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Wind Energy Assessment for The Coastal Part of Bangladesh

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Abstract: Earlier measurement and study of wind speed for the coastal part of Bangladesh showed that some of the areas of this part would be useful for wind power generation. But till now no measurement at the hub height of wind machine has yet done. Data has been collected from different sources and analysis has been done using logarithmic law and micro scale modeling software, WAsP for wind energy assessment over the coastal part. It has been found that the speed varies from 4m/s to 5.7 m/s at a height of 50m above ground level depending on the land type. Wind power density varies from 100 to 250 w/m^2 indicate the wind power can play an important role in the energy sector.

Key words: Wind power density, wind speed, WAsP analysis, monsoon, obstacle

INTRODUCTION

Bangladesh which has the lowest per capita consumption of commercial energy in South Asia has about 725km long coastal belt in which hilly coastal line is 200 km long. The coastal area consists of around 50 islands, many more small but inhabited islands and the areas along the south coast of Bangladesh with Burma in the east and India in the West. About 50 upazila's of 14 districts (out of 507 thana's in 64 districts) constitute the coastal zone, with a population of about 10 million. They live in the danger zone of frequent cyclones and tidal bores but these areas have a great potential for greater economic activities in agriculture, fisheries, salt making, other small industries as well as in trade and commerce. An initial small survey conducted in some of these areas showed that the population would welcome full-time reliable electricity to meet their power needs. At present they have expensive localized diesel units or short-time electricity at few places frequented with load-shedding[1]. The World Bank has estimated that Bangladesh loses around $1 billion per year in economic output due to power outages and unreliable energy supplies[2].

Most of the households in the coastal areas do not have access to electricity as there is no power distribution network in the far flung areas. Kerosene is the most common fuel used by the households for illumination purposes. Price of kerosene is often subject to fluctuations with the price going up in the event of scarcity of supply. Some of the market places are connected to the distribution networks of Bangladesh Power Development Board (BPDB) or Polly Biddut Somity (PBS) of Rural Electrification Board (REB) and suffer from frequent load-shedding. BPDB's isolated Diesel Power Stations are supplying electricity in the main islands but it has been found that most of the time they are out-of-order due to lack of maintenance and skilled operator. Private diesel gensets are in operation in some of the market places to provide electricity to the shops for limited hours.

WIND SPEED STUDY IN THE COAST BANGLADESH

In Bangladesh, adequate information on wind speed over the country and particularly on wind speed at hub heights of wind machines is not available. A previous study showed that the wind monitoring stations of Bangladesh Meteorological Department (BMD), situated in built up areas, measure low wind speed near the ground level at height of around 10 meter. M Hussain *et al.* collected data form BMD for 30 years (1931-1960) and did analysis for 14 different places in Bangladesh. It was found that at seaside, Chittagong-Cox's Bazar seacoast and coastal islands will have a good many locations with prospective wind speed[3]. Another study was shown that off-shore islands were expected to have sufficiently good wind speeds to a run wind machine cost effectively and wind generators with a diesel back up system will be most suitable for the off-shore islands[4,5]. Based on these study and analysis, in 1996-97 under the WEST project

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Table 1: Status of the collected data

Organizations	Interval	Measuring Instrument	Anemometer Height (m)	Collected by RERC
BMD	3 h	Cup anemometer with mechanical / electrical recorder	Around 10	3 hour intervals (1981-2001) for most of the stations
BCAS (WEST Project)	10 min	Cup anemometer with data logger (Campbell)	25	The raw data has been collected
GTZ data.(TERNA Project)	10 min	Cup anemometer with data logger (WICOM EL)	20	Monthly average wind speed
BCSIR	1 hr	Cup anemometer with data logger	20 and 30	Monthly average daily wind speed

Table 2: Measured and predicted values at BCAS locations using BMD data and log law

	Kuakata			Charfassion			Patenga			Kutubdia			Cox's Bazar			Teknaf		
Month	BMD	M	P	BMD	M	P	BMD	M	P	BMD	M	P	BMD	M	P	BMD	M	P
Sept	1.3	3.6	3.0	0.7	3.3	1.9	2.1	3.4	3.6	1.1	3.6	2.7	1.4	3.7	3.7	0.6	3.5	1.7
Oct	1.0	2.2	2.4	0.9	3.7	2.3	2.6	3.2	4.5	1.2	4.0	2.8	1.5	3.7	4.1	0.5	3.3	1.5
Nov	0.5	1.9	1.1	0.4	***	****	0.6	2.6	1.1	0.8	3.2	1.9	1.0	2.9	2.6	0.4	2.3	1.1
Dec	0.7	3.4	1.6	0.5	3.1	1.2	1.0	3.0	1.7	1.1	3.4	2.7	1.0	1.8	2.6	0.4	1.4	1.2
Jan	0.8	3.2	1.8	0.6	2.8	1.6	1.0	3.3	1.7	1.2	3.7	2.9	1.2	2.3	3.3	0.7	2.1	2.0
Feb	0.8	3.4	1.9	0.7	2.7	1.8	1.3	2.7	2.3	1.3	3.3	3.1	1.1	2.0	2.9	0.7	1.9	2.0
Mar	1.5	4.8	3.6	1.1	3.5	3.0	2.6	3.1	4.5	1.5	3.5	3.6	1.6	2.5	4.3	0.8	2.3	2.4
Apr	1.4	4.9	3.4	1.0	3.3	2.7	2.0	2.9	3.5	1.3	3.1	3.0	1.3	1.8	3.4	0.7	1.7	2.0
May	2.6	6.3	6.1	1.8	4.8	4.7	4.0	5.0	6.8	2.0	4.9	4.7	2.8	4.0	7.5	1.4	3.1	4.2
Jun	2.9	7.3	6.8	1.6	5.8	4.4	4.4	5.8	7.6	2.7	5.9	6.3	2.8	4.6	7.4	0.7	3.3	2.0
Jul	2.4	7.3	5.7	1.2	5.2	3.3	5.2	5.7	8.9	2.7	6.2	6.3	2.7	4.8	7.3	0.8	4.3	2.4
Aug	3.1			1.6	5.2	4.4	4.5	4.9	7.8	2.1	5.3	5.0	2.5	4.3	6.6	0.8	4.0	2.3
Ave	1.6	4.4	3.4	1.0	3.9	2.9	2.6	3.8	4.5	1.6	4.2	3.8	1.7	3.2	4.6	0.7	2.8	2.0

Table 3: Wind atlas for four coastal location using BCAS data

Charfassion		Roughness				Chittagong		Roughness			
Height	Speed	0.00m	0.03m	0.10m	0.40m	Height (m)	Speed	0.00m	0.03m	0.10m	0.40m
10 m	ms-1	4.3	3	2.6	2	10	ms-1	4.5	3.1	2.7	2.1
	Wm-2	118	50	32	16		Wm-2	116	46	30	15
25 m	ms-1	4.7	3.5	3.2	2.7	25	ms-1	4.9	3.7	3.3	2.8
	Wm-2	149	76	55	33		Wm-2	148	73	53	31
50 m	ms-1	5	4.1	3.7	3.2	50	ms-1	5.3	4.3	3.9	3.3
	Wm-2	179	101	78	52		Wm-2	179	100	77	50
100 m	ms-1	5.4	4.9	4.4	3.9	100	ms-1	5.7	5.1	4.7	4
	Wm-2	236	158	119	78		Wm-2	234	158	119	78
200 m	ms-1	6	6.1	5.5	4.7	200	ms-1	6.3	6.4	5.8	4.9
	Wm-2	341	320	234	149		Wm-2	333	317	233	147

Kutubdia		Roughness				Cox's Bazar		Roughness			
Height	Speed	0.00m	0.03m	0.10m	0.40m	Height (m)	Speed	0.00m	0.03m	0.10m	0.40m
10 m	ms-1	4.9	3.4	3	2.3	10	ms-1	4.3	2.9	2.6	2
	Wm-2	165	68	44	21		Wm-2	132	56	37	18
25 m	ms-1	5.4	4.1	3.6	3.1	25	ms-1	4.7	3.5	3.2	2.6
	Wm-2	208	104	76	45		Wm-2	167	85	62	37
50 m	ms-1	5.8	4.7	4.3	3.7	50	ms-1	5	4.1	3.7	3.2
	Wm-2	251	141	108	71		Wm-2	200	112	87	57
100 m	ms-1	6.3	5.6	5.1	4.4	100	ms-1	5.5	4.8	4.4	3.8
	Wm-2	331	221	166	109		Wm-2	265	174	131	85
200 m	ms-1	6.9	7	6.3	5.4	200	ms-1	6	6	5.5	4.7
	Wm-2	475	446	325	206		Wm-2	383	353	259	163

Bangladesh Centre for Advanced Studies (BCAS) with the support of Local Government Engineering Department (LGED) measured wind speed and direction at 25 m height for seven coast side near the seacoast, but for around one and half year only[6]. At the same time GTZ, a German Organization, also measured wind speed for another three coastal location at a height of 20m[7]. From 1999-2001, Bangladesh Council for Scientific and Industrial Research (BCSIR) has measured only wind speed for Dhaka (inland), Teknaf (coast side) and Sent Martin (island) location[8]. Presently LGED in collaboration with Bangladesh University of Engineering and Technology (BUET) and Chittagong University of Engineering and Technology (CUET) has been measuring (from March 2003) the speed and direction at 20 locations all over the Bangladesh under the WERM project at the height of 20 and 30 m[9]. Beside this project, in 2004, BPDB has come forward to install grid connected wind generation system after getting some better results from their wind mast at 40m height in Feni. The studies show

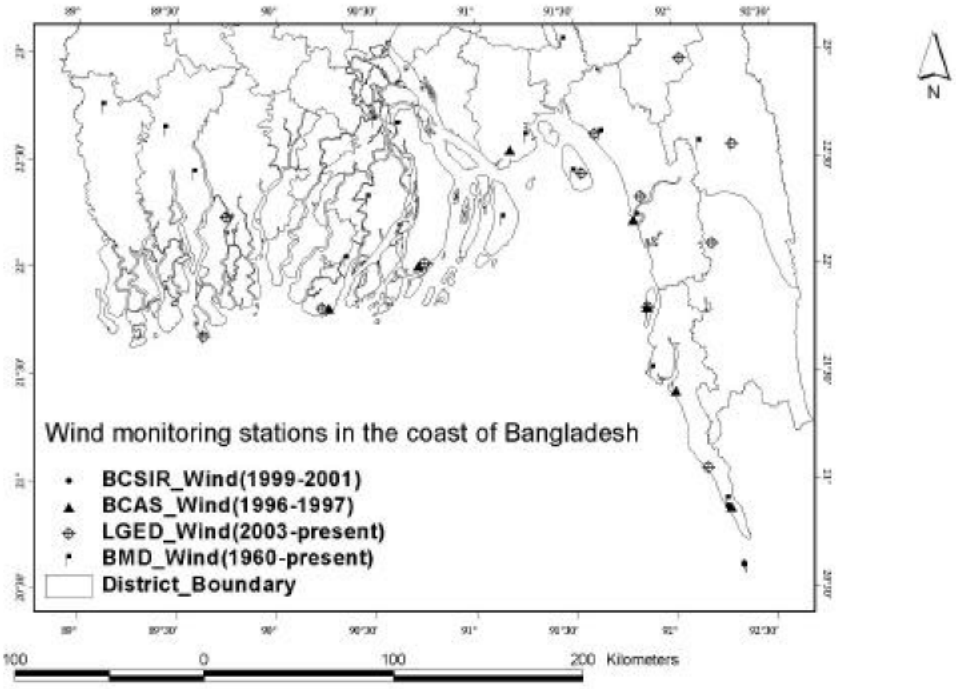

Fig. 1: Wind monitoring stations in the coastal areas of Bangladesh

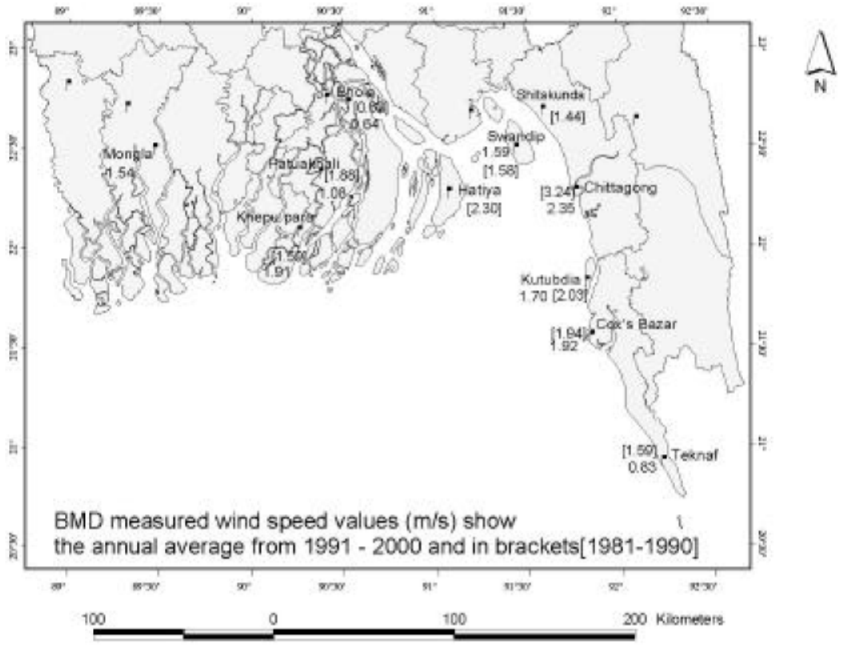

Fig. 2: BMD measured wind speed for the period of 1981-2000

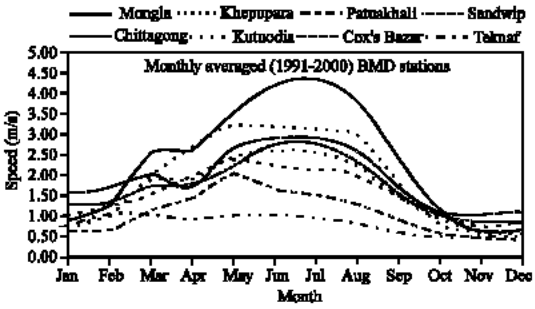

Fig. 3: Monthly variation of wind speed for BMD locations

that some locations have much better speed than for Meteorological Stations.

Data collection: For the wind energy assessment study in the coastal areas, data has been collected from different organizations and Table 1 shows the status of the collected data.

Data analysis: Only 20 yrs (1981-2000) of BMD data and one year (Sept 96-Aug 97) of BCAS raw data has been collected for the analysis. BMD has 3 hrs interval data where for BCAS it is 10 min. BMD measures by manual recording where as BCAS measured electronic data logger for digital recording. For other organizations, raw data is not available for the analysis.

As BMD has the measured data for a long period a detail analysis has been done using the BMD data and Fig. 2 shows the variation of wind speed for the BMD locations during the average period of (1981-1990) and (1991-2000). It has been found that BMD data gives the lower value and it is due to the obstacles effect by trees, buildings close to the met stations. Monthly analysis has also been done for the locations and it shows in Fig. 3 that seasonal effect is very strong in Bangladesh. During monsoon period (May-Aug), wind speed is very high and for rest of the month it is low where in Oct-Nov it is minimum.

Data for BCAS locations for the period of 1996-97 at a height of 25 m has been collected and it has been found that the speed is higher than the BMD measured. Figure 4 shows the speed for selected BCAS locations and nearby BMD stations.

Logarithmic law[11,12] has been used to predict the wind speed at 25 m height for BCAS locations using BMD data (Table 2). It shows that the predicted values give a large error. It has been found that two problems are

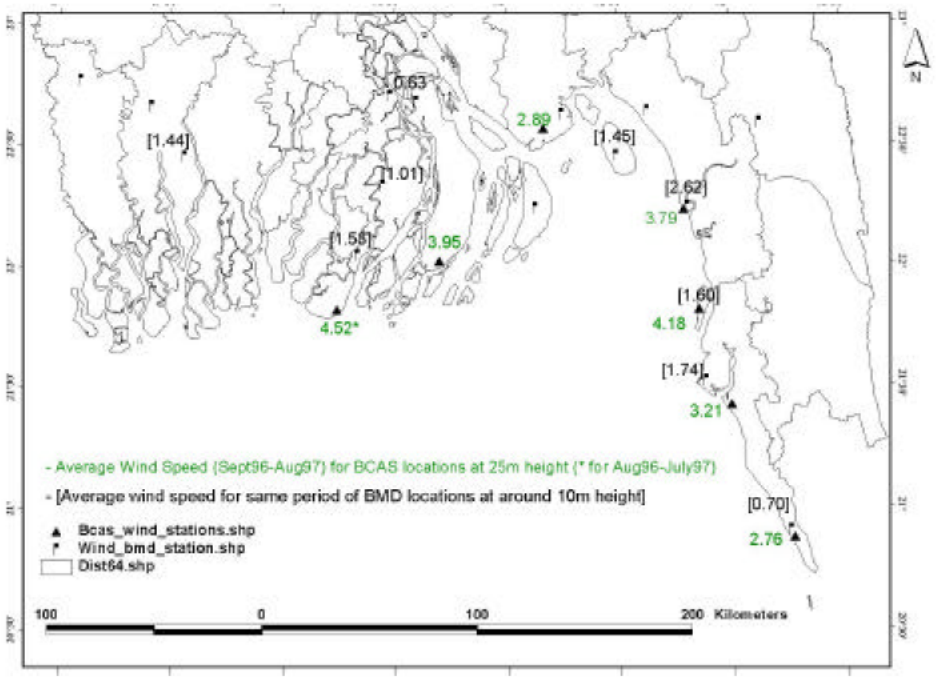

Fig. 4: Average wind speed (Sept 96-Aug97) for BCAS and BMD locations

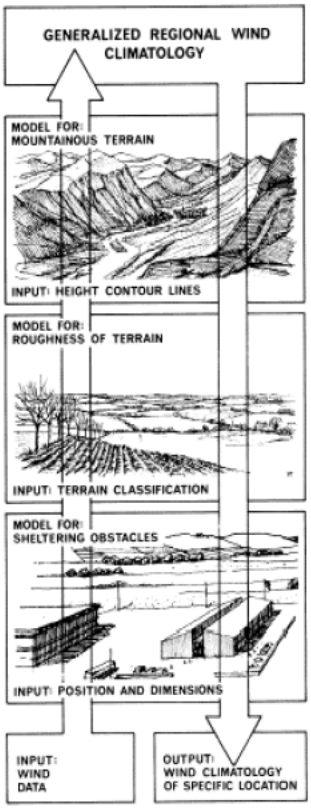

Fig. 5: WAsP methodology

strictly associated with this prediction. One is the obstacles closed to the met stations and the other one is the mast on the roof.

Wind energy assessment: Most of the BMD stations are two stored buildings and situated in the locality and therefore effects of obstacles like trees, buildings are very high. Also anemometer has been placed on the roof of the met stations building. For this two reasons measured wind speed in the BMD met stations are very low. Prediction using BMD data and logarithmic law give poor result. But for BCAS locations obstacles are very less than BMD and the anemometer is placed on a tower which gives the better measured value. During analysis it also has been found that hourly and monthly variation of wind speed for Bangladesh is very high. Therefore, for energy assessment, as the power is the cube of wind speed, hourly data analysis is very essential which affects the values of Weibull parameters for the locations.

To overcome all this situation and for better prediction of wind speed and for assessment of wind energy in the coastal part of Bangladesh, Wind Atlas

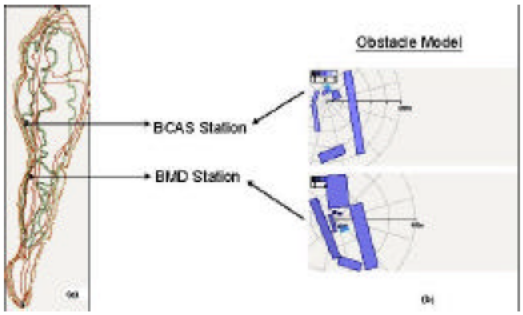

Fig. 6: (a) Digitized map of Kutubdia with BCAS and BMD wind stations (b) Obstacles model of the stations

Analysis and Application program (WAsP), a micro-scale modeling software has been used. WAsP is based on the physical principles of flow in the atmospheric boundary layer and takes into account the effects of different surface roughness conditions, sheltering effects due to buildings and other obstacles and the modification of the wind imposed by the specific terrain height variations around the met station. Latitude, longitude and anemometer height are the pre-requirements to input the data for any location. Considering the effects for the obstacles, roughness and terrain the WAsP develops a wind atlas for a region around 100 km^2 in area[13]. Horizontal and Vertical Extrapolation for Prediction of wind speed using BMD and BCAS data has been done and after that Wind Atlas has been developed for the desired locations using BMD data for 10 yrs (1991-2000) and BCAS data for 1 yr (Sept96-Aug97). Figure 5 shows the WAsP methodology to predict wind speed and to generate regional wind climate. Figure 6a shows a digitized map of Kutubdia Island where two wind monitoring stations of BMD and BCAS has been located and (b) models for obstacles at BCAS and BMD locations where for BMD location obstacles effect are very high due to cyclone shelter building and lot of trees which are much closed to the met stations.

WASP Analysis shows that the predicted power density with corresponding wind speed at a certain height generated by wind atlas using BMD data (Sept 96-Aug 97) gives much higher values than that of BCAS. And it is due to the over prediction of wind speed and power density also by obstacles model and mast on the roof. Table 3 shows the developed wind atlas for the four coastal locations of Bangladesh using one year data of BCAS. It shows that at 50m height for the roughness value from 0m (open sea, water areas) to 0.03 m (Farm land

with very few buildings, trees, airport areas etc) wind speed varies from 4.1 to 5.8 m/s with a power density of 100-250 w/m^2.

CONCLUSION

Day by day generation of electricity from Wind energy becomes very much promising where wind speed and power density is high. In Bangladesh, mainly at coastal areas there are some Islands and Inlands also where wind energy can play an important role to improve the economy of the country. From the assessment it has been found that the wind speed in the coastal areas may vary from 4m/s to 5.8 m/s. But as there is a strong seasonal and diurnal variation in Bangladesh so wind power density is quite higher than for locations having the same annual wind speed with a low speed variation. Recent technology improvement also shows that manufacturer's now developing low capacity wind turbines with a lower cut-off speed at around 2.5 m/s. So it may be concluded that measured wind speed at hub height of 50 m or above could give an accurate assessment of wind energy and its prospect of utilization in Bangladesh.

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