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A Review on the Prospects of Wind Energy in Bangladesh

M. A. Sattar[1], M.A Hossain[1],M. J. Hossen[1], M. A. Khatun[1], A. Amin[2]
[1](*Department of Physics, Hajee Mohammad Danesh Science & Technology University, Dinajpur 5200, Bangladesh)*
[2](*Department of Mathematics, Hajee Mohammad Danesh Science & Technology University, Dinajpur 5200, Bangladesh)*

ABSTRACT: *Bangladesh has been suffering from a major power outage for the past few years, but at present this situation is improving by using fossil fuels or different nuclear power plants. As a result, fossil fuels are becoming scarcer by the day. Bangladesh should seek more renewable energy sources. Wind might be able to help with this issue due to its being a good source of renewable energy. Bangladesh has a large stretch of coastline. In different seasons, the wind blows in distinct patterns. In coastal zones, wind turbines should be able to endure winds of up to 250 km/hr. The potential of wind energy in different parts of Bangladesh has been assessed using previously obtained data. The review aims to discuss wind perspectives around the world and the present energy scenario in Bangladesh. Besides, it also focuses on the potential places for wind energy as well as government policy with the BPDB project in the case of wind energy in the previous and upcoming years.*

KEYWORDS: *Energy Scenario, wind energy, Global Perspective, Wind Potential, Government Policy etc.*

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I. INTRODUCTION

With 166 million people, Bangladesh is a heavily populated nation [1]; by 2041, that number is expected to rise to 189 million [2]. The government of Bangladesh has set a goal to transform Bangladesh into a high-income nation by the year 2041, hence this year is critical [3]. Bangladesh must place a strong priority on industrialization if it wants to become a high-income (or, in common parlance, developed) nation, which calls for a reliable and sustainable electricity supply. However, it was predicted in [4] that the demand for electricity will be 19,034 MW in 2021 and 82,292 MW in 2041 [4, 5].The primary fuel for the power sector is natural gas. However, the amount of natural gas being provided is insufficient to meet the current demand for electricity. Additionally, this demand is constantly rising. Government-created rapid rental schemes, which mostly rely on diesel and furnace oil, were established to meet the current demand. The government is heavily subsidizing hydroelectric power sources in the energy sector. Bangladesh would be wise to switch to renewable energy sources given the current circumstances. In this case, renewable energy sources are the greatest choice. Wind offers the greatest potential of all the renewable energy sources.Despite the fact that wind energy has been around for a very long time, it has only recently been effectively used to generate power through the use of wind turbines [6]. Bangladesh is located between 88.04 and 92.44 degrees East and 20.30 to 26.38 degrees North latitude [7]. Its coastline is around 700 km long [8]. According to CWET India's analysis of upper air data, Bangladesh's wind energy supply is insufficient for grid-connected wind parks [9]. To place a wind turbine in a specific location, Farha et al. estimated the rotor dimension [10]. However, a number of research projects are currently being carried out, mostly by Bangladesh Power Development Board (BPDB), with the assistance of Bangladesh University of Engineering & Technology (BUET).The feasibility of installing tiny wind turbines in coastal areas has already been shown. In order to attract investors, economic feasibility must also be clearly established in addition to technical feasibility. A project to harness wind energy has already been started in Bangladesh at the Muhuri Dam, Feni, with a capacity of 0.99 MW, and Maheshkhali, with a capacity of 2 MW [11].

II. DATA AND METHOD

The qualitative method is the basis of this paper. Secondary data sources from numerous relevant publications, comprising books, journals, newspapers, articles, white papers, websites, and annual reports, have been used.

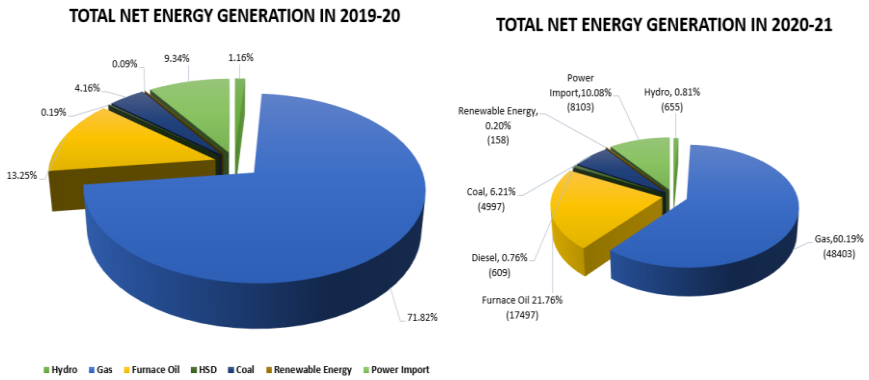
PRESENT ENERGY SCENARIO IN BANGLADESH

The aggregate government and non - governmental power generation capacity as of June 2021 was 25,235 MW, leaving 20% capacity for maintenance and forced outages; the accessible generation capacity

should be around 20,188 MW in the absence of fuel constraints. Up until June 30 of 2021, the largest generation actually achieved was 13,792 MW, which was less than 20,188 MW. It might have happened because of a shortage of fuel.Distribution of the overall generation capacity between governmental and private sector companies is 46% and 49%, respectively, with 5% coming from imports. Bangladesh began importing 500 MW of electricity from India in October 2013; an additional 100 MW starting in March 2016; and 560 MW starting in December 2018; these imports accounted for 10% of total power generation. Figure 1(b) depicts the total net energy generation for FY 2020–21, which was 80,423 MkWh, up 12.61 percent over figure 1's depiction of the net generation for the prior year, which was 71,419 MkWh (a). Net energy generation for the governmental sector was 31,916 MkWh, joint venture energy production was 3812 MkWh, and private energy production was 36,592 MkWh (including REB).Through the link in Bheramara and Tripura, an additional 8,103 MkWh was imported from India. The following table summarizes the total net energy produced by public and private sector power plants throughout several fiscal years.

Table 1: Total capacity installed in the public and private sectors across various fiscal years

Fiscal Years	Public Sector	Private Sector	Total installed capacity(MW)
2021-2022	659	495	1154
2022-2023	190	700	890
2023-2024	561	1209	1770
2024-2025	125	51	176
Total From FY 2022 to 2025	1535	2455	3990



(a) **(b)**

Fig. 1: Total net energy genration in fiscal year (a) 2019-2020 (b) 2020-2021(Source:annual report on 2020-2021).

Figure 1 depicts the breakdown of the primary energy mix for electricity generation in FY 2019–20. (a). In 2019–20, 77 percent of the electricity generated was produced domestically (from natural gas, coal, and hydropower), 13.25 percent was produced with imported petroleum fuels (diesel and furnace oil), and 9.34 percent was imported from India as part of cross-border energy exchange. However, the percentage of renewable energy climbed to 0.20 percent in FY 2020–2021, as indicated in figure 1(b). It highlights the use of renewable energy.

WIND ENERGY

Electricity is generated by the air flowing naturally through the atmosphere of earth. Something as straightforward as a set of 8-foot sails placed to catch prevailing winds and turn a boulder or process grains might generate wind energy (a gristmill). Or it might be as intricate as a 150-foot vane rotating a generator that generates electricity to be deployed over a power distribution system or stored in a battery. The most major source is wind energy. Due to the turbine's rotation when employing this source, electricity is produced [12]. The amount of wind energy produced by each river varies, for example, the muhuri dam in Feni produces 900KW whereas Kutubdia Island produces 1000KW [13].Figure 2 depicts the block diagram of a solar-wind hybrid energy system.

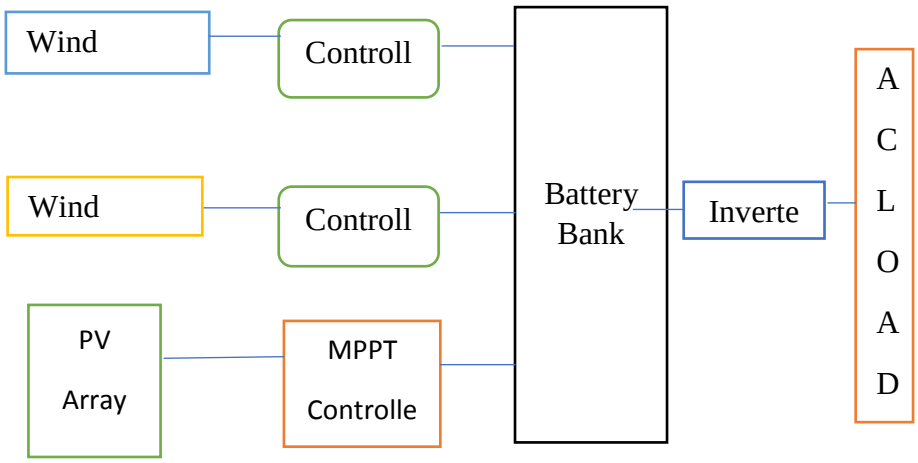
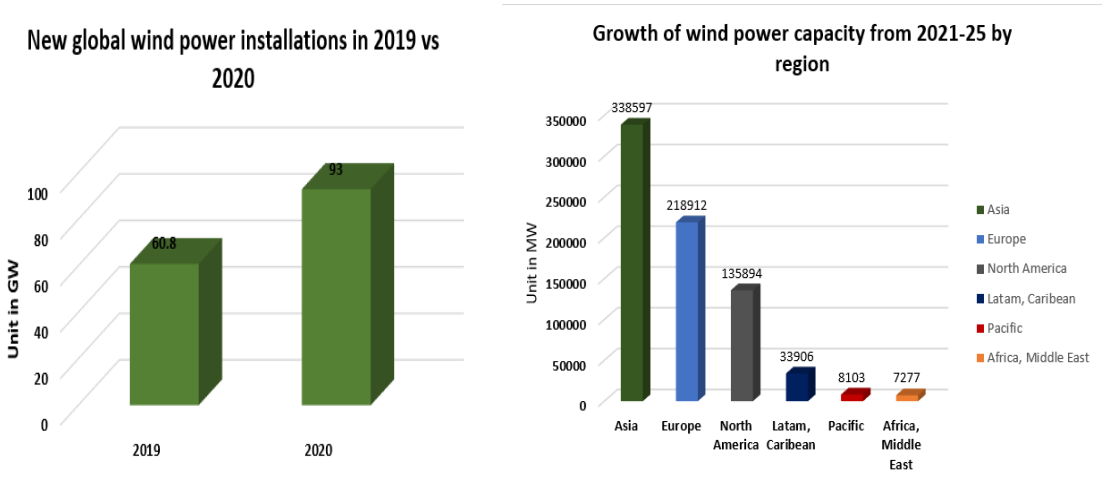


Fig. 2: Block diagram of a solar wind hybrid energy system [14].

WIND ENERGY: GLOBAL PERSPECTIVE

Wind power is one of the renewable energy sources that is expanding quickly. Due to the abundance of vast onshore and offshore areas and its low production costs, wind energy has become increasingly necessary and popular worldwide since it was first developed in the UK in 1887. Its generation capacity expanded around 75 times between 1997 and 2018, from 7.5 GW in 1997 to 564 GW in 2018. The majority of renewable energy used to generate electricity each day is wind energy [15].Figure 3(b) focuses on the expansion of wind power capacity from 2021–2025 by various locations around the world. Figure 3(a) depicts the new worldwide wind power installations in 2019 vs. 2020. According to 3(a), the installation of wind power reached 60.8 GW in 2019 and 93 GW in 2020.



(a) **(b)**

Fig. 3: (a) New global wind power generation in 2019 vs 2020 and (b) Growth of wind power capacity from 2021-2025 by region around the world [16].

The upward trend of the bars, which represent the decade from 2010 to 2020, indicates an annual increase in installed capacity. Onshore wind's installed capacity was approximately 180,000 MW in 2010, and it increased to over 680,000 MW in 2020, or more than 3.7 times that capacity. The picture also shows that offshore wind capacity, which was incredibly minimal in 2010, has significantly expanded. Since 2006, the use of wind energy has been expanding quickly worldwide, according to the European Commission [17]. According to IRENA, the amount of power produced by wind increased by twofold between 2009 and 2013 and accounted for 16% of all renewable energy sources in 2016 [15]..

However, Asia has surpassed Europe in this area. The top five nations in terms of total wind capacity are China, the United States, Germany, Spain, and India. China, which is the most adept at using wind energy to generate power, contributes 29% of the world's 91,424 MW total wind capacity. There are 61,091 MW, 34,250 MW, 22,959 MW, and 20,150 MW of wind capacity in the USA, Germany, Spain, and India, respectively [18]. Since the EU additionally benefits from stronger offshore wind and possesses almost 70% of the world's floating

wind energy capacity, it has been predicted that wind energy in the EU would reach 350 GW by 2030, which will satisfy 24% of the member countries' electricity demand [17].

WIND ENERGY POTENTIAL IN BANGLADESH

Bangladesh's potential for wind energy was researched by the Sustainable and Renewable Energy Development Authority (SREDA) and Bangladesh Meteorological Department (BMD). While BMD tracks wind speed in several towns and cities across the nation, SREDA gathered wind speed in 13 locations across the nation. In order to assess the potential for wind energy in Bangladesh, the Bangladesh Centre for Advanced Studies (BCAS) also looked over the BMD wind statistics. The analysis of this wind statistics points to Patenga, Cox's Bazar, Sitakundu, Teknaf, Saint Martin's Island, Char Fashion, Kutubdia, and Kuakata as possible wind energy harvesting sites in several coastal regions of Bangladesh [19–24].Between March and October, the wind speed in these areas ranges from 4 to 7 m/s above sea level (5-50 m). However, during the summer and monsoon season, there can be significant wind gusts with speeds far over 35 m/s. Except for certain areas, Bangladesh's wind energy potential is relatively constrained [25]. Although there has not yet been much research on offshore wind speeds for wind energy harvesting, existing satellite data suggests that offshore wind speeds are a little bit higher than those in the coastal zone. The feasibility study was done by BPDB at several places in Bangladesh, and it predicted that wind energy sources may generate up to 667 MW of electricity [26].The Muhuri Dam in Feni and Kutubdia Island, respectively, already has a wind power plant with a 900 kW and 1 MW capacity limit erected by BPDB. There are plans to build a second 50–200 MW wind power facility in the Perky Brach area on an IPP basis [27]. Strong southerly or south-westerly winds from the Indian Ocean invade Asia during the monsoon season. The Bangladeshi coast is exposed to this wind. From March to September, this wind blows over Bangladesh with an average speed of 3 to 6 m/s. In the months of October to February, wind speed is consistently lower. June through July experience the greatest wind speed [28]. Surprisingly, the suction head in Bangladesh is just 6 meters in the majority of places (at least 50%) [29, 30].Typically, a pump with a 12-meter head and a 2-cusec capacity is needed [28]. The installation of windmills will increase the nation's power production from a dependable source while also reducing the greater cost of pumping water for agriculture purposes.

Table 2: Bangladesh's various locations Wind Conditions for Electricity Generation Feasibility [31].

Site	Reference Height (m)	Annual-Average Wind Speed (m/s)
Cox’s Bazar	10	2.42
Sandip Island	5	2.16
Teknaf	5	2.16
Patenga Airport	5	2.45
Comilla Airport	6	2.21
Khepupara	10	2.36
Kutubdia Island	6	2.09
Bhola Island	7	2.44
Hatia Island	6	2.0

STATISTICAL DATA

Wind speed data in different places of Bangladesh is available in Bangladesh Meteorological Department (BMD). Wind data has been collected from BMD and other possible sources to assess the potentiality of wind energy. Bangladesh government had a project named as WEST (Wind Energy Study Project). Under this project, monthly average wind speed data in six potential coastal spots has been recorded for a period of one year [32]. The data at 25-meter height are shown in figure 4.

During this period, average monthly wind speed varies from 3.68 m/s to 7.03 m/s. Kuakata has the best suited place among the six spots. Besides Kuakata; Patenga, Kutubdia and Char Fassion have the good probability to be the sites for installing wind turbine. It will not be a good decision to establish wind mill in Teknaf. But wind energy is extractable from all the places from the six spots around the year. Monthly extractable wind energy is shown in table 3.

Table 3: Extractable monthly wind power [33].

Month	Extractable Wind Energy (watt-hr/m^2)					
	Patenga	**Cox's Bazar**	**Teknaf**	**Char Fassion**	**Kua- kata**	**Kutub- dia**
Jan	6.42	2.38	1.47	4.03	5.90	9.08
Feb	3.46	1.47	1.30	3.57	7.09	6.60
Mar	5.74	2.67	2.12	8.14	20.95	8.21
Apr	4.48	1.18	0.86	6.60	22.27	5.63
May	22.68	11.75	5.47	20.43	45.47	21.47
Jun	36.38	18.34	6.36	35.09	71.72	37.71
Jul	33.47	20.30	14.91	26.11	72.60	43.12
Aug	24.79	14.70	12.02	25.37	68.53	27.96
Sep	7.22	9.38	7.74	6.72	10.00	8.57
Oct	6.02	9.60	6.60	9.30	1.90	11.75
Nov	3.30	4.62	2.23	2.54	1.47	6.19
Dec	4.86	1.07	0.57	11.32	6.90	7.09

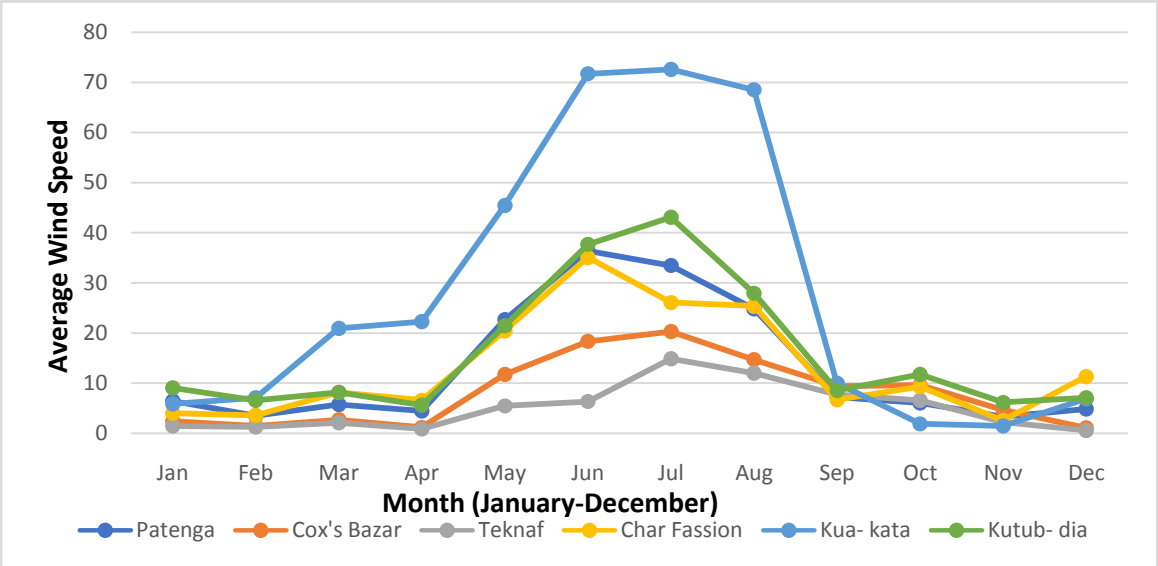


Fig. 4: Monthly Average Wind Speed in Six Different Coastal Spots.

Table 4: Scenario at Dhaka.

Month	Average Wind Speed (m/s)	Extractable Wind Power (watt-hr/m^2)
Jan	3.39	7.01
Feb	3.26	6.48
Mar	4.39	11.75
Apr	5.77	20.30
May	6.33	24.44
Jun	5.71	19.88
Jul	6.01	22.03
Aug	5.89	21.16
Sep	4.39	11.75
Oct	3.45	7.26

Nov	2.64	4.25
Dec	2.95	5.30

From table 4, it is clear that Dhaka is not a suitable place for installing wind turbine. But it can be noted that, it has potential to support the demand of irrigation during the May and August. This will be a good support to the national grid.

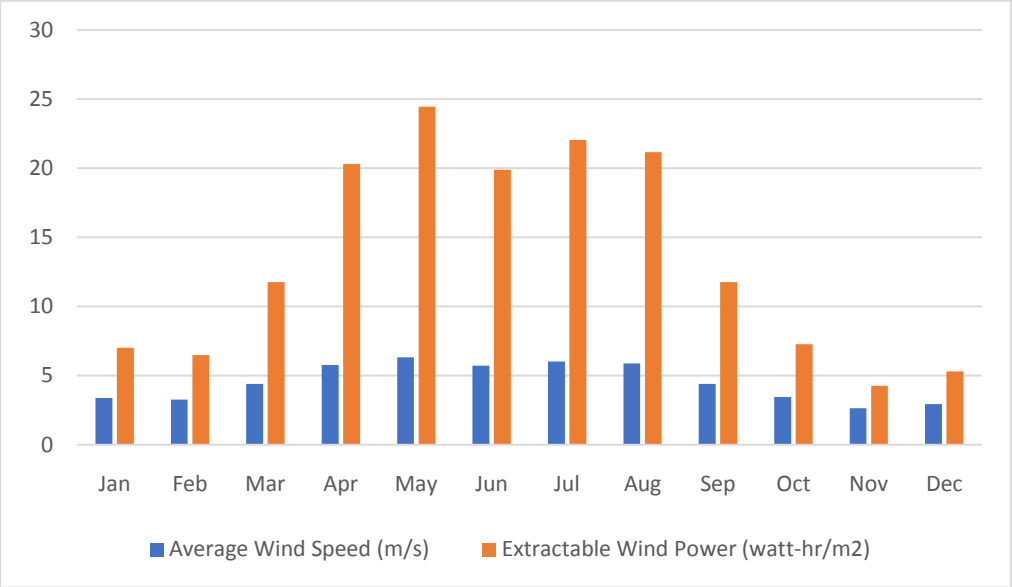


Fig. 5: Scenario of Average Wind Speed (m/s) And Extractable Wind Power (watt-hr/m^2)

SAMPLE CALCULATIONS

Let us consider the month of May for Dhaka.

Average wind velocity, V = 6.33 m/s

Air density, $\rho = 1.22$ kg/m^3

Wind energy (Ideal) = $0.50 \times \rho \times V^2$

$= [0.50 \times 1.22 \times (6.33)^2]$ watt-hr/m^2

$= 24.44$ watt-hr/m^2

Total loss = Co-efficient of performance of WT × Generator loss × Transmission loss

Usually, Co-efficient of performance of WT = 0.40

Generator loss = 0.85

Transmission loss = 0.90

So, total loss = $0.40 \times 0.85 \times 0.90$

$= 0.306$

Actual available amount = (0.306×24.44) watt-hr/m^2

$= 7.47$ watt-hr/m^2

The average extractable wind energy at Dhaka is 13.46 watt-hr/m^2.

GOVERNMENTAL POLICY ON RENEWABLE ENERGY AND WIND ENERGY

Bangladesh has established specific renewable energy goals in light of the growing awareness of the need for renewable energy to reduce the amount of greenhouse gases. Biomass, solar, and wind energy are viable options for achieving these renewable energy targets. Because the country lacks significant height disparities, hydropower has little potential. Large-scale production of biomass is not feasible because the available land should be used primarily for food production. According to claims, Bangladesh has a substantial technical potential for the production of renewable energy. Bangladesh may create more than 6,000 GWh of renewable energy yearly, of which 1250 GWh can come from wind resources, according to the GoB's Investment Plan for Scaling up Renewable Energy Program (SREP) (SREDA, 2015).However, for the time being, Bangladesh's generation portfolio only makes up a minor fraction of renewable energy. Currently, 437 MW of installed renewable energy generation capacity is available, with the only grid-connected renewable resource being the 230 MW Kaptai Hydropower plant. Off-grid installations and rooftop solar that provide site-specific service make up the remaining MWs. The "RE Development Targets" are goals established by the GoB

for the development of a number of renewable energy technologies for each year between 2015 and 2021. By 2021, 3,100 MW more in renewable energy capacity must be installed in order to meet these goals. Wind and solar together should supply 1,676 MW, or 54%, of the increased capacity (1,370 MW, or 44 percent). There are also targetsfor biomass(47 MW), biogas (7 MW) and hydroelectricity (4 MW).

Table 6: Scenario of wind project in Bangladesh [34].

SL No.	Project Name	Capacity	Location	Agency	Completion Date	Present Status
1	1000 kW Capacity Wind Battery Hybrid Power Plant	1 MWp	Kutubdia Upazila, Cox's Bazar	BPDB	2015-12-31	Completed & Running
2	1000 kW Capacity Wind Battery Hybrid Power Plant	1 MWp	Kutubdia Upazila, Cox's Bazar	BPDB	2008-12-31	Completed & Running
3	0.9 MW Grid Connected Wind Turbine Power Plant	900 kWp	Sonagazi, Feni	BPDB	2006-09-27	Completed & Running
4	Sirajganj 150 MW Power Plant	2 MWp	Sirajganj Sadar Upazila, Sirajgonj	BPDB	2022-12-29	Implementation Ongoing
5	60 MW Wind Power Project	60 MWp	Chakaria Upazila, Cox's Bazar	BPDB	2021-12-31	Implementation Ongoing
6	100 MW Wind Power Plant Project	100 MWp	Maheshkhali Upazila, Cox's Bazar	CPGCBL	2026-12-30	Under Planning
7	30 MW Wind Power Plant	30 MWp	Sonagazi, Feni	BPDB	2023-11-22	Under Planning
8	55 MW Wind Power Plant	55 MWp	Mongla Upazila, Bagerhat	BPDB	2023-11-15	Under Planning
9	50 MW Grid-tied Wind Power Plant	50 MWp	Cox's Bazar Sadar Upazila, Cox's Bazar	BPDB	2023-10-24	Under Planning
10	50 MW Grid-tied Wind Power Plant	50 MWp	Chandpur Sadar, Chandpur	BPDB	2023-07-12	Under Planning
11	10 MW Wind Power Plant	10 MWp	Kalapara Upazila, Patuakhali	RPCL	2022-12-31	Under Planning
12	Feasibility Study for Installation of Wind Firm in Matarbari Island	0 kWp	Maheshkhali Upazila, Cox's Bazar	CPGCBL	2019-06-30	Under Planning

III. COST ESTIMATION & COMPARISON

According to a group of NREL researchers, every 2-MW wind turbine needs some half a square kilometer area in total [35].

Hence, to generate 200-MW electricity, 100 numbers of 2 MW turbines are required in a land of 50 km^2 area. Considering 40% more area for operation flexibility, office building and responsible personnel's residence and other facilities, total required land area is 70 km^2 or 1,729,896 decimals (1 sq. km = 24,712.81 decimal). In Bangladesh, the value in rural arable land or coastal land is comparatively less than in urban areas.

Let per decimal arable land requires BDT 50,000. Then, the price of1729896 decimal land is BDT 86,494,800,000. Each two MW turbine costs $3–$4 million [36]. Hence, each turbine having a capacity of 2 MW costs BDT 50,000,000 (including value-added tax), and then, the cost of 100 sets of turbines is BDT 5,000,000,000. Moreover, a cost might incur due to import process of the turbines and other machinery of the plant, which can assume BDT 10,000,000. Let the repair and maintenance cost for each turbine every year is BDT 10,000,000. Then, for 100 number of turbines in 10 years, cost will be BDT 100*10,000,000*10 = BDT 10,000,000,000. Majorly, Bangladesh is a country of plane land. Hence, the land development cost will be less. It can be assumed a lumpsum amount of BDT 400,000,000 for this purpose.

Cost of unit electricity generation using different sources of power are given below [37][38].

Solar PVelectricity generation cost 80000.68(BDT/MWh).
Dieselelectricity generation cost 23000.5 (BDT/MWh).
Coal (imported) electricity generation cost 8000.60 (BDT/MWh).
Wind electricity generation cost 6000.08 (BDT/MWh).

Natural gas electricity generation cost 3000.10(BDT/MWh).

OUTCOME AND FUTURE PROSPECTS

In this paper we have tried to find out wind energy estimation in different places in Bangladesh. According to cost estimation of wind energy, comparing among all other energies we can see that the wind energy is better than all other energies. Because wind energy costs around only 6 thousand BDT for per MWh electricity generationwhereas all other energies cost about 8000 BDT, 23000 BDT and 80000 BDT for per MWh electricity generation. Although natural gas costs us the least 3000 BDT for per MWh electricity generation but it will run out at some point. Therefore, if we discuss the remaining four energy sources without considering natural gas, it is seen that wind energy is the easiest and cheapest energy source for electricity generation. So, we must use wind energy to add energy inour national grid of Bangladesh. Another advantage is Diesel and coal cause a lot of damage to the environment but wind energy will not cause any damage to the environment. Hence, we have no chance of any natural calamity due to windenergy. So, Bangladesh government should take powerful action to createwindenergy electric generation center as soon as possible. Then wind energy can play a very important role in meeting our future electricity shortage.

IV. CONCLUSION

Bangladesh has a lot of places with good wind potential, it has been shown.From the above discussion, it is clear that there are lots of projects under construction or most of the projects are ongoing. To stimulate investment in wind energy, Bangladesh's government could offer investors low-interest loans. Since wind velocity rises with height, wind turbines should be installed as high as possible. The success of these initiatives will undoubtedly inspire us to build windmills on a large scale, relieve the demand for fossil fuels.

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