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Prospects of Wind Energy in the Coastal Region of Bangladesh

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Abstract— In the case of the emerging energy problem in Bangladesh, wind energy holds good prospects. The wind speeds of the coastal regions of Bangladesh have been considered in this paper. The data and calculation for 650 MW of power indicates the prospective source of wind energy is available in coastal regions of Bangladesh. Proper types of wind turbines may be use for the purpose of extracting wind energy from the coastal regions of Bangladesh.

Index Terms— Wind speed, Wind energy, Wind turbine, Coastal area,Global Engery,Windmill,Energy Consumption.

1 INTRODUCTION

Bangladesh encountering difficulties in supplying energy to maintain its economic growth. The electrical load demand of Bangladesh is nearly 7,500 MW. The current demand for energy exceeds the available resources and this gap is projected to increase significantly in the near future. your paper.

2 BACKGROUND OF WIND POWER SYSTEM IN BANGLADESH

For geographical position of Bangladesh wind power system has a good potential. Bangladesh Power Development Board (BPDB) and Local Government Engineering Department (LGED) have committed lots of research work on wind power system. There is a project in Muhuri which have a rated capacity of 0.99 MW [6]. All the research works in Muhuri indicate that it has a potential of 100 MW wind power capacity. In Bangladesh, winds are available mainly during the Monsoons and around one to two months before and after the Monsoons. During the months starting from late October to the middle of February, winds either remain calm or are too low to be of any use by a traditional windmill. Except for the above mentioned period of four months, a windmill if properly designed and located, can supply enough energy to be marketable.

3 CURRENT STATUS AND FUTURE PROSPECTS

Wind is the world's fastest growing energy source today and it has been retaining this position consecutively for the last five years. The global wind power capacity has increased by a factor of 4.2 during the last five years. The total global installed capacity is 1, 76,470 MW in 2011. Over 73% of the global installations are in Europe. Germany is the European leader, followed by Spain and Denmark [7], [9]. With the increasing thrust on renewable and reducing cost of wind generated electricity, the growth of wind energy will continue in the years to come. According to European Wind Energy Association (EWEA), wind with its expected 230,000 MW installation, can supply 12 % of the global energy demand by 2010[8]. This indicates a market worth around 25 billion Euros. The installed capacity may reach a level of 1.2 million MW by 2020[3], [4].

4 STATISTICS OF WIND DATA IN THE COASTAL AREA OF BANGLADESH

Wind speed for eight different sites has been collected from the Meteorological department of Bangladesh shown in table 1.

TABLE 1
WIND SPEED OF DIFFERENT SITES AT DIFFERENT HEIGHT

SL.	LOCATION	HEIGHT	AVERAGE SPEED (M/S)	REMARKS
1	COX'S BAZAR	25m	3.792	GOOD
2	CHARFESSION	25m	4.433	BETTER
3	CHITTAGONG	25m	4.367	BETTER
4	KUAKATA	20m	3.135	GOOD
5	KUAKATA	30m	4.146	BETTER
6	KUTUBDIA	20m	3.642	GOOD
7	SITAKUNDA	20m	3.015	GOOD
8	SITAKUNDA	30m	3.554	GOOD

The wind speed is for a duration of twelve months for eight different sites which is the most recent data from the Meteorological department of Bangladesh. The coastal area includes Saint Martein,

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Teknaf, Cox'sBazar, Patenga, Chittagong, Sitakunda, Kuakata, Kutubdia, Hatiya, Sandwip, Mongla etc. In this section the wind speeds of these locations are shown at different heights. Figure 1, 2, 3 and 4 represent that months versus wind speeds of Cox's Bazar, Kutubdia, Kuakata and Saint Martin respectively.

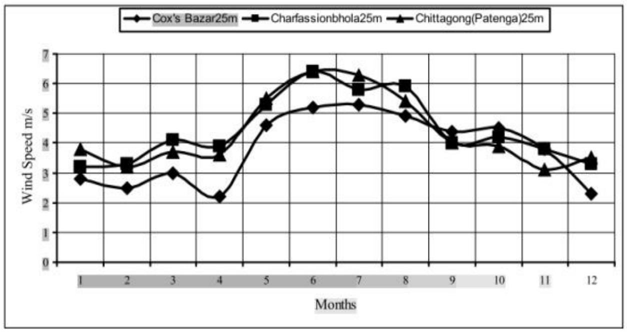

Fig. 1. Month Vs Wind speed of Cox's Bazar, Charfassion & Chittagong.

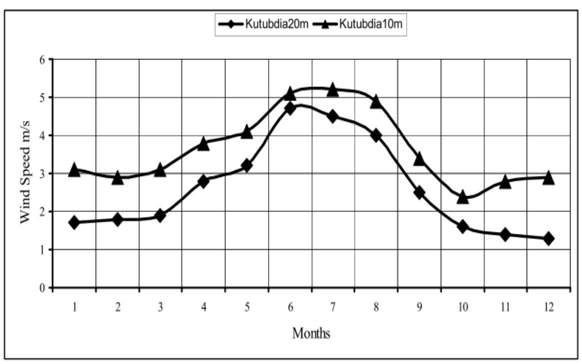

Fig 2. Month Vs Wind speed of Kutubdia.

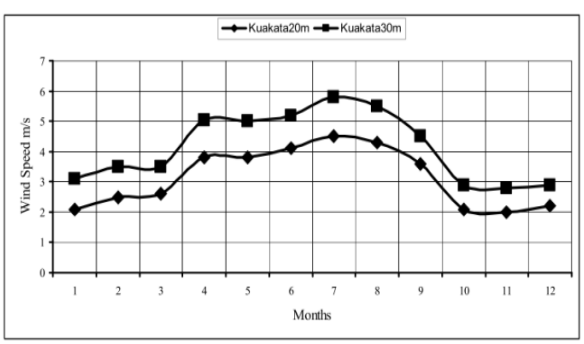

Fig 3 Month Vs Wind speed of Kuakata.

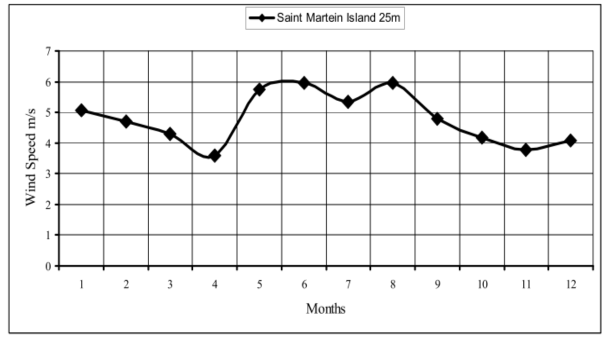

Fig 4 Month Vs Wind speed of Saint Martin Island

TABLE 2
MONTHLY AND ANNUAL AVERAGE WIND SPEED AT 50 METER

MONTH	MUHURI DAM, FENI (m/s) H=50m	MOGNAMAGHAT COX'S BAZAR (m/s) H=50m	PARKY SAIKAT PATENGA, CHITTAGONG (m/s) H=50m	KUAKATA PATUAKHALI (m/s) H=50 m
JANUARY	5.10	5.30	4.90	5.802
FEBRUARY	5.30	4.80	5.10	5.50
MARCH	7.00	7.30	7.60	7.70
APRIL	7.70	7.90	7.80	8.30
MAY	8.10	8.20	8.20	7.90
JUNE	7.20	8.00	7.60	6.90
JULY	7.40	8.40	8.10	7.70
AUGUST	6.80	7.70	7.40	7.50
SEPTEM-	6.70	7.10	6.90	6.90
OCTOBER	6.20	6.80	6.40	6.30
NOVEM-	5.60	5.90	5.60	5.50
DECEM-	4.90	5.40	5.10	4.80
ANNUAL AVERAGE WIND SPEED(m/s)	6.50	6.90	6.725	6.733

Table 2 [10] shows the wind speeds at four locations in the coastal areas of Bangladesh. These locations are Parky Saikat near Patenga, Chittagong; Mognamaghat, Pekua, Cox's Bazar; Muhuri Dam, Sonagazi, Feni; and Kuakata, Patuakhali. These four sites are representatives of the entire coastal areas of our country. It was found that the annual average wind speed in these four sites is more than 6.5 m/s. It an internationally accepted thumb rule that a site having annual average wind speed of 6.0 m/s or higher is feasible for harnessing wind electricity with commercial viability[9]. From this data, we can understand that generating electrical energy with commercial viability in Bangladesh is possible.

5 THEORY & CALCULATION

Wind turbines work by converting the kinetic energy in the wind first into rotational kinetic energy in the turbine and then electrical energy that can be supplied, via the national grid. The energy available for conversion mainly depends on the wind speed and the swept area of the turbine [5]. When planning a wind farm it is important to know the expected power and energy output of each wind turbine to be able to calculate its economic viability. With the knowledge that it is of critical economic importance to know the power and therefore energy produced by different types of wind turbine in different conditions, in this section the rotational kinetic power produced in a wind turbine at its rated wind speed is calculated. This is the minimum wind speed at which a wind turbine produces its rated power. The following symbols show the definition of various variables used in this theory:

E = Kinetic Energy(J)	ρ = Density(kg/m3)
m = Mass (kg)	A = Swept Area(m^2)
v = Wind Speed (m/s)	Cp = Power Coefficient
P = Power (W)	r = Radius (m)
t = time (s)	x = distance (m)
$\frac{dm}{dt}$ =Mass flow rate(kg/s)	$\frac{dE}{dt}$ =Energy Flow Rate (J/s)

Under constant acceleration, the kinetic energy of an object having mass m and velocity v is equal to the work done W in displacing that object from rest to a distance s under a force F is

$$E = W = F \times s \qquad (1)$$

According to Newton's Law

$$F = m \times a \qquad (2)$$

Hence,

$$E = m \times a \times s \qquad (3)$$

Using the third equation of motion:

$$v^2 = u^2 + 2as \qquad (4)$$

we get,

$$a = \frac{(v^2 - u^{2)}}{2s} \qquad (5)$$

Since the initial velocity of the object is zero, i.e. $u = 0$,

we get , $$a = \frac{v^2}{2s} \qquad (6)$$

Substituting it in equation (3), the kinetic energy of a mass in motions is:

$$E = \frac{1}{2} m v^2 \qquad (7)$$

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

$$P = \frac{dE}{dt} = \frac{1}{2} v^2 \frac{dm}{dt} \qquad (8)$$

As mass flow rate is given by:

$$\frac{dm}{dt} = \rho A \frac{dx}{dt} \qquad (9)$$

The rate of change of distance is given by:

$$\frac{dx}{dt} = v \qquad (10)$$

Substituting it in equation (9) it is found that,

$$\frac{dm}{dt} = \rho A v \qquad (11)$$

Hence, from equation (8), the power can be defined as:

$$P = \frac{1}{2} \rho A v^2 \qquad (12)$$

The power coefficient needs to be factored in equation (12) and the extractable power from the wind is given by:

$$P_{(avail)} = \frac{1}{2} \rho A v^3 C_p \qquad (13)$$

The swept area of the turbine can be calculated from the length of the turbine blades using the equation for the area of a circle:

$$A = \pi r^2 \qquad (14)$$

6 ESTIMATION OF NUMBER OF TURBINES, POWER RATING AND ROTOR SIZE FOR 650 MW POWER GENERATION

The following assumptions were made for calculating the number of turbines, power rating and rotor size for generating 650 MW of power by using wind energy.

Annual energy consumption required = 6,50,000 KWh

Coefficient of performance, Cp = 0.40

Density of air = 1.2 kg/m3 (Sea level)

No. of hours in a year = 8760 hours.

Wind speed at 50 meter height is 6.733 m/s.

Capacity factor = 30% =0.30

Power density (Power per unit area) of wind turbine hub at 50 meter height is considered.

Power density of wind (ideal) = $\frac{1}{2}\rho v^3$

$= 0.5 \times 1.2 \times (6.733)^3$

$= 183.137$ watt / m^2

Considering Losses, Cp = 0.4

Transmission losses (rotor to generator) = 0.90

Generator losses = 0.90

Overall loss factor =0.4 ×0.9 × 0.9 = 0.324

Actual power density = Ideal power density × Overall Loss Factor

= 183.137 × .324

= 59.336 w /m^2

Annual power density = Actual power density × No. of hours per year.

= 59.336 × 8760

= 519.787 kWh /m^2

The real annual energy density will be less as the wind of rated speed will not blow for 8760 hours. Thus the capacity factor need tom be considered.

Real annual power density = Annual energy density × capacity factor.

= 519.787 × 0.30

= 155.936 kWh /m^2

The area of the turbine can be estimated from the real annual energy density.

Area of the rotor $= \frac{650000}{155.936}$

= 4168.376 m^2

Radius of the rotor blade covered area,(R)=πR^2 = 4168.376

R = 36.425 meter

Power Rating of Turbine = Actual Power density × Area of rotor

= 59.336 × 4168.376

Power Rating of Turbine = 247.334 ≈ 250 kw

Annual energy requirement = 650000 kWh.

Turbine power rating= 250 kw

Monthly energy consumption = $\frac{650000}{12}$

= 54166.66 kw

Daily energy consumption = 54166.66 /30

=1805.55kw (1.805MW per day)

No. of turbines required = 1805.55/250

=7.22 ≈ 8

Therefore for producing 650 MW electricity annually(with rated average wind speed of 6.733m/s) for this we need 8 numbers of turbine(rated 250 KW) is needed.

7 COST CALCULATION

The most comprehensive measure of wind energy cost is the per unit cost of energy (CoE). This measure incorporates all elements of cost i.e., installed capital cost(ICC), cost of operations and maintenance(O&M) over a year

Per Unit CoE = $\left[\frac{ICC + O\&M}{Energy\,Production/Year}\right]$ £/(kWh/yr)

One 250KW rated turbibe costs £235,000 (including 50m Tower and Complete unit Installation and Grid connection costs) .Also the annual operation and maintenance needs a cost of £12,640

Per unit CoE = $\frac{£235,000 \times 8 + £12640}{650,000}$

= 2.9117 £/(kWh/yr.)

Now, 1£ ≈ 130 Taka (in Bangladesh)

So, Per unit CoE for this design (2.9117 × 130) = 378.521 Tk./(kWh/yr.)

Daily per unit CoE for this design = 1.04 Tk/KWh

8 COST ANALYSIS

A. Investment Cost (given in Million Taka):

EQUIPMENTS	BDT Million
EIGHT 250KW WIND TURBINES	140.4
LAND & SITE DEVELOPMENT	1.90
BUILDING	0.76
BATTERY, INVERTER ETC INCLUDING ONE-TIME REPLACEMENT	3.12

Total Investment Cost = BDT 146.18 (Million)

B. Operation & Maintenance Cost:

MAN-POWER COST	2.2
REPAIR & MAINTENANCE COST	1.6432
LUBRICANTS	1.2

Total Operation & Maintenance Cost = BDT 5.0432 (Million)

C. Revenue:

GROSS GENERATION OF ELECTRICITY	0.650GW
ELECTRICITY SALE (95%)	0.617GW

Revenue = (0.2326 × 617 MW) =BDT 143.5457 (Million)

D. Gross Profit per year:

Revenue - Total Operation & Maintenance Cost= BDT 138.5025 (Million).

9 CONCLUSIONS

As it is the 21st century, life is directly depending on electricity. But the energy crisis is becoming a huge threat for economical development of Bangladesh. Still only 39% of the populations have access to electricity. In the coastal area and the isolated Island where grid connection is not feasible, alternate electric source like wind power system can be very cost effective. On the other hand other renewable energy system like PV system is at least 4 to 5 times more expensive than wind power system. Therefore the above calculation indicates that it is possible to generate electricity by using wind energy at a very reasonable rate. The per unit cost will be cheaper if the generation is more than 650 MW. So government and the private sectors should emphasis on wind power system as a solution of power crisis in Bangladesh.

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