss

One of main performance measures for firms in the electricity sector is systems loss. System loss must be substantially decreased if targeted performance and sector viability are to be achieved. [7] To lessen the system loss, a number of strategies including ongoing utility performance monitoring, reforms, and goal-oriented strategies are put into place.

Table 6 displays the system loss during 2010 to 2022 (July 2022).

Year	Distribution loss	Transmission loss	Total Loss
2010	12.75%	1.98%	14.73%
2011	12.26%	2.35%	14.61%
2012	12.03%	2.58%	14.36%
2013	11.96%	2.17%	14.13%
2014	11.34%	2.2%	13.54%
2015	10.96%	2.14%	13.10%
2016	9.98%	2.21%	12.19%
2017	9.60%	2.27%	11.87%
2018	9.35%	2.61%	11.96%
2019	7.58%	2.45%	10.03%
2020	7.40%	2.5%	9.90%
2021	7.25%	2.2%	9.45%
2022	7.00%	1.98%	8.98%

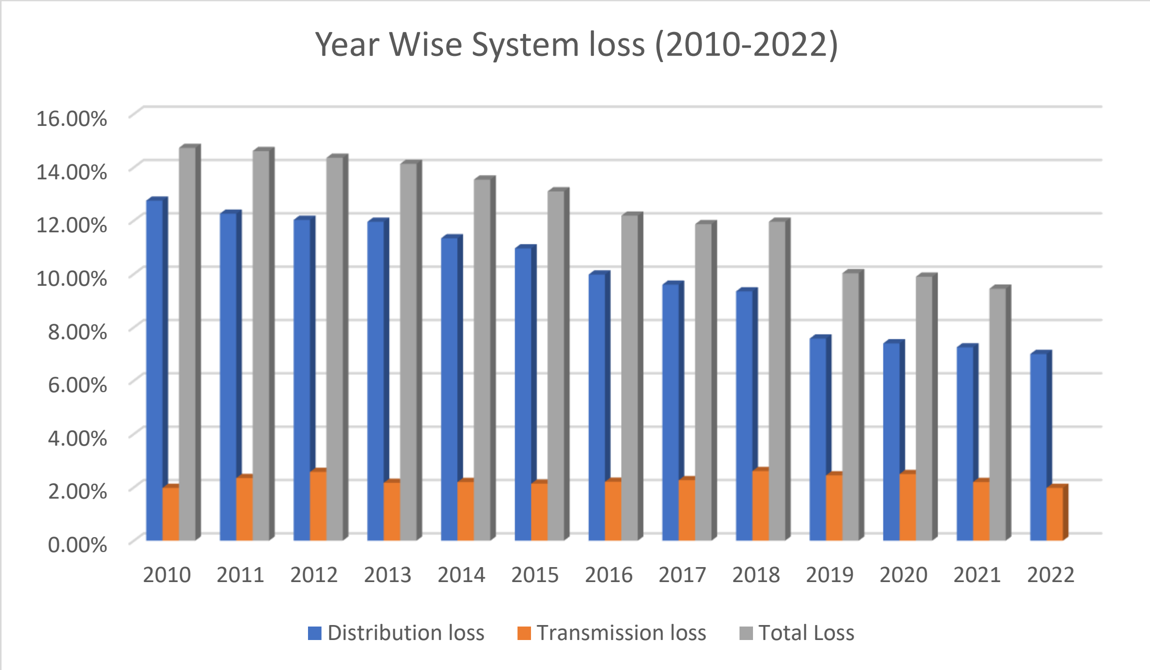


Figure 5 Year Wise System loss (2010-2022)

2.7 Consumption and Generation per capita/kwh

The power bills recently underwent modification by BERC. In all electricity-related segments, the unit rate has gone up a little bit more than before. The revised value rate is necessary for all Bangladeshi electricity branch firms. Bill has to be paid Tk 5.72 per unit for consumers of 76-200 units, Tk 6 per unit for 201-300 units, Tk 6.34 per unit for 301-400 units, Tk 9.94 per unit for 401-600 units, and Tk 11.46 per unit for consumers of over 600 units. [8]

Table 7 Consumption and Generation per capita/kwh

Year	Total Net Generation (GWh)	Total Population (In Million)	Total sale (MkWh)	Per Capita Generation (kWh)	Per Capita Consumption (kWh)
2004-05	21408	137	16338	156.26	119.26
2005-06	22978	140	18128	164.09	129.67
2006-07	23268	142	18696	164.09	131.85
2007-08	24946	144	20415	173.48	141.97
2008-09	26533	146	21955	181.98	150.59
2009-10	29247	148	24596	197.88	166.42
2010-11	31355	150	26587	209.46	177.60

2011-12	35118	152	29974	231.65	197.72
2012-13	38229	154	32740	248.73	213.01
2013-14	42195	156	36233	270.83	232.56
2014-15	45836	158	39624	290.28	250.95
2015-16	52193	160	45299	326.41	283.30
2016-17	57276	162	50264	354.10	310.75
2017-18	62677	164	55103	383.00	336.71
2018-19	70533	166	62037	426.05	374.73
2019-20	71419	168	63364	426.23	378.16
2020-21	80423	169	71470	475.00	422.13

2.8 Impactive of Economical and Environmental

Through this research we will know power production and generation is currently taking place in Bangladesh and its economic and environmental impact on the country. In particular, the production and proper use of renewable energy is protecting the environment from pollution in a big way, currently the government of Bangladesh is undertaking a major plan to expand it. Through this renewable energy production, the country does not have to be dependent on imports and through this, economic new dimensions will be added to the GDP. The most notable among renewable energy are solar PV system, solar home system, wind power, wind gas, wind power, hydro power. [9]

CHAPTER-3

POTENTIAL SOLAR ENERGY IN BANGLADESH (ENVIRONMENAL ANALYSIS)

3.1 Introduction

Every day, a substantial amount of electricity and energy is required inside the globe to continue its development operations as the population increases. Energy may be converted into a variety of forms and moved from one location to another. Since power resources are finite, Asia's energy strategy has established that it must be used cautiously and effectively. Different kinds of energy that can be converted into usable forms for use in industry as well as other applications. The purpose of emerging countries is to provide and create a necessary electrical plant for their population. Bangladesh is just a heavily packed nation in South Asia. Bangladesh is likewise a developing nation with an excessively huge population and insufficient energy in many isolated locations. Bangladesh's government took a step in this direction a few years ago. In 1972, the Bangladesh Power Development Board (BPDB) began operations with just 200 MW of generation capacity. BPDB recently announced a major capability expansion project for power production in Bangladesh. As a result, on May 29, 2019, the installed capacity was increased to 20,000 MW. However, with a total installed capacity of 20,000 MW, maximum power production in 2019 was 12,893 MW, compared to a requirement of 14,796 MW. Bangladesh's power generating capacity has increased to 23,436 MW, including over 97 percent of the population now having access to electricity. In Bangladesh, not that all demand-side energy production is efficient, posing a challenge to the nation's growth and progress. [10]

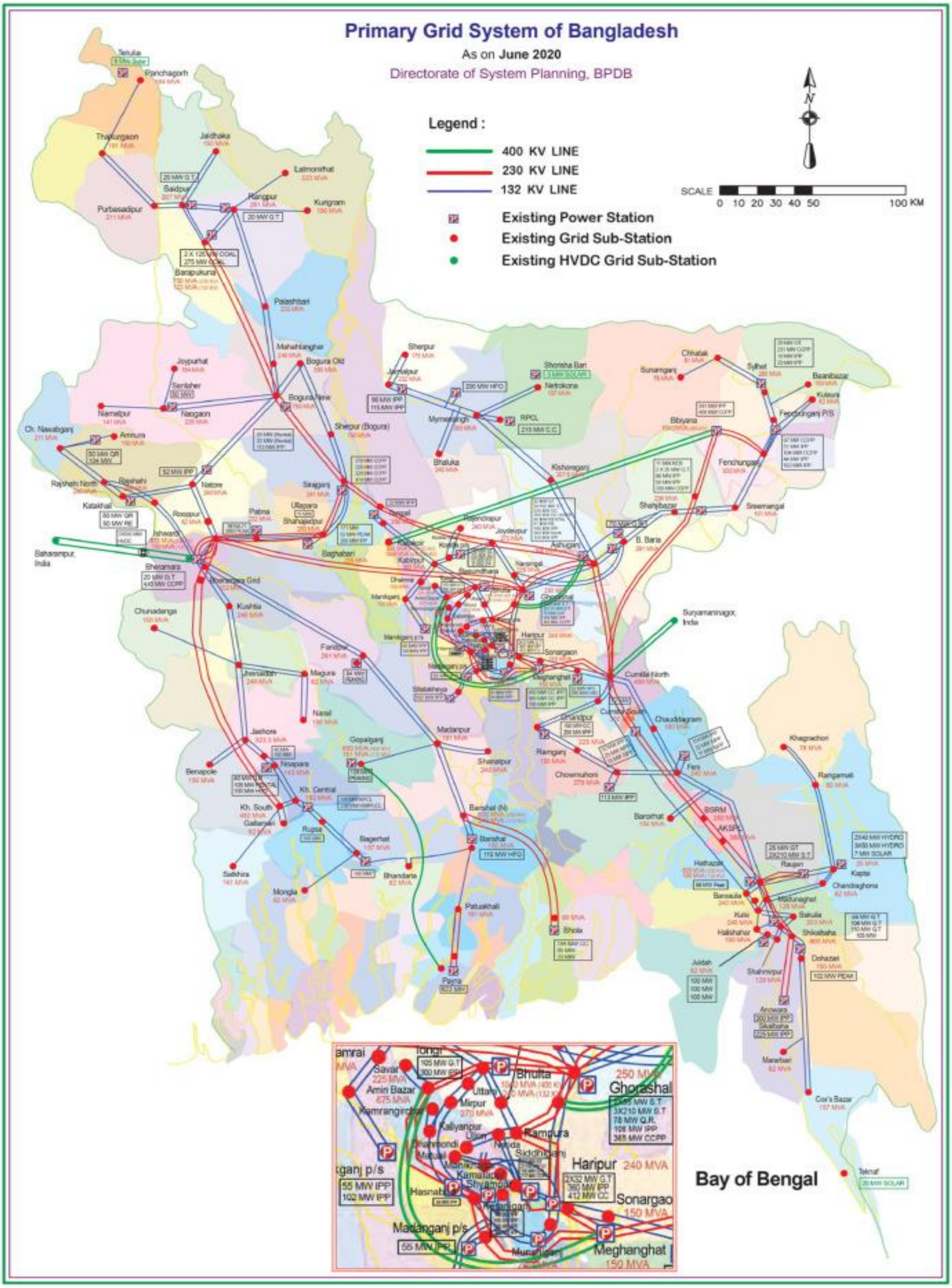


Figure 6 Principal of grid system seen in Bangladesh

Inside the form of solar energy, Bangladesh's prospects for renewable and sustainable energy appear excellent. In Bangladesh's agricultural, mountain, and seaside locations, renewable radiation is a common source of renewable energy. Small and sub plants have previously been created in Bangladesh. Bangladesh aims to create 24,000, 40,000, and 60,000 megawatts of power by 2021, 2030, and 2041, respectively. Although the nation confronts significant challenges in meeting its earlier goal, it has gained pace ever since. We believe it is doable if renewable and sustainable energy sources are expanded for electricity production.

Bangladesh has explored the current and future prospects of renewable and sustainable energy resources in order to combine them into different commercial and public initiatives aimed at meeting the state's energy needs. It would give the government prior recommendations on these industries in order for the government's strategy to be effective.

3.2 Current Situations of Renewable & Sustainable Energy in Bangladesh

- **Solar energy:** Considering rural communities of Bangladesh were located distant from of the power distribution line, the power crisis becomes extremely uncomfortable. The cost and difficulty of providing the grid electricity network in marine and hilly areas is higher. Since they do not even have electricity access, some individuals in Bangladesh are without electricity. Around fifteen million urban people utilize oil lamps inside their home since they don't have access to electricity. In this case, it SHS might be an ideal solution for supplying electricity to those rural communities. Integrating SHS on the roofs of people's dwellings in rural locations can provide immediate benefits. It allows individuals to have lighting in their homes, making it simpler for their children to study at night and watch television. Moreover, by decreasing kerosene usage, it is possible to reduce domestic pollution levels.

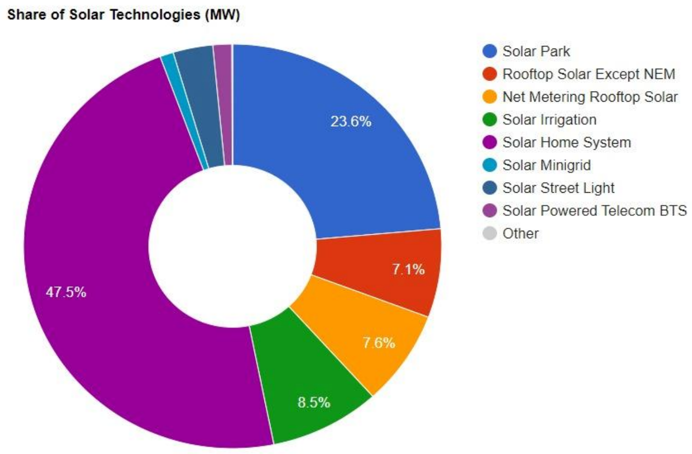


Figure 7 Share of Solar Technology (MW)

Bangladesh is undeniably a tropical nation when it comes to solar exposure. There really is great news for establishing the SHS. The government of Bangladesh have undertaken several significant steps to encourage individuals in urban areas using the SHS. The SHS program was launched by Infrastructure Development Company Limited (IDCOL) in January 2003.

In 2021, every Bangladeshi resident would have access to power, confirming the govt's objective. In January 2019, the firm, which is a Bangladeshi government entity controlled by a non-banking fiscal institute, supported the building of nearly 4.13 million SHS in urban areas (Source: IDCOL Projects and Programs). Bangladesh should devote more resources to enhancing the impact of SHS on economics and fiscal stock prices. First and foremost, SHS recipients can acquire their homes with just a 10% minimum deposit. To pay the remaining money, micro finance institutions (MFI) arrange a monthly payment.

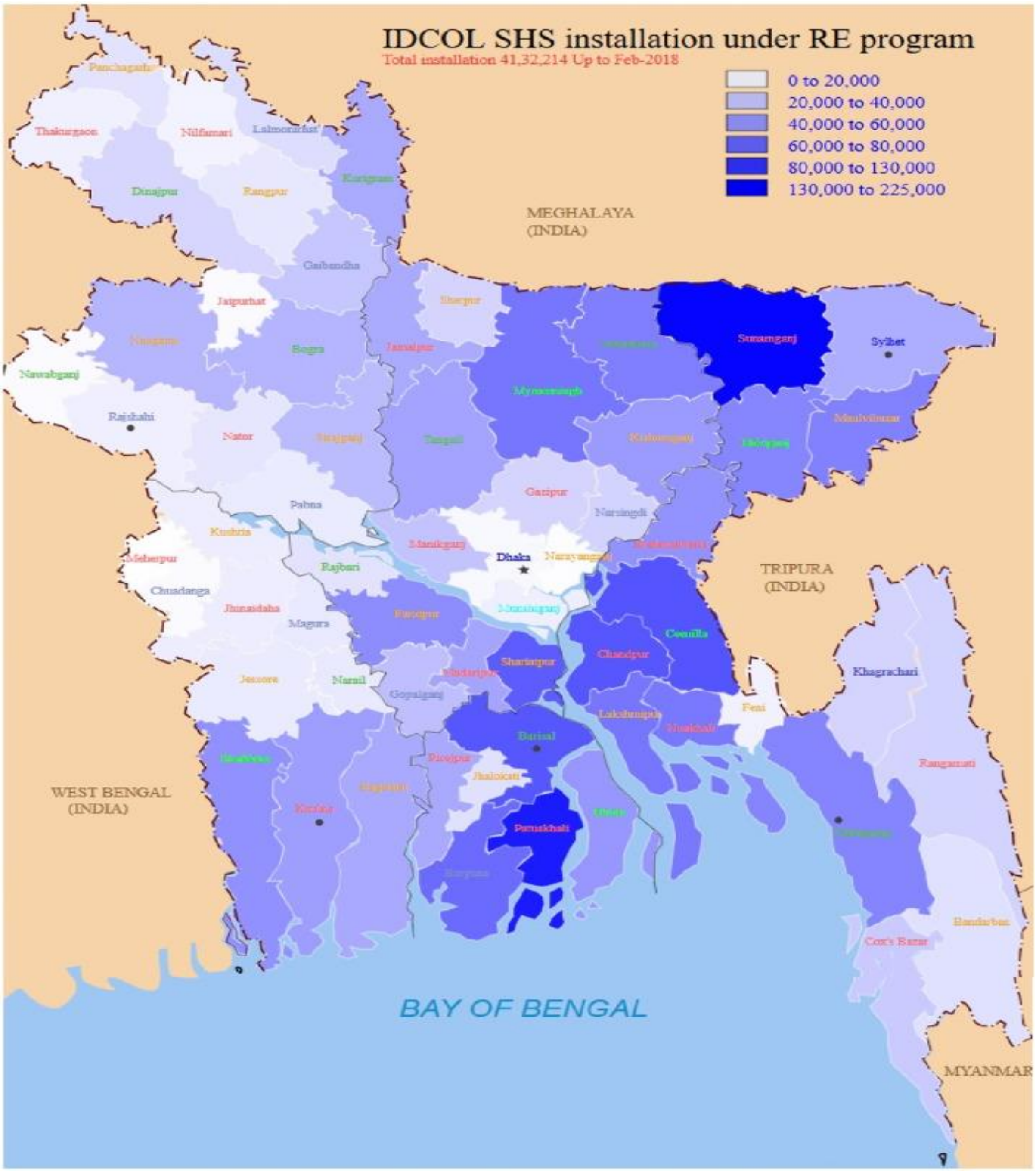


Figure 8 Implementation map of solar home system in Bangladesh (IDCOL)

The current installation of solar home system/renewable energy installed capacity of a total of 554.85 (MW) among the capacity Off-grid capacity of 349.96(MW) and On-grid capacity is 204.9(MW).

This year the report of the Infrastructure Development Company Limited (IDCOL) statistics of Charging station has 0.28 MWp out of 14.4 KWp and the solar irrigation pump install capacity is 42.08 MWp out of 1523 quantities installed.

Table 8 Technology based solar energy generation

Source	Technology	Quantity	Off-grid MWp	On-grid MWp	Total MWp
Solar	Solar Park	7	0	131	131
	Rooftop Solar Except NEM	115	14.201	25.139	39.34
	Net Metering Rooftop Solar	1595	0	42.204	42.204
	Solar Irrigation	2391	46.598	0.732	47.33
	Solar Home System	6037601	263.67	0	263.67
	Solar Mini grid	28	5.805	0	5.805
	Solar Microgrid	0	0	0	0
	Solar Nano grid	2	0.001	0	0.001
	Solar Charging Station	14	0.266	0.016	0.282
	Solar Street Light	296861	17.065	0	17.065
	Solar powered Telecom BTS	1933	8.06	0	8.06
	Solar Drinking Water System	82	0.095	0	0.095
					Total 507.522 MWp

- **Hydro Power:** It's always been valid, and this will continue to just be truly the case, that a safe, stable, and inexpensive consumption of power is critical for any country's economic expansion. The force created by moving water could be converted into electricity. The much more widespread usage of renewable electricity today is the power of moving water dependent on gravitation. The volume of water is utilized to generate hydroelectricity, which is a renewable resource. The globally installed production of hydropower has risen up to 1267 GW, accounting for the greatest share of electricity generated from renewable power sources. Hydroelectric power is a renewable and environmentally favorable way to generate electricity. In Bangladesh, the Karnafuli hydropower project inside the Chittagong hill tract zone was built with such a 230 MW installation ability. The energy station consists of 5 sections. The JICA (Japan International Cooperation Agency) has lent an assist inside the construction of two new unit, each with its own capacity of 50 MW. Bangladesh is building more hydropower projects to ensure the stability of its electrical grid. In 2005, a 50-kW mini-hydro power plant was established in Barkal Upazila, Rangamati neighborhood. Some other mini hydropower station with a capacity of 50 kW is under development in Mirershorai, Chittagong. Other 2 hydroelectric plants proposed by the BPDB in Bangladesh were Matamuhuri (75 MW) and Sangu (50 MW) (140 MW).

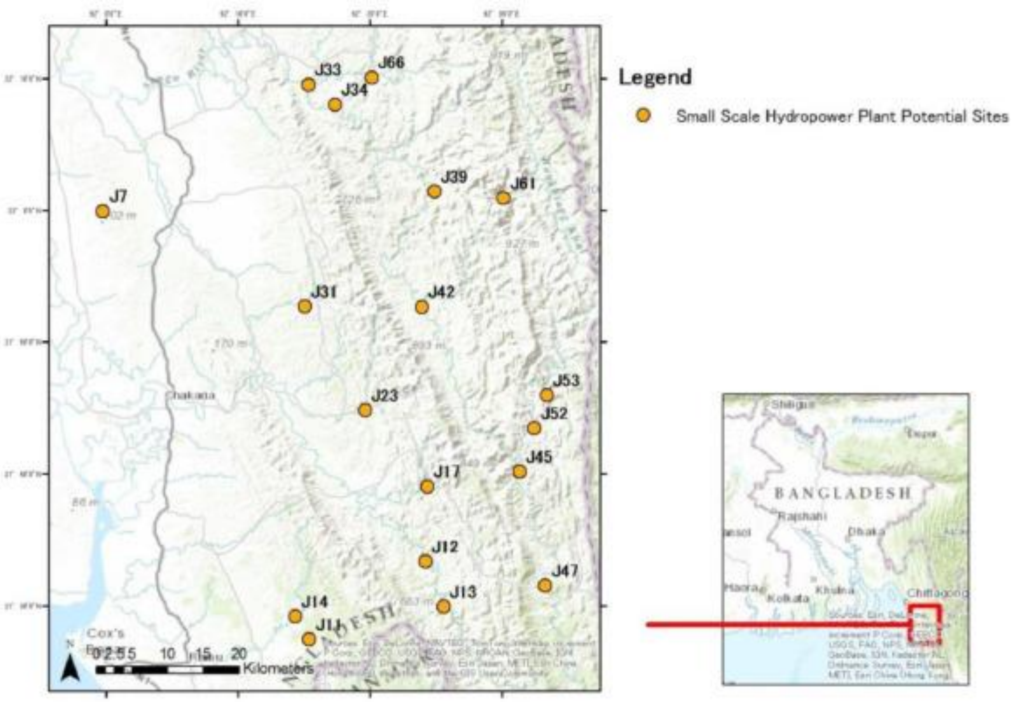


Figure 9 In Bangladesh, a map depicting suitable locations of small-scale hydropower plants has been created.

At present all the hydro projects have technically produced a total of 230 WMp of Off-grid and On-grid in RE generation statistics in 1 quantity. Besides, bigger projects are being undertaken in this sector.

Many possible sites here on Sangu River's tributaries are expected, dry periods when water flow is restricted. As a result, the sites don't really appear to be economically secure. In this situation, those making incredible to be unsuitable for such construction of hydropower plants. We expect that through the govt's sustainable power strategy, pumped space or mini-scale hydropower projects among 30 kW and 5 MW will be developed shortly to help alleviate the current problem.

- **Wind Power:** Wind power is formed by the rotating velocity of a rotor blades via the air which is one of the solar and wind power. Mechanical power could be converted to electrical energy using a conversion form of wind velocity. Geologically, the north and south western parts of Bangladesh were mountainous. The Bay of Bengal is located in the state's southern region. The month of June–July has the highest airspeed, while the month of October–February has the lowest. The north-eastern area has winds of much more than 4.5 m/s, whereas the rest of the nation has winds of roughly 3.5 m/s. In Bangladesh, the air is visible throughout the rainy season. It mostly streams in the coastal area of Bangladesh, like Patenga, Cox's Bazar, Teknaf, Char Fassion, Kutubdia, Sondwip, Kuakata, and Mongla. When cyclones reach these areas, their intensity frequently rises dramatically. It has the potential to have a significant impact as a long-term solution to Bangladesh's electrical dilemma. The air turbines could develop in such places with thorough inquiry and evaluation. Bangladesh's Bay of Bengal is home to a slew of tiny island as well as a 725-kilometer-long coastline. During the summer, the southern section of Bangladesh has significant sustained winds. Wind velocities with in northern section of Bangladesh are at their lowest during the colder months. The fundamental wind velocity maps in Bangladesh is shown in Figure-9.

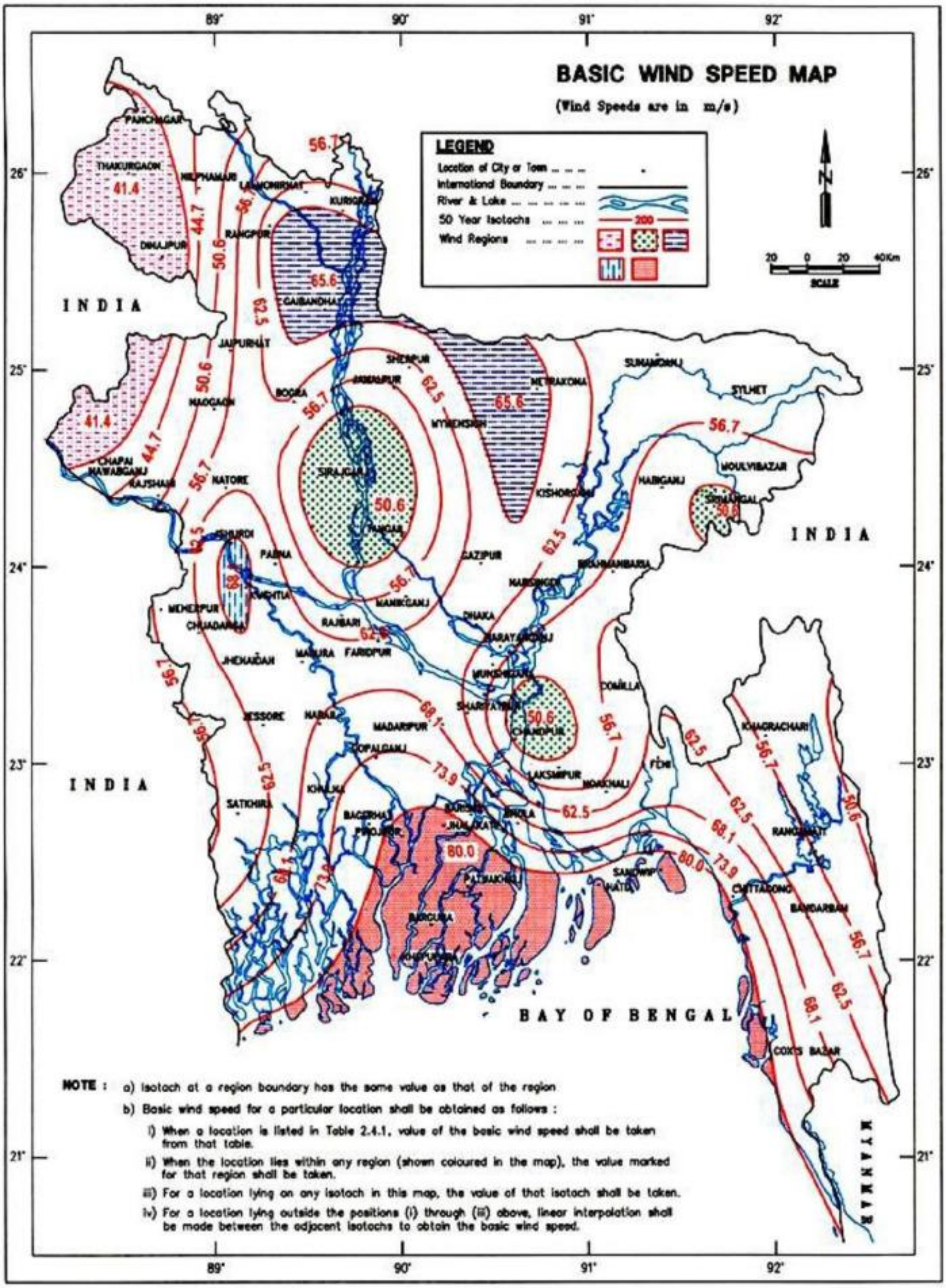


Figure 10 Primary air velocity map in Bangladesh

At present all the wind projects have technically produced a total of 2.9 among of these WMp of Off-grid 2MWp and On-grid 0.9 MWp in Renewable Energy (RE) generation statistics in 3 quantities. Besides, bigger projects are being undertaken in this sector. [11]

- **Others Renewable and Sustainable Power:** Among the really intriguing aspects suggested innovative assessment the hybrids logistics chain for sustainably lighting the Saint Martin Island in Bangladesh is technical improvement of electric drivetrains for energy production. PV systems hybrid methods have been increasingly popular with the off uses among private users in agricultural locations around the world. The approach produces an efficient result in urban places by utilizing natural environment in an expense and long-term manner. The Rohingya refugee movement from Myanmar to Bangladesh has raised awareness about the importance of using power. Bangladesh's government intends to accommodate them by relocating people to the off-grid coastal zone of Bhasan Char. For this region of electricity, the solar-wind hybrid energy system is a viable alternative. In this refugee camp, they might use a solar dish burner for home cooked food. Some population of Bangladesh consume livestock dung or cow manure. They learnt how to build up mini biogas plants at house using cow manure, which allows people to eat or generate energy. The IDCOL biogas development plan in Bangladesh is shown in Figure-10. Biogas continues to play an essential role inside the living in urban power usage. Biogas technique was first introduced in Bangladesh in the early 1970s by the Bangladesh Council of Scientific and Industrial Research (BCSIR) and Bangladesh Agricultural University (BAU). Thus far, approximately 50,000 units have indeed been erected across the state, from a combined power of 4 million biogas plants. With IDCOL's assistance, two rice husk-based power stations with capacities of 250 KW and 400 KW have already been developed at Gazipur and Thakurgaon, respectively. Another seven chicken sludge power stations have already been established now at entrepreneurial sector's desire with IDCOL's assistance on various sites, with combined capacity exceeding 1 MW. With the support of its 38 alliance partners, IDCOL has funded the construction of approximately 53,200 biogas stations around the state till December 2019. Annually, the system security 51,000 tons of timber and saves 45,000 tons of artificial fertilizer. It also offers 3,16,000 tons of organic fertilizer. It also has the potential to save 2,04,000 tons of CO_2 each year. By 2021, IDCOL plans to develop 60,000 biogas stations in Bangladesh. The Gazipur-based Paragon Poultry Limited generates 350 kilo Watts of energy out from trash of 25 million chicken parental equities.

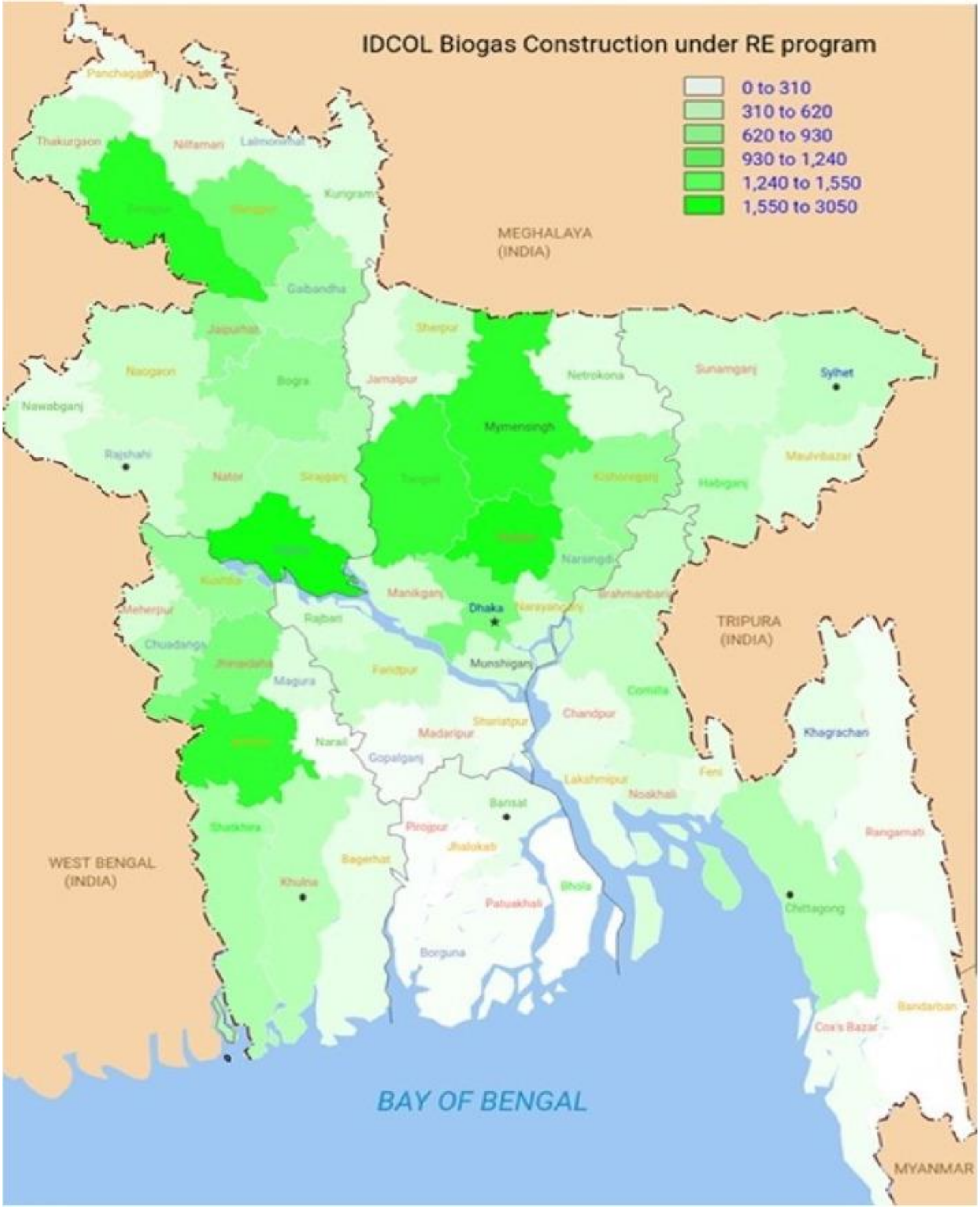


Figure 11 Bangladesh's IDCOL biogas development plan

Biogas and biomass are one of the technologies in renewable energy installation capacity, at present technically its production capacity – Off-grid and On-grid of biogas combined total 0.69MW and total production capacity of biomass Off-grid and On-grid combined 0.4 MW.

3.3 Current capacity of Renewable and Sustainable Power Resources

Bangladesh's government has taken efforts to minimize its reliance on natural gas as energy generation, with plans to shift to coal and nuclear power facilities by 2030. Bangladesh's recent progress of such power generation is insufficient for generating energy. Till far, Bangladesh's effective use of these energy supplies has had insufficient impact on this matter.... According to the administration's objective for 2021, renewable and sustainable electricity production will account for 10% of total capacity. According to this concept, the greatest renewable and sustainable energy generation capacity will be roughly 3700 MW. Table 2 shows Bangladesh's capacity for renewable and sustainable energy. [12]

Table 9 Bangladesh's renewable and sustainable power capacity is expected to be realized by 2021.

Name of the Technology	Install Capacity	Resource of the Energy
Solar Park	131 MWp	solar
Net Metering Rooftop solar	42.63 MWp	solar
Solar Irrigation	47.4 MWp	solar
Solar Rooftop (On-Off Grid)	9.38 MWp	solar
Solar mini, nano Grid	5.8MWP, 1 kWp	solar
Solar Charging System	282.4 kWp	solar
Solar Drinking Water System	95.23 kWp	solar
Solar Home System	263.67 MWp	solar
Solar Street light	17.07 MWp	solar
Wind (On-Off-Grid)	900 kWp/ 2MWp	Wind
Large Hydro (On-Grid)	230 MWp	Hydro
Biogas (Off-Grid)	900 kWp	Biogas
Biomass (Off-Grid)	400 kWp	Biomass
Total Capacity: 741.62MWp		

Renewable and Sustainable power capacity it shown the chart form below.

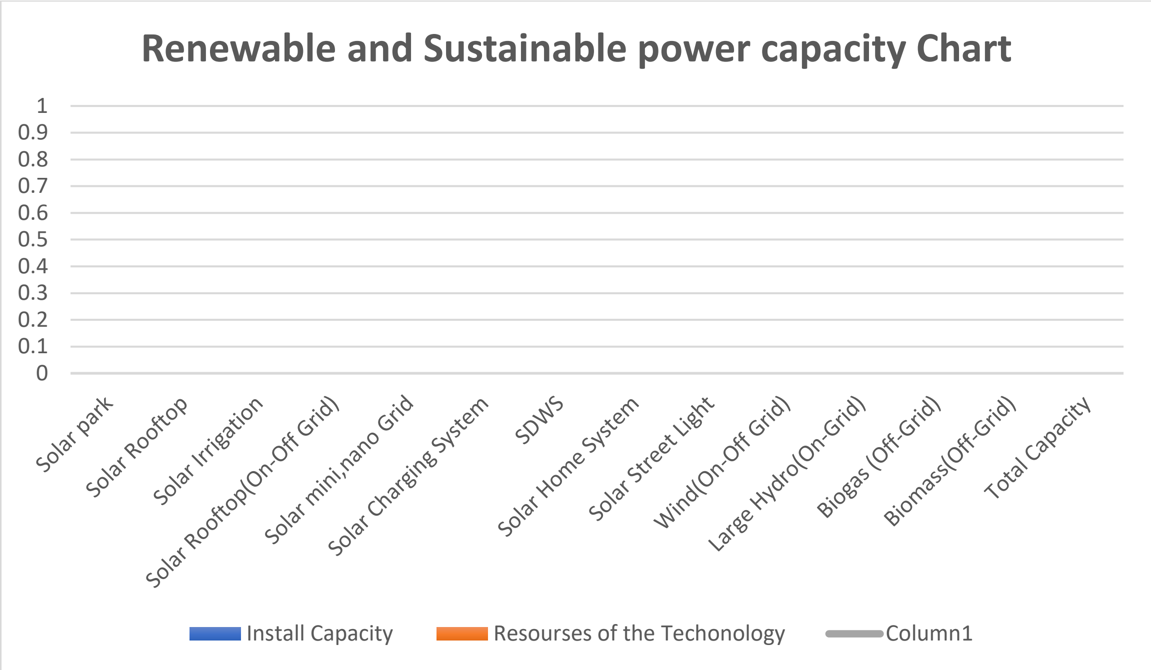


Figure 12 Renewable and Sustainable power capacity source From Sredra

This wind energy system in Bangladesh offers promise in several areas, including Chandpur's Kachua, Khulna's Mongla, Patuakhali's Kuakata beach, and Cox's Bazar's Inani beach. Coastal areas (where wind blows at high speeds) can use winds energy efficiently than every place in Bangladesh. In order for wind energy to create energy in Bangladesh, certain areas must be kept in mind. examined the potential of wind power for electricity generation using various transection techniques. In Bangladesh's Kutubdia Island, researchers looked into the viability of wind power generation.

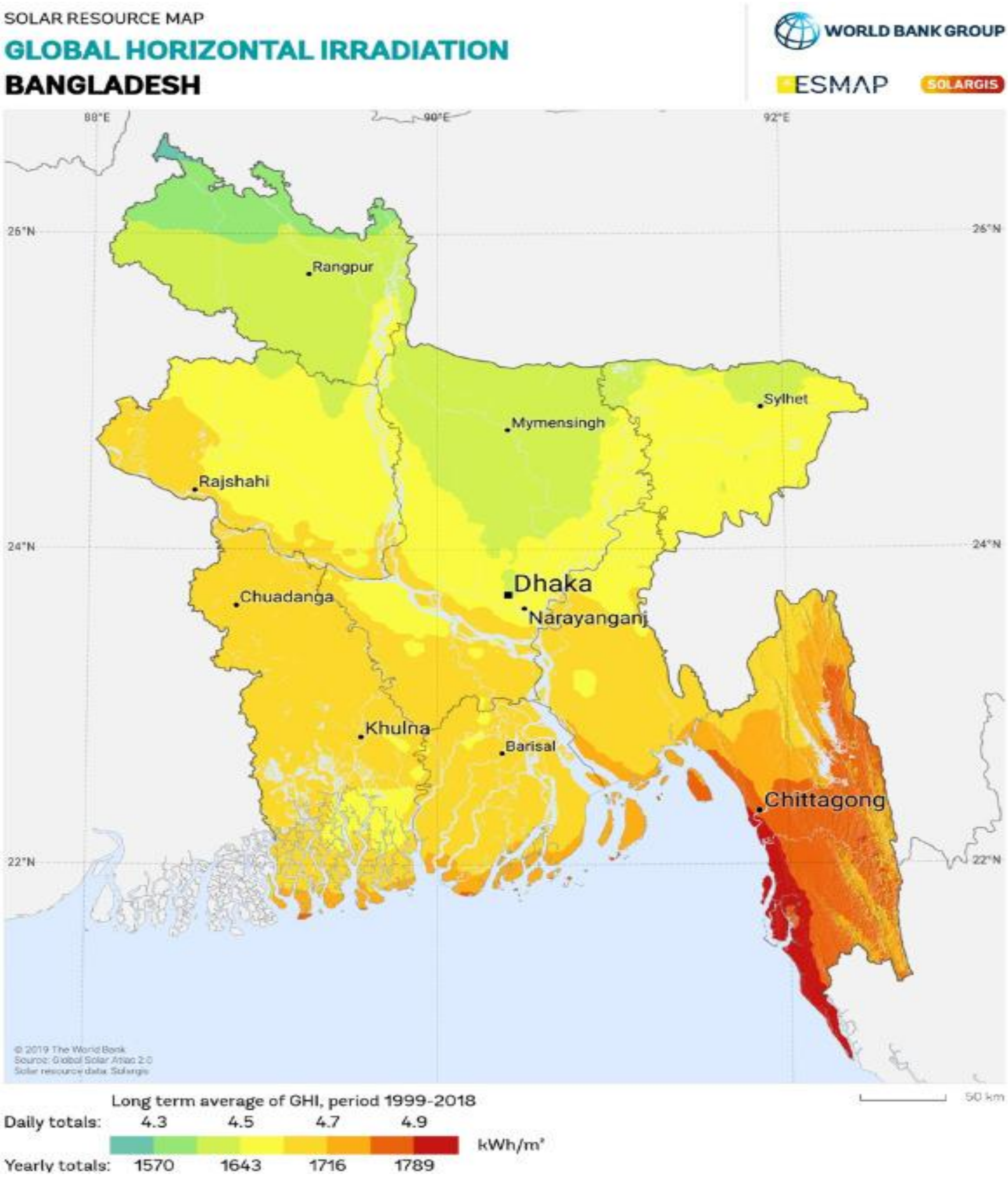


Figure 13 Bangladesh's solar radiation maps

3.4 Rechargeable System of Electric Vehicles

In our state, 2 categories of electric poles are currently operational. One would be nicknamed called "fast bicycle" in the area.

It has the appearance of a conventional CNG-powered auto - rickshaws, but it uses electricity. A two-seater rickshaw is the second mode of transportation. Both of these are power and ecologically sustainable, but they're well all throughout globe, especially in Bangladesh. Based on the scale and operating speed, 50 Am, 80 Am, 100 Am, and 120 Am batteries are typically used. There are really currently no way recharge facilities for them unless they require much more power from the grid. [13] As a result, we propose the installation of a solar-powered electric vehicle charging station. This approach, like solar panels, might be

Figure 14 Rechargeable Electric vehicles


Figure 15 Rechargeable Electric vehicles

3.5 Daily and monthly Electricity Generation and Income

Our system's capacity is projected to be around 8kW. Multiply this figure by the average monthly sunshine length to compute daily energy generation. Increase daily electricity production by the length of time within every month to get monthly electricity production. Table 2 displays the calculated information. [14]

Table 10 Total Energy Production in kWh on some kind of Daily and Monthly basis

Month	Period of a sunlight	Daily Power Production (KWh)	Monthly Power Production (KWh)
January	8.8	70.6	2,257.6
February	9.3	73.1	2,138.4
March	8.7	70.9	2,282.4
April	8.3	72.2	2,636
May	8.5	67.8	2,333.6

June	5.9	40.5	1,876
July	6.1	46.8	1,764.8
August	5.9	48.8	1,538.4
September	7.0	47.0	1,588
October	7.8	70.8	1,824
November	8.6	69.8	2532.8
December	9.9	71.9	2836
Total	94.8	750.2	25,608(KWh)

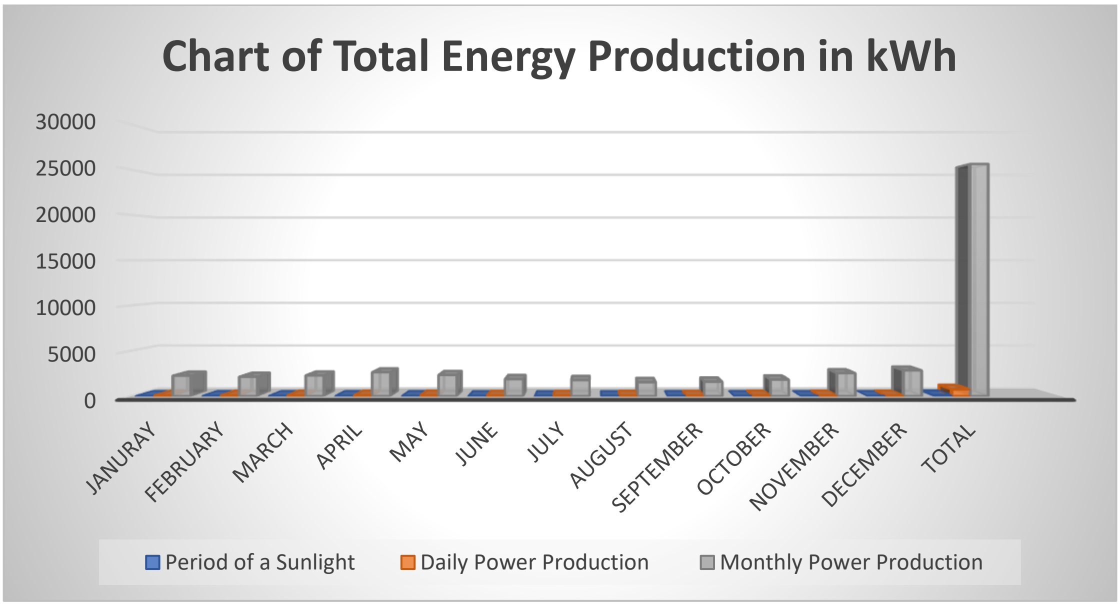


Figure 16 Total Energy Production in kWh Chart

Calculating the monthly electricity output is simple. Monthly income may be calculated using monthly energy generation, and yearly income is the sum of monthly income, allowing us to calculate the payback period of our proposed system. Monthly profits are shown in Table 2 and are determined using a variety of parameters.

Table 11 Year wise Generation of all RE large and small technology

Year	Small Technology	Large Technology
2006	0.8 kWp	900 kWp
2008	---	1 MWp
2010	---	172.14 kWp
2011	49 MWp	40.03 kWp
2012	26.83 MWp	107.12 kWp
2013	34 MWp	84.14 kWp
2014	33.31 MWp	1.64 MWp
2015	25.56 MWp	18.41 MWp
2016	10.03 MWp	19.36 MWp
2017	50 MWp	18.79 MWp
2018	16.51 MWp	39.99 MWp
2019	22.07 MWp	41.57 MWp
2020	21.48 MWp	60.16 MWp
2021	0 kWp	64.11 MWp
2022	---	6.15 MWp
	Total- 288.8 MW	Total- 272.49MW

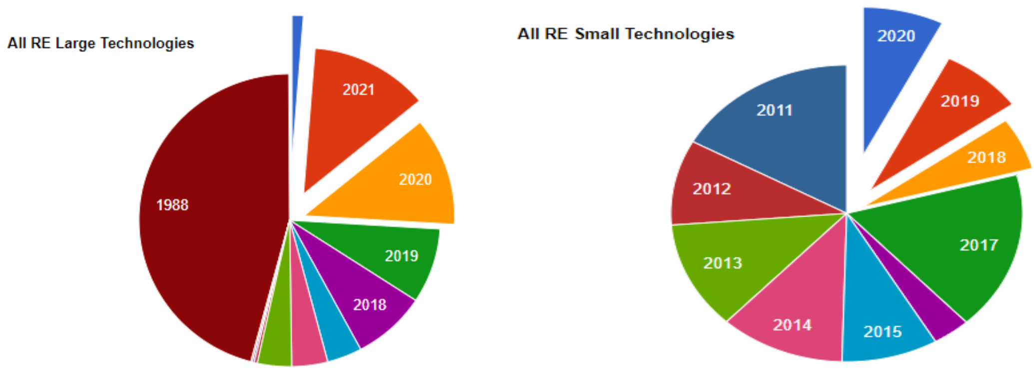


Figure 14 Generation of all RE large and small technology.

3.6 Opportunities and Benefits

Every day, 360 MW to 550 MW of electricity were utilized, the majority of it illicit, to recharge an Easy-bike.

This theme may be used to remedy this issue.

Recharging an eclectic vehicle cost between 35 and 45 Tk.

Due to the lack of a voltage source inverter and a storage bank, the expenditure is lower than that for conventional solar systems. [15]

3.7 Challenges and Limitations

- A fuel station owner must make a significant initial investment.
- Insufficient knowledge of sustainable renewable energy technology.
- Insight into future trends is lacking.
- At night or when the sun is not shining brightly enough, the system will not work. [16]

CHAPTER-4

POTENTIALITY/PROBABILITY OF WIND POWER ENERGY IN BANGLADESH

4.1 Wind Power

As Bangladesh is a developing country, it needs a lot of electricity to keep pace with its ongoing development and meet the electricity needs of the people. After the success in generating electricity through renewable sources like hydropower, solar energy, etc., the government has paid special attention to power generation from another renewable source wind. Part of it is windmill. [17] The Sustainable and Renewable Energy Development Authority (SREDA) is working tirelessly for the expansion of wind power under the direction of the Government of Bangladesh and the Department of Power. [18]

The main and prerequisite for setting up a wind power plant is the feasibility study of wind power or wind resource assessment. The probability of a place being assessed by considering the nature of the wind motion over the last 10 years or the possible change in the weather over the next 10 years. Bangladesh has always relied on financial and technical assistance from foreign donors for this wind resource assessment. Currently Shreda has started working on Wind Resource Assessment in her own skill. So, at the beginning you need to know what steps to go through in the wind resource assessment program.

Step: 1

In determining the potential location for wind power, one must first look at the wind data of a country for the last 20-50 years which is available from various open-source platforms such as Metadata, Global Wind Atlas, NREL Map, etc. It is possible to identify potential areas for wind power in Bangladesh by reviewing the information available from these platforms.

Step: 2

After initially identifying potential areas, plans have to be adopted to extract site-specific information. For example, the metadata shows that the coastal areas of Bangladesh (Cox's Bazar, Chittagong, Khulna, Patuakhali, Bhola, etc.) are particularly suitable for setting up wind power plants. Site shortlisting is required to retrieve site specific information. In this case, the infrastructural location of the areas (infrastructure development), the availability of national gridline, communication system, settlement, etc. are considered. After site shortlisting, information on wind speed, direction, humidity, temperature, etc. at a height of 120 m in a certain area is collected for at least two years using Met Tower or remote sensing equipment such as sodar, lidar and all this information is stored on a server. Failure to comply with international standards IEC-614001 may result in the complete failure of the air data collection process.

Step: 3

In addition to storing the information received on the server, the quality control is continued to check whether the information received. There are many types of faults in the collection of wind information which are checked daily by experienced engineers and quality is ensured. This is very important because a major part of investors' risk assessment is the quality of air data (Bankability of Data). After verifying the quality of the information obtained, wind farm modeling or determining the maximum amount of wind power possible using a particular model of wind turbine in a particular area begins. This is a big part of the wind power feasibility study. After wind farm modeling one can get a definite idea of how safe it is for investors to set up wind power plants in an area. Except for the above three steps, no power plant can be planned in any area.

Table 12 Information on Wind Measurements at Nine Sites

Site	Type of Station	Installation date	Data Collection started	Monitoring End data	Coordinates of Station
Rajshahi	Guyed Lattice 80-m Tower	06/11/14	June 2014	12/20/2017	24.17035°N 88.90734°E
Chandpur	Guyed Lattice 60-m Tower	11/06/14	June 2014	12/04/2017	23.21116°N 90.64237°E
Sitakunda, Chattogram	Guyed Lattice Tower-80m	18/12/14	December 2014	12/20/2016	22.60416° N 91.6601° E
Parkay Beach, Chattogram	Guyed Lattice 80-m Tower	24/12/14	December 2014	07/14/2017	22.18513°N 91.81767°E
Gouripur Mymensingh	Guyed Lattice 80-m Tower	13/08/15	August 2015	12/13/2017	24.71546°N 90.4668°E
Madhupur Tea	Guyed Lattice	19/10/15		11/22/2017	24.37778°N

Estate,Habigonj	80-m Tower		October 2015		91.57462°E
Dacop, Khulna	Guyed Lattice 80-m Tower	31/10/15	October 2015	12/25/2017	22.47342°N 89.56826°E
Inani Beach, Cox's Bazar	SoDAR 40-200m	07/25/14	July 2014	08/02/2015	21.14732°N 92.07575°E
Badarganj Rangpur	SoDAR 20-200m	05/08/15	August 2015	04/19/2017	25.60641°N 89.06877°E

Site Specific Wind Resource Assessment was initiated by three power generation companies between 2016-2017. In 2016, Coal Power Generation Company of Bangladesh Limited (CPGCBL) collected data and verified the possibility of setting up a wind farm on Matarbari Island in Maheshkhali upazila of Cox's Bazar district. Wind data collection period was from February 2016 to February 2017. Min wind speed is 5.7 m / s at 100 m altitude. A wind resource study was conducted in Sonagazi upazila of Feni on the initiative of Electricity Generation Company of Bangladesh (EGCB). LIDAR is used as a wind measurement instrument. The data collection period was from June 2017 to September 2018. Min Wind Speed - 5.38 m / s at 100 m altitude. In 2016, North-West Power Generation Company Limited (NWPGCL) commissioned the Fujian Electric Power Survey and Design Institute (FEDI) of China to set up a North West Power Generation Company (NWPGCL) power plant at Pigeon Thermal Power Plant in Kalapara Upazila, Patuakhali District. Is employed to extract air data. Preliminary data submitted by the FEDI in November 2019 shows that the mean wind speed at an altitude of 120 m is 5.48 m / s.

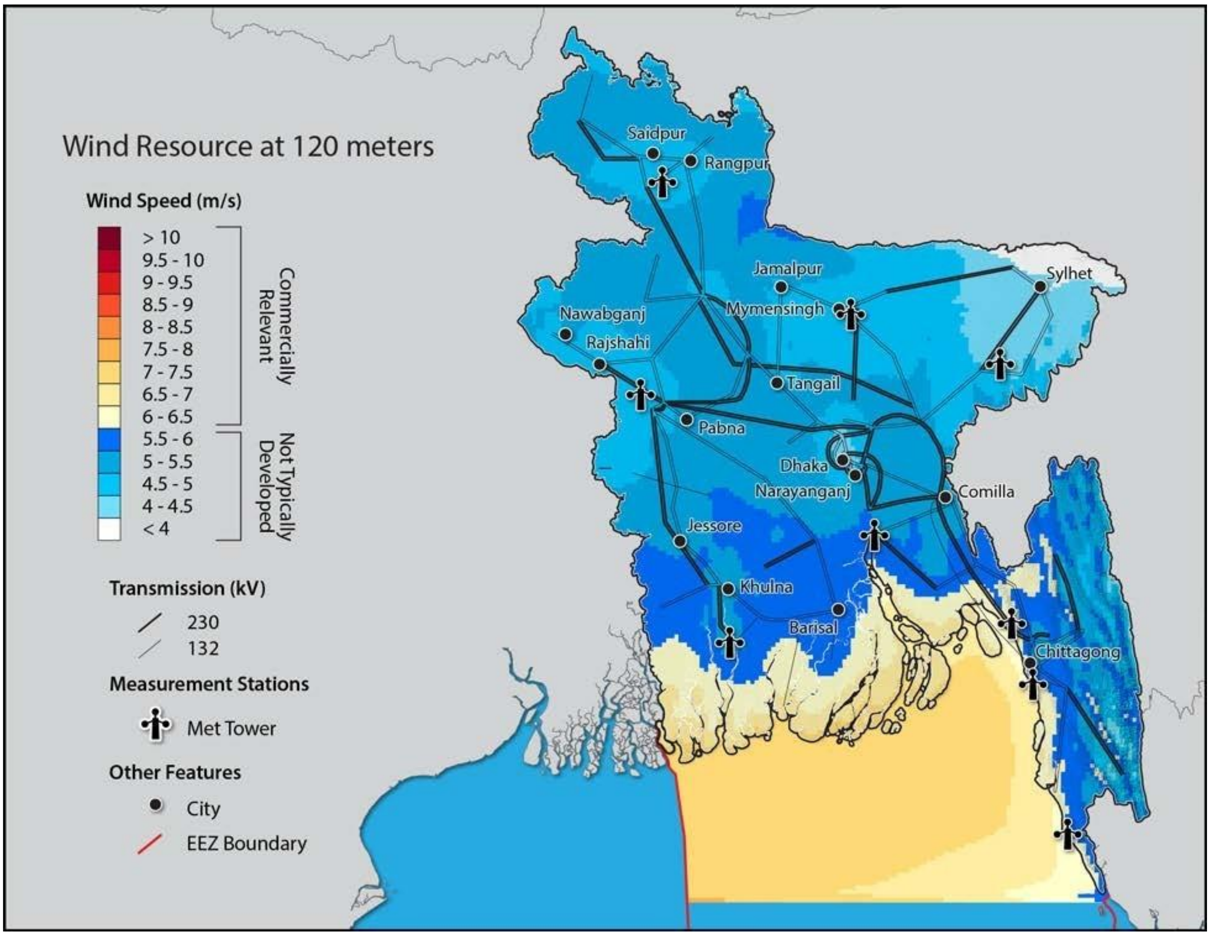


Figure 15 Bangladesh Wind Energy Mapping

4.2 Current Status of Bangladesh in Wind Power Generation

In a preliminary study conducted in 1982, data from 30 meteorological stations in the country showed that Chittagong and Cox's Bazar districts were suitable places for wind power generation. After further experimentation, as part of a pilot project to generate electricity from wind energy, the first wind power plant in Bangladesh was set up in 2005 on 6 acres of land in Lamchi mouza of Khojaj along the banks of Mahuri river and Sonagazi char in Feni. Although it is less than the demand, it is added to a feeder of rural electricity and it has a role to meet the demand of electricity to some extent. However, in 2006 it was shut down for several years due to technical glitches, mismanagement and inadequate ventilation. [19]

It was later reformed and re-launched on February 10, 2014. After the launch, the total production in 2014 was about 2 lakh 2 thousand 4 hundred 39 units. At that time the average production was 16 thousand 630 units daily. At present, under the PDB project, Pan Asia Power Service Limited has made arrangements to generate 200 kilowatts and 900 kilowatts of electricity by using wind through four turbines. Its maximum generation capacity is 0.90

MW. Another wind power plant in Bangladesh is at Kutubdia in Cox's Bazar. The power generated from the center was also distributed experimentally to 600 customers on the first day of Baishakh 2007, where there were 50 turbines. Each has a capacity of 20 kilowatts In other words, the power generation capacity of this center is 1 MW. Although the country's largest wind power plant was shut down for several years due to mechanical faults after an experimental distribution of electricity, it has been reopened. The Government of Bangladesh has set a target of generating 1360 MW of electricity from wind power by 2030 and a total of 1153 MW of electricity generation from wind energy by 2021. The precondition for setting up a wind power plant in a place is to collect and store data on the movement and adequacy of wind flow in that place for a long period of time.

To this end, wind flow data has been collected under the "Wind Resource Mapping Project" to assess the feasibility of wind power in the following 9 (nine) places of the country including coastal areas. Wind mapping activities have been completed in all the places mentioned in December 2017.

Reviewing the report provided by NREL, it is seen that in coastal areas of Bangladesh especially in Dakop of Khulna, Anwara of Chittagong and river estuaries of Chandpur the wind speed at 100 m altitude is more than 8 m / s which is very potential for wind power generation. The report further states that Bangladesh has an area of about 20,000 sq km where the wind speed is 5.75-6.75 m / s through which about 30,000 MW of wind power can be obtained. Although these figures depend on many regulators, the report is promising enough to expand wind power in Bangladesh.

4.3 Fuel Efficiency and Conservation Potential

Oil Potentially and Efficiency [20]

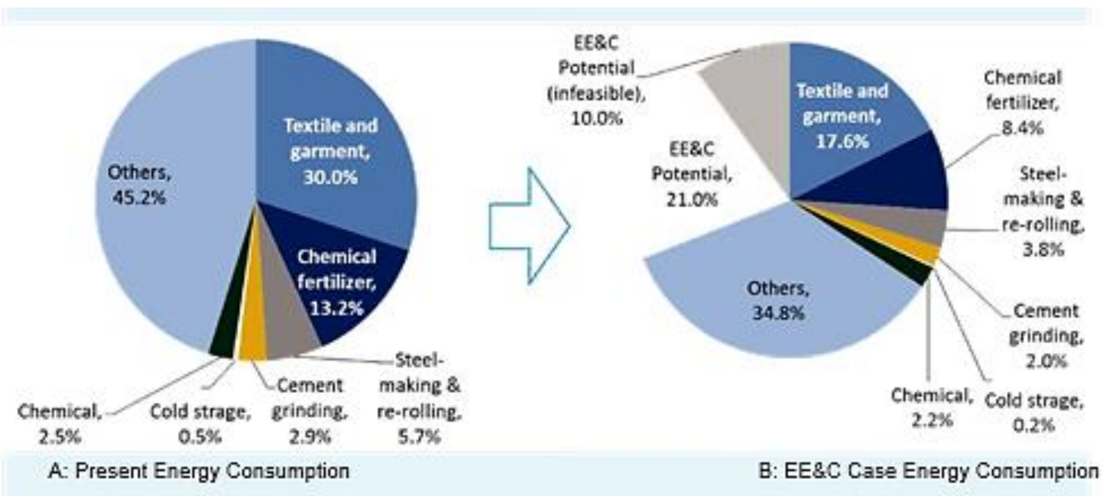


Figure:18 Possibility of energy saving in the industrial sector.

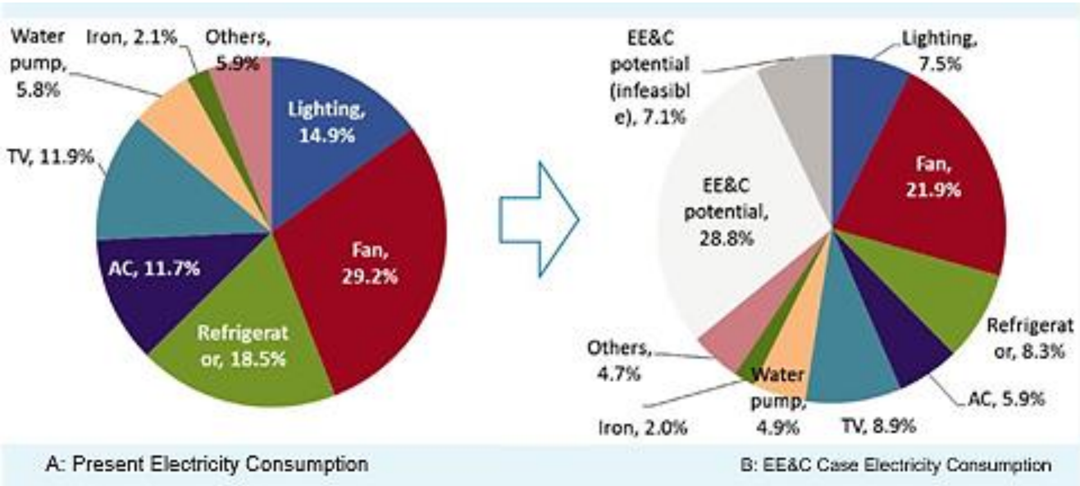


Figure 16 Potential energy savings in the residential sector

4.4 Future Plans and Goals (Renewable Energy)

Various activities are being taken to generate electricity from renewable energy as per the targets announced in the Renewable Energy Policy. Shreda continues to plan, implement, oversee, coordinate with various agencies, encourage public-private investment, etc. [21] for renewable energy development activities. The National Solar Energy Roadmap, 2021-2041 has been prepared with the support of SREPGen project, which is awaiting finalization.

Also, the activities that Shreda is taking – Initiatives taken to update the Renewable Energy Policy, 2008

Motivation to install solar rooftop systems on commercial basis in industrial establishments

Collection of Solar Radiation Resource Assessment Data Power Factor Study for Net Metering Customers There is a huge potential for offshore and onshore based wind power plants in the coastal areas of the country. Surveys and GIS mapping on biogas and biomass fuels Generating electricity from municipal waste Initiative to set up floating solar power plant (Floating solar PV) Feasibility of solar heating in the home

4.5 Current Situation of Energy Efficiency and Conservation

Energy is a mandatory endeavor for economic growth and human development that builds the relationship between both economic development and energy use. In order to keep sustainable GDP growth at 8% or above by 2030 and beyond, energy requirements need to be met. The demand for electricity is increasing day by day. In order to achieve energy sustainability, not only the supply of fuel but also the use of energy must be improved. In this regard, it is necessary to reduce the amount of fuel required to provide various products and services. Energy efficiency and renewable energy are called the two pillars of sustainable energy. [22]

The two primary effects of improving energy efficiency are (1) development of energy security and (2) effective environmental management. This campaign will yield good results in the effective energy use movement and will later reduce carbon emissions in Bangladesh.

The Energy Efficiency and Conservation Master Plan 2030 aims to save 15% of energy by 2021 by using and conserving primary and secondary energy at the user level for sustainable energy security, including low carbon emissions.

The government has taken the following initiatives to use efficient energy and reduce fuel consumption:

National textbook curricula, energy efficiency systems, alternative and renewable energy issues have been introduced in madrasas and colleges;

Work is underway to install solar panels in all government, private and autonomous organizations; Rooftop Solar Tariff Setting Regulation is being drafted.

Work is underway to replace incandescent bulbs with fuel LED lights and replace them with magnetic ballasts, electronic ballasts. Users are encouraged to use affordable lights such as LEDs. Energy audit policies have been formulated for large scale consumers.

Building Energy and Environment Rating is being drafted. To amend the building rules by including the issues of energy efficiency and solar energy in the new building rules.

Switching from an advanced rice per-boiling system to an efficient rice per-boiling system. Public awareness program has been started to save energy.

CHAPTER-5

PHOTOVOLATIC CELLS (PV)

5.1 Introduction

A photovoltaic (PV) cell has the ability to mimic, catch, or pass-through light. The PV cell is comprised of a semiconductor with metal and insulator characteristics. As a result, it is the sole device that can convert light to electricity. When light radiation is absorbed by a silicon, their energy is transformed to electrons, which allows electrical current to pass. This current passes through the semiconductor and onto metallization before being utilized to power your house as well as the remainder of an electric grid. [23]

Solar cells may be made using a number of organic semiconductors. More information on the most regularly used materials is available in the categories below.

5.2 Silicon

Silicon has been the most prevalent photovoltaic element, contributing for over 95 percent of all units on the market today. It may be the world's second most abundant mineral (after oxygen) and the most widely used semiconductor in computer chips. Silicon atoms are organized in a crystal lattice in crystallized silicon cells. This lattice creates an orderly structure that improves the efficiency of light-to-electricity conversion. [24]

At the moment, photovoltaics offers a decent blend of efficiency, cost, and lifespan. The modules must survive at least 25 years and provide more than 80% of the power that was originally available.

5.3 Thin-Film Photovoltaic

A thin-film solar cell is made by depositing one or so more thin layers of Semiconducting material on a supporting piece of glass, plastic, or metal. Cadmium telluride (CdTe) and copper indium gallium Di selenide (CIGD) are the two most prevalent thin-film PV semiconductors available today (CIGS). These materials may be immediately applied from the front and rear surfaces of the module. CdTe is the most used PV material after silicon because it is economical to produce. While this provides them with a more cost-effective choice, their efficiency levels remain low. [25] CIGS cells have strong electrical and optical properties, but combining four elements is a challenging procedure, making the transition from lab to manufacturing problematic. Power conversion efficiency of 10% are possible with devices based on these materials (AM1.5 illumination). For lengthy outside performance, both CdTe and CIGS demand extra insulation that silicon.

5.4 Organic Photovoltaic

This rapid advancement suggests that OPVs could be marketed in the near future if some technical issues can be addressed. OPV development has evolved on four fronts: (i) a greater grasp of how photons convert to electrons, (ii) novel materials with certain energy levels and solubilities, (iii) novel processing techniques for generating optimum microstructures in the active layer, (iv) innovative interfacial layers in new device designs. We review and give recommendations for materials, active layer microstructures, device topologies, and interfacial layers that have recently been developed for OPVs in this study.

5.5 Concentration Photovoltaic

In concentrating PV, also called as CPV, a mirrors or lens is utilized to solar radiation onto a solar cell. Less PV material is needed by focusing sunlight into a small region. As light becomes more concentrated, PV materials become more efficient in energy conversion, hence CPV cells and modules have the highest total efficiencies. [26] Due to the need for more expensive ingredients, production procedures, and tracking, showing the significant cost advantage over modern global silicon modules has been difficult.

5.6 Performance of Solar Cells

The amount of energy a cell begins with the sun is simple reduced by the amount of electrical power it produces. The quantity of energy generated by PV cells is measured by the characteristics (intensity and wavelengths) of a usable light, as well as the cell's multiple performance variables.

CHAPTER-6

SOLAR THERMAL ENERGY (STE)

6.1 Introduction

At a cumulative annual growth rate (CAGR) of 19.5 percent, global installed solar thermal generating capacity expanded from 1,106.3 kilometers (MW) in 2010 to 6,596.6 MW in 2020. By 2030, the installed solar energy capacity in the world is estimated to reach 14,172.8 MW. [27]

CST technology can be utilized in the industrial world to purify water, improve water electrolysis for hydrogen production, create heat for CHP, and increase oil recovery. Because of their extensive use, these technologies' efficiency, which is based on direct-beam irradiation, is improving.

As a result, STE plants thrive in dry and semi-arid climates with plenty of sunlight. Curved mirrors focus solar energy onto a receiver that is heated by the sun in these facilities. The receiver is used to provide heat to a fluid that is travelling through it. To generate concentrated solar power, the heated fluid spins a generator that converts solar energy into electrical energy.

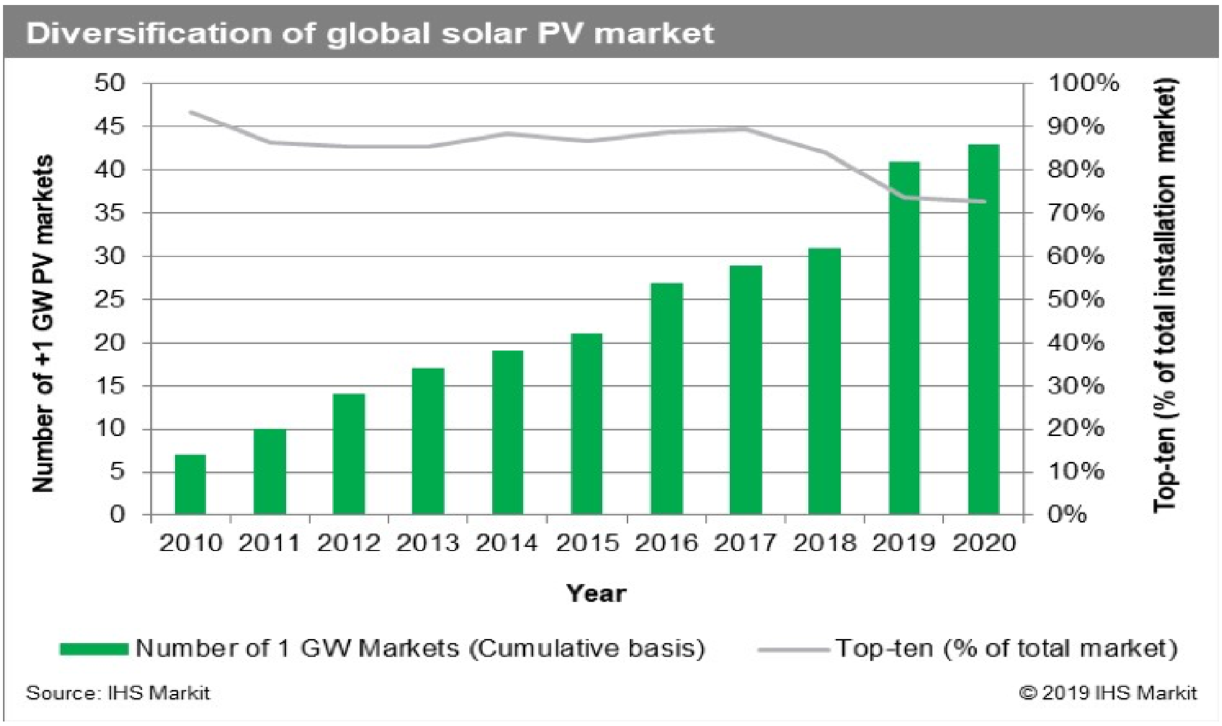


Figure 17 STE capacity has increased globally on a cumulative basis (IEA20)

Since 2010, the STE sector has been growing significantly, primarily in United states and Spain, but also in a number of other nations with rising energy use (Fig. IEA 2020). In terms of early STE development, the United Arab Emirates and India have had the largest plants, with each other in Morocco and South Africa under development. Smaller solar fields are also found in Algeria, Australia, Egypt, Italy, and Iran, in which they are typically incorporated into bigger fossil fuel facilities. Moreover, market rates appear to be declining as technological advancements have matured and new ideas have arisen.

6.2 Solar Radiation Intensity

Solar energy is the most plentiful source of energy on the globe, with solar radiation impacting the earth's surface at roughly 1 kilowatt per square meter (kW/m2) in sunny weather whenever the sun is near its zenith. Straight or beam radiation, which comes straight from of the planet's surface, and diffuse, which gets the planet after being dispersed in all directions by the atmosphere, are the two types of solar radiation. As a result, the sum of both elements equals total solar radiation (direct and diffuse radiation). Many uses need energy at temperatures above those attained by solar irradiance falling on the earth's crust. Solar is concentrated in collectors that capture and focus radiation from the sun onto a smaller surface to achieve high temperatures. [28]

The fundamental metric for sunlight concentration is uniform solar irradiation (DNI), which corresponds to the concentration of the available solar energy per unit of area on surfaces parallel to the direct sunbeam. The atmosphere distributes the sun's rays in humid tropical areas, and storms and particulates have a considerably bigger influence on DNI than world irradiance. In STE plants, DNI quality is critical 1.2.3 Concentrated Solar Thermal (CST) Techniques.

6.3 Solar Thermal Concentration (STC) Systems

As technology progresses, STE plants are becoming increasingly common. Solar thermal systems are the most common component of solar systems, and concentrating solar thermal technology currently offer a wide range of alternatives. These collectors, as previously said, absorb incident radiation and concentrate solar beams to heat a liquid, which then power a turbine as well as an energy generation directly or indirectly. Due to high concentration of sunlight, the fluid may achieve operating temperature high enough to assure expense performance in transforming heat to electricity while reducing heat wastage in the receiver. [29]

Solar tower (ST), parabolic-trough collector (PT), and linear Fourier are the four primaries commercial STC systems (Fig) that are characterized by the way the sun's rays are concentrated and the technology utilized to gather solar energy (Fig).

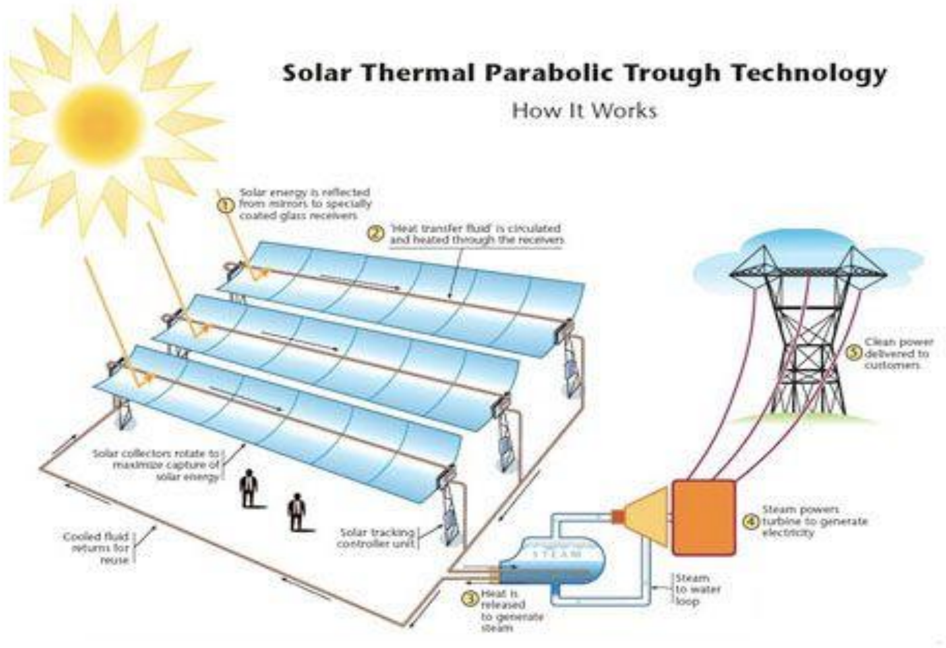


Figure 18 STE technologies (IEA)

According on the receiving type (stationary or mobile) and the degree of intensity (medium or high concentration). The linear Diffraction system and the concentrated solar power receiver are mechanically separate from the concentrate system, which would be used by all reflectors. In PT and PD systems, each receiver and concentrating mechanism move simultaneously, resulting in an optimal concentrated solar combo.

This warmth of a receivers is proportional towards the collector's concentration range (Fig) PT and LF, as a consequence, refract on a target line with 60–80 matter contains (medium-concentration technologies) and high heat of around 550°C. Reflections focus light on a single focal point in PD and ST plants, resulting in greater matter contains and temperature conditions (high-concentration technologies), with a maximum temperature of 550°C. On the one hand, central receivers obtain concentration ratios of roughly 600 and temperatures of 800 degrees Celsius, whereas parabola dishes achieve different ratios of over 1000 and heat of 1600 degrees Celsius. A solar furnace is also utilized as a testing facility, able of focusing 10,000 times the sunshine and reaching heats of above 100°C.

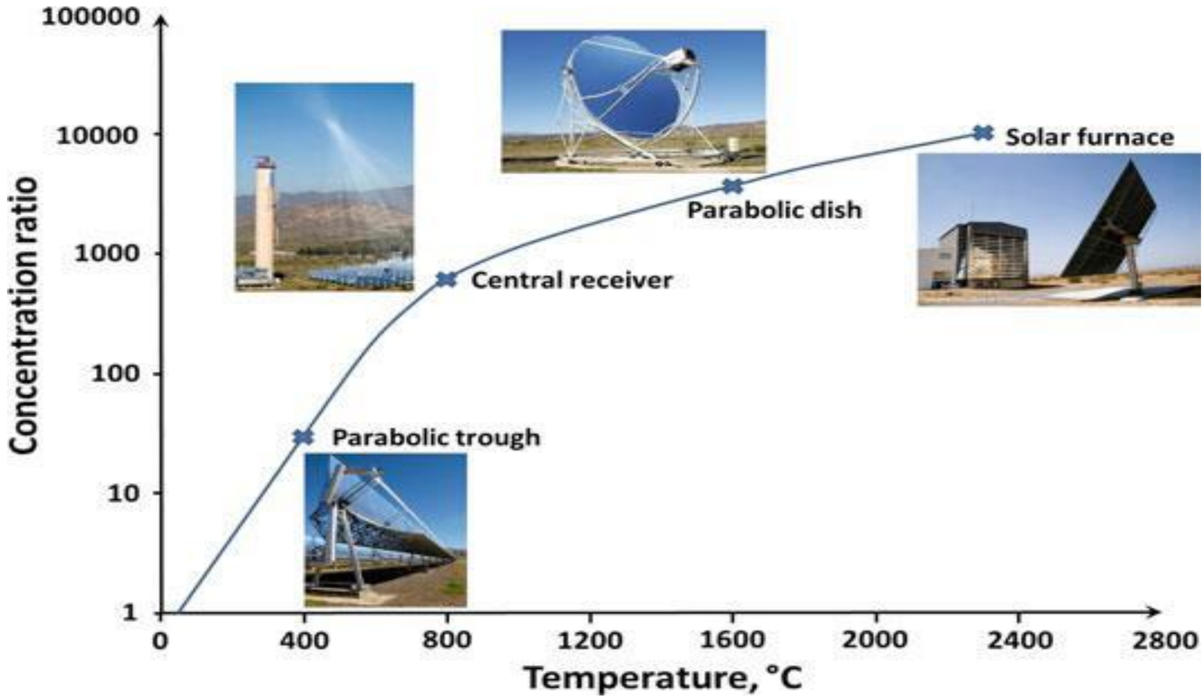


Figure 19 The STE technologies' concentration ratios V

6.4 Collectors for Parabolic Troughs

It is the most sophisticated CST technologies, with much more over 90% of present STE capacity coming from it. Trough photovoltaic fields, as seen in Fig. 2.4, concentrate sunlight onto such a linear receiver affixed towards the parabola's focus axis using curved predominant purpose mirrors. The collectors are linked in huge lines of 100 meters and follow the movement of the sun along a single axis during the day (usually East to West).

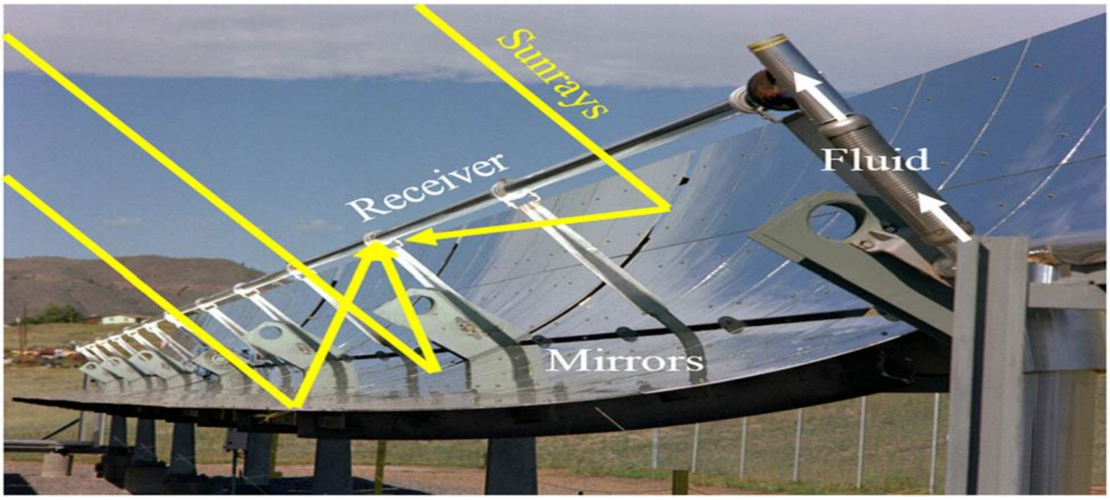


Figure 20 Parabolic dish collector

6.5 Linear Reflector

Figure 21 Linear Reflector

These parabolic reflectors are manufactured by twisting a strip of reflective tape into a conical form (silvered low-iron float glasses) and focusing the sun's light onto one receivers or absorber tubes filled with such a heat transfer fluid. A unique coating on these metal tubes or pipes enhances energy absorption while reducing infrared re-irradiation. The tubes operate in an evacuated tube environment to reduce convective thermal losses. [30]

The heat transfer (e.g., synthetic oil, molten salt) absorbs the heat energy and transfers it to a steam generator, which produces the amazingly steam that powers the turbine. The fluid is re - circulated back into circulation for reuse after it has transmitted its energy (up to 400 °C). The steam is also cooled, condensed, and re-used. In PT technology, the heated fluid may be utilized to heat storage systems, that can be used to create energy whenever the sun is really not shining.

Today's PT units have highly complex from 14 to 80 MWe, efficiency of 14-16 percent (i.e., the ratio of irradiance energy to net electric generation), and maximum working temperatures of 390 °C, which are restricted by the degradation of lubricating oils used for heat exchange.

In PT plants, through use of molten salt at 550°C for heat exchange is being investigated. Plant efficiency (e.g 15–17%) and thermal storage capabilities may be improved by using high word molten salt.

CHAPTER-7

CONCLUSION

7.1 Conclusion and Discussion

Bangladesh is a developing and populous country. About 16 crore people live in this country, with the aim of providing electricity to this huge population, the government has adopted a master plan now and in front of the year 2030. As per 2022 estimates, 100% electricity supply to the public has been ensured. At present Bangladesh is producing about 25514 MW of electricity. Out of 100% electricity generation and supply, 54% is being financed by the government and 44% percent is being supplied privately. Current electricity generation cost, supply cost, system loss, etc. are quoted per unit kWh cost. [31]

This report mentions the sustainable development and potential of renewable energy, electricity status and potential of Bangladesh.

Especially among sustainable and renewable energy, solar power, technology-based solar power 507.522 MW, hydro power 230 MW, wind (On-Off Grid) 900 kWp, Biogas (Off Grid) 900 kWp and Biomass (Off Grid) 400 kWp are generating electricity.

There is no alternative to sustainable development and renewable energy in economic and environmental considerations. Multifaceted initiatives have been taken to advance this sector by government, private and private initiatives. We are doing various researches for its progress and are ongoing. Solar thermal system or photovoltaic cell (PV), silicon, thin-film photovoltaic, organic photovoltaic can be used to produce renewable energy at low cost. This will save both cost and environment damage.

The report highlights the current technology base production capacity, feasibility and future planning of renewable energy sources in Bangladesh such as solar, hydropower, wind power and other renewable sectors. And the power source and charging cost of rechargeable electronic vehicles, the benefits, challenges and limitations.

Above all, through this research, we can get a better idea about the renewable energy of Bangladesh and it will be helpful in building a productive and self-reliant country in the future.

REFERENCES

[1] M. A. Rahim, Writer, *Theme of the Research.* [Performance]. August,2022.

[2] "International Scholarly and Scientific Research & Innovation," 14 February 2013. [Online]. [Accessed 5 may 2015].

[3] "Jarnal of Asia Pacific Wednesday, July, 2022," mon july 2020. [Online]. [Accessed 5 August 2022].

[4] "Directorate of Public Relations, BPDB," 25 jan 2015. [Online]. [Accessed 23 Octobor 2021].

[5] "Directorate of Public Relations, BPDB," 24 jun 2015. [Online]. [Accessed 14 octobor 2021].

[6] Bangladesh Power Development Board, Dhaka: BPDB, 2010-2021.

[7] "Bangladesh Department of Energy and Mineral Resources," EMRD, Dhaka, 2022.

[8] "Hydrocarbon Unit Ministry of Power, Energy and Mineral Resources," 14 jan 2020. [Online]. [Accessed 28 july 2021].

[9] A. Rahim and A. Rahim, Writers, *Impactive of Economic and Enviornmental.* [Performance]. 2022.

[10] M. R. AminBhuiyanaHayatiMamurbJahanaraBegumc, "A brief review on renewable and sustainable energy resources in Bangladesh," *Cleaner Engineering and Technology,* octobor 2021.

[11] M. R. AminBhuiyanaHayatiMamurbJahanaraBegum, "A brief review on renewable and sustainable energy resources in Bangladesh," *Cleaner Engineering and Technology,* Octobor 2021.

[12] S. a. R. E. D. Authority, "Current capacity of Renewable and Sustainable Power," SREDA, 2022.

[13] P. B. M. Hurtado-Pérez, *Multicriteria power generation planning and experimental verification of hybrid renewable energy systems for fast electric vehicle charging stations*, Rechargble Electric Vihecal.

[14] "Year wise Generation of All RE Large Technologies," SREDA, 2022.

[15] "Oppourtunities and Benefits," in *Abdur Rahim, Mostaque*, Dhaka, july,2022.

[16] A. R. Mostaque Ahmed, Writer, *Challenges and Limitation.* [Performance]. 2022.

[17] A. Rahim, "Solar system," *Possibility of Renewable and Sustainable energy in Bangladesh,* pp. 35-36, 2022.

[18] S. a. R. E. D. Authority, "Wind Power Generation," in *SREDA*, Dhaka, 2022.

[19] M. R. A. Md. Alamgir Hossain, "Current Status of Bangladesh in Wind Power Generation," *Present Energy Scenario and Potentiality of Wind Energy in Bangladesh,* 17 Seomrmber,2015.

[20] H. R. J. I. S. G. M. T. K. M. N. M. A. H. M. N. Kabir, "Fuel Effency and Conservation Potential," *POWER SCENARIO OF BANGLADESH: A BRIEF DISCUSSION ON POWER SECTOR OF BANGLADESH*, February ,2015.

[21] A. Faysal, "Future Plans and Goal (Renewable Energy)," *Present Energy Scenario, Necessity and Future Prospect of Renewable,* August 2018.

[22] A. Rahim, "Current situation of Energy Efficiency and Conversion," SREDA, Dhaka, june, 2022.

[23] M. F. R. Shaikh Shahadat Hossain, *Prospects of Solar Energy in Bangladesh,* 6 January , 2019.

[24] S. S. H. Md. Fazly Rabby, "Silicon," *Prospects of Solar Energy in Bangladesh*, January,

2019.

[25] M. F. R. Shaikh Shahadat Hossain, "Thin-Flim Photovoltaic," *Prospects of Solar Energy in Bangladesh,* January, 2019.

[26] S. S. H. Md. Fazly Rabby, "Concentration Photovoltaic," *Prospects of Solar Energy in Bangladesh,* January, 2019.

[27] A. Faysal, "Solar Tharmal Energy STE)," *Present Energy Scenario, Necessity and Future Prospect of Renewable Energy in Bangladesh.,* August 2018.

[28] S. S. Hossain, "Solar Radiation Intensity," *Prospects of Solar Energy in Bangladesh,* August 2020.

[29] S. S. Hossain, "Solar Thermal Concentration (STC)," *Prospects of Solar Energy in Bangladesh,* January 2019.

[30] A. Foysal, "Linear reflection," *Necessity and Future Prospect of Renewable Energy in Bangladesh,* August 2018.

[31] A. R. Mostak Ahmed, Writer, *Conclusion and Discussion.* [Performance]. August,2022.

THE END