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Wind Energy: The Promising Future of Bangladesh Power Sector

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ABSTRACT : *As fossil fuel reserves have been rapidly drained over the past few years, Bangladesh has had severe electricity problems. Bangladesh should explore alternative sources of energy. The issue can be resolved by the wind. The wind is a great source of renewable energy that is also free. Long coastal area is observed in Bangladesh, where a good amount of wind is found all around the year. It sustains several blows in different seasons' various fashions. In this study, some statistical information is gathered about wind flow rates in Bangladesh's various locations and, after figuring out the cost of extracting the wind energy, it is compared to other energy sources in Bangladesh. Furthermore, the feasibility of installing wind power plants in Bangladesh is also discussed.*

KEYWORDS: *wind energy, coastal area, CoE, wind turbine, MMcf, EFR*

I. INTRODUCTION

Nowadays without power a country's development can't be imagined. Moreover, for a developing country like Bangladesh, it's the foremost important factor. Now, Bangladesh is encountering difficulties in supplying energy to keep up its economic process. Electricity is the main source of power for many of the country's economic activities. Bangladesh's total installed power generation capacity (including captive power) was 15.351 GW in January 2017 [1] and 20 GW in 2018 [2]. As of 2015, average 77.9% people have access to electricity [3]. To sustain above 7% of its economic process, Bangladesh will need an estimated 34 GW of electricity by 2030[4]. Power sector of Bangladesh is basically engaged with gas, accounting for about 72% of total commercial energy use and 63.19% of the overall electricity generated [5]. The overall reserves for the exhaust gas (proven and probable) is 20.5 TCF (Trillion Cubic Feet). As of April 2010, the overall gas consumption was 8.5 TCF, the overall reserve was 12 TCF. The daily consumption is about 2000 MMcf (Million Cubic Feet) [6]. Accordingly, it'll expire after a particular period. There are several small deposits of coal within the northeastern part of the country, but they need peats, low calorific value and really deep soft coal [7]. Statistics say that this demand for energy exceeds available resources, and this gap is probably going to extend significantly within the near future. On the other hand, fuel reservation is decreasing day by day. As a result, due to the shortage of energy supply, the expansion of industrialization is being caught up in Bangladesh. Wind energy can optimize the matter. The aim of this study is to focus on the potential of wind energy in Bangladesh. Wind can supply mechanical energy as well as electricity without producing any pollutants, hence its environment friendly [8]. Bangladesh is situated between 20.30 - 26.38 degrees North latitude and 88.04 - 92.44 degrees East [9]. There are 574 km long coast lines and plenty of small islands within the Bay of Bengal. These are enriched with strong southwesterly winds during the summer months and mild northeastern trade winds and ground winds during the winter months [10]. Other studies have estimated that the potential for wind generation alone is 20 GW [6]. Here, the measured values of wind speed in different places are analyzed and it is estimated the possible power generation by establishing wind power plants as a viable solution to scale back the shortage of electrical power generation in Bangladesh. Furthermore, this study encompasses the long run prospects and utilization of wind energy in Bangladesh.

II. METHODOLOGY AND WIND ENERGY ESTIMATION

2.1 WIND POWER GENERATION PRINCIPLE

The kinetic energy of wind initially converted into the turbine's motion mechanical energy and then to the electrical power. The generated power can be added to the national grid. The wind energy for conversion mainly depends on the wind speed and therefore the sweptback space of the rotary engine [6]. To establish a power plant it's important to analyze the expected energy output of every turbine and calculate its economic reliability. It is important that critical economic importance is sought to understand the source of power. Therefore energy production by different wind turbines in several conditions are different. During this section we'll calculate the motion velocity and kinetic energy made by a turbine at its rated wind speed. This can be the minimum wind speed at which a turbine produces its rated power. The subsequent symbols show the definition of used variables utilized in this theory:

E = Kinetic Energy(J), ρ = Density(kg/m3), m = Mass (kg), A = Swept Area(m2), v = Wind Speed (m/s),
Cp = Power Coefficient, P = Power (W), r = Radius (m), t = time (s), x = distance (m),
dm/dt = Mass flow Rate (Kg/s) , dE/dt = Energy flow Rate(J/s)

Under constant acceleration, if the kinetic energy of an object having mass 'm' and velocity 'v', is equal to the work done 'W' which is equal to multiplication of the displacement of that object from rest to a distance 's' and given force 'F' i.e,

$E = W = F \times s$……..……..……..……. (1)

According to Newton's Law,

$F = ma$, hence $E = m \times a \times s$……..……..……..……(2)

Kinetic Energy, $E = 0.5 \times mv^2$ ……..……..……(3)

The wind power is given by the rate of change of Energy:

$P = \frac{dE}{dt} = \frac{1}{2}v^2\frac{dm}{dt}$ ……..……..……..……..……..……..……(4)

As mass flow rate is given by:

$\frac{dm}{dt} = \rho A\frac{dx}{dt}$……..……..……..……. (5)

Here, $\frac{dx}{dt} = v$ hence, $\frac{dm}{dt} = \rho Av$……..……..……(6)

Equation (4) implies, $P = \rho Av^2$ ……..……..……..……(7)

Adding power coefficient (Cp) in (7) and we get the extractable power:

$P\,(avail) = \frac{1}{2}\rho Av^3C_p$ ……..……....(8)

The swept area of the turbine:

$A = \pi r^2$……..……(9)

From the length of the turbine blades we can calculate the area.

2.2 WIND POWER SCENARIO IN BANGLADESH

Wind is free and a good form of renewable energy. In Bangladesh, research in the field of wind energy began only a few years ago. The research result shows that some coastal areas of Bangladesh have a very good potential of wind energy [11]. It has a long coastal area. After analyzing the wind data by Center for Wind Energy Technology (CWET) India says that the wind energy resource of Bangladesh is not good enough (<7m/s) for electricity production in most of the region of the country for grid connection. This sector is under research and mainly focused on the coastal zone [12]. Bangladesh has a long coastline of 574 km in the Bay of Bengal. The strong monsoon south/south-westerly wind comes from the Indian Ocean which, after traveling a long distance over the sea, enters into the coastal areas of Bangladesh. This maximum wind blows over the country from March to October. The wind speed is increased when it enters the coastal regions of the country of V-shaped [13]. This wind blows over Bangladesh, has an average speed of 3 m/s to 6 m/s.Wind speed remains relatively lower from October to February. During June-July the maximum wind speed is gained [14]. The annual average wind speed at 30 m height is more than 5 m/s along the coastal area of Bangladesh. In north-eastern parts in Bangladesh the wind speed is above 4.5 m/s and the other parts of the country has average wind speed of around 3.5 m/s [15]. To get better power extraction, the region should have wind velocity of at least 7 m/s. Hub-height generally fixes from 20 to 40 m for proper operation of the wind turbine [13]. It has been observed after height correction that above 30 m height there is a great potential for extracting wind power for electricity generation in some sites like Teknaf, Charfassion, Patenga, Cox's Bazar, Kuakata, Kutubdia, etc. In different seasons the wind blows in different patterns. In coastal zones wind turbines need to have the capacity to withstand 250 km/hr wind.

At present, Bangladesh Power Development Board (BPDB) mainly undertakes some very good research works. It is found that,In coastal zones it is feasible to establish small wind turbines[7]. Research has shown that some regions of Bangladesh have a very good potential for wind energy [11]. Bangladesh Centre for Advanced Studies (BCAS) associated with Local Government and Engineering Department (LGED) and with the support of an international organization namely Energy Technology and Services Unit (ETSU) from UK with the funding from Department of Foreign and International Development (DFID) has monitored wind conditions at seven coastal sites for a period of one year in 1996-97. Wind parameters at a height of 25 m were measured [16]. At present, some fruitful wind resource work is ongoing in the country by Bangladesh Council of Scientific and Industrial Research (BCSIR), Local Government Engineering Department (LGED),Bangladesh Power Development Board (BPDB), and Bangladesh University of Engineering and Technology (BUET). Measuring wind speeds at some typical locations of Bangladesh has been started[17]. In Bangladesh pioneer of generation of electricity from wind is at Muhuri Dam, Feni which has a capacity of 0.9 MW (225 KW, 4

Turbines) and another one at Kutubdia Island (20 KW, 50 turbines) having a capacity of 1 MW [18]. Vesta Company of Denmark has been committed that they will invest in a 100 MW wind power plant which will be made in Patuakhali which will be the largest wind power plant of Bangladesh [8]. Government has also launched a project of extracting wind power with a capacity of 2 MW in Maheshkhali[19].

2.3 STATISTICAL DATA OF WIND IN BANGLADESH

The Meteorological department of Bangladesh measured the wind speed in different heights for six different sites shown in table 1.

Table 1: Wind Speed For Six Different Sites In Different Heights

Sl.	Location	Height (M)	Average Speed (M/S)
01.	Cox's Bazar	25	3.792
02.	Charfassion	25	4.433
03.	Chittagong	25	4.367
04.	Kuakata	20	3.135
05.	Kuakata	30	4.146
06.	Kutubdia	20	3.642
07.	Sitakundu	20	3.015
08.	Sitakundu	30	3.554

The Bangladesh government had another project named WEST (Wind Energy Study Project). Under this project, for a period of one year, monthly average wind speed data in six potential coastal spots has been recorded[20]. Based on the project, the wind speed data at 25 meter height in different coastal regions of Bangladesh are shown in figure 1.

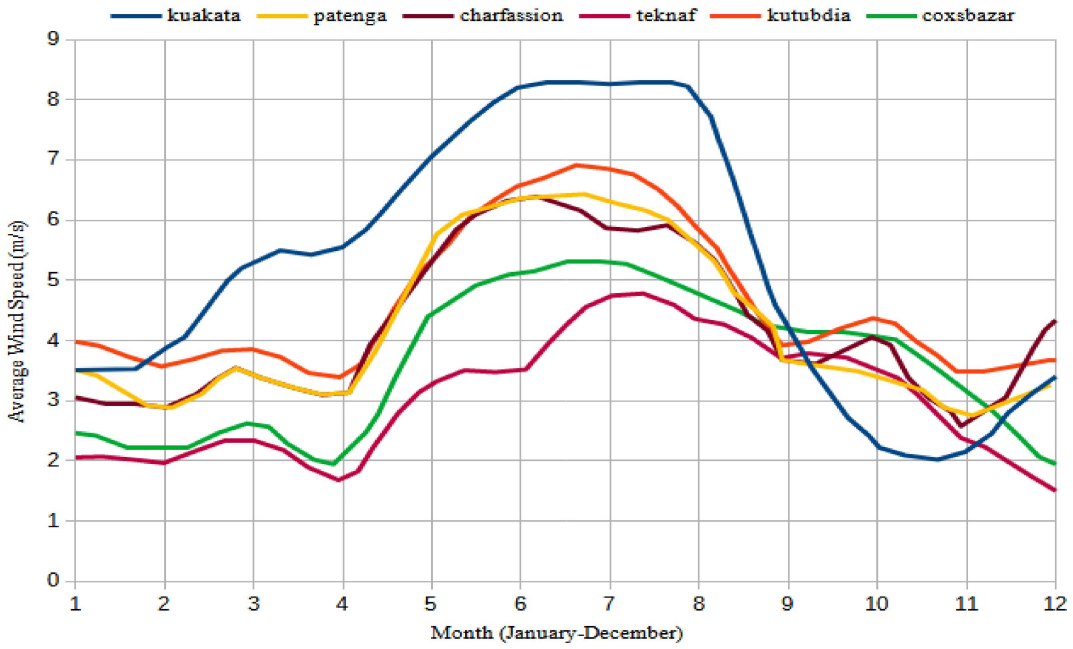

Fig.1. Average wind speed throughout the year in different sites of Bangladesh

It has been observed from figure 1 that, May to August is the most suitable period for extracting wind energy. 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 Charfassion have a good probability to be the sites for installing wind turbines. Wind energy is extractable from all the places from the six spots around the year. Monthly extractable wind energy is shown in table 2.

Table 2: Extractable Energy From Wind Throughout The Year in Different Location

Month ↓	Extractable Wind Energy (watt-hr/m^2)					
	Patenga	Cox's Bazar	Tecnaf	Char fassion	Kuakata	Kutubdia
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	20.9	8.21
Apr	4.48	1.18	0.86	6.60	22.3	5.63
May	22.7	11.8	5.47	20.4	45.5	21.5
Jun	36.4	18.3	6.36	35.1	71.7	37.7
Jul	33.5	20.3	14.9	26.1	72.6	43.1
Aug	24.8	14.7	12.0	25.4	68.5	27.9
Sep	7.22	9.38	7.74	6.7	10.0	8.57
Oct	6.02	9.60	6.60	9.3	1.90	11.8
Nov	3.30	4.62	2.23	2.5	1.47	6.19
Dec	4.86	1.07	0.57	11.3	6.90	7.09

III. RESULT AND ANALYSIS

3.1 COST CALCULATION

The most important measurement of wind energy cost is the per unit Cost of Energy (CoE). This measure is incorporated with all elements of cost i.e., Installed Capital Cost (ICC), cost of Operations and Maintenance (O&M) over a year.

$$Per\ Unit\ CoE = \frac{ICC + O\ \&\ M}{Energy\ Production/Year}\ \text{USD/(kWh/yr)}$$

Average One 250KW rated turbine needs a cost of USD 248,000 (including 50m Tower, full Installation and Grid connection costs) .Also the annual operation and maintenance needs a cost of USD 13,350.

So, Per Unit CoE== 3.08 USD/(kWh/yr.)
Now, 1 USD ≈ 103 BDT (in Bangladesh as per December 2022)
So, Per unit CoE for this design (3.08 × 103) = 317.24 BDT / (kWh/yr.)
Daily per unit CoE for this design = 0.869 BDT / KWh

3.2 COST COMPARISON

Though we can see from previous sections wind energy has economical benefits. But some other energy sources in Bangladesh are economically cheaper than wind. Here, the comparison on the value of unit electricity generation cost using the sources in Bangladesh shown in table 4.

Table 03: Cost of Unit Electricity Generation Using Different Sources of Power[7].

Fuel	**Unit Electricity Generation Cost (BDT/kw-hr)**
Solar PV	80.68
Diesel	20.45
Coal (Imported)	8.60
Coal (Local)	3.50
Wind	6.00
Natural Gas	3.10

Local coal and natural gas are cheaper but the resources are about to end in Bangladesh. Besides, wind energy has the advantages of no pollution, no imported fuels needed, no natural gas needed, easy and cheaper maintenance, supply of power in the areas where grid power is unavailable, low land needed etc. But there are some disadvantages too. The two major disadvantages of wind power include initial cost and technology immaturity. Construction and maintenance costs are the primary costs of wind turbines [20]. New technology is needed for making the costs lower, increasing reliability and energy production, expanding the resource area, developing infrastructure and manufacturing facilities, and mitigating known environmental impacts. Therefore, we can say that the implementation of wind energy must be delayed until technological advancements are made. Other disadvantages include Aesthetic impact, Wildlife troubles, Remoteness of location, Noise, Pollution, Sea safety etc. [21]

IV. CONCLUSION

For a developing country like Bangladesh Energy crisis is a huge threat for economic development. Though the government statistics show that about 95% (end of 2018) of total demand has been fulfilled, the most contributing sources (coal and gas) are about to end. Now, non renewable energy sources(wind, solar PV) are the alternatives. Wind energy is a green energy. Generation of power from wind energy is a sustainable solution to resolve the energy crisis in Bangladesh. It should have accurate data of wind speed at higher altitudes of the sites to implement wind farms. By 2025, it is possible to produce more than 10 percent of the total power demand from renewable energy sources. Cost comparison shows production electricity by wind is much cheaper than diesel and solar PV. The main obstacle to investing in wind farms is the very high initial cost. It is almost 4-5 times higher for wind than natural gas. If it is possible to establish wind turbines on a mass scale, unit electricity generation cost will surely reduce. We should engage more international and national resources to extract electricity from wind sources, since the prospects of wind energy in Bangladesh looks very promising.

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