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WIND POWER FOR RURAL AREAS OF BANGLADESH

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ABSTRACT

The available wind data collected by the meteorological department of Bangladesh for a period 16 years on 20 stations at different height between 5m to 10m have been converted for the 20m hub-height using power law expression. From these data monthly average speeds have been calculated. It is observed that for few regions of Bangladesh, there is reasonable wind speed available throughout the year to extract power.
In the coastal region, villages are remotely situated, therefore most of the village are not supplied with electricity, drinking water and irrigation facilities. Supplying electricity to these villages from far of grids and from inadequate generated electricity will not be economically feasible. Harnessing of wind energy by installing wind turbine can be a good solution to solve energy crisis problems of the coastal villages, islands and rural areas. To present a generalized design for Bangladesh, a nomogram and an empirical relation have been developed for the rotor and the pump sizing for a particular region of Bangladesh.

1. INTRODUCTION

Recent developments in the area of wind power generation are very encouraging; particularly in the tropical regions of Asia and Australia. From irrigation projects in India to power supply in the remote farms in Australia, wind power generation can play a vital role [5].

With the increasing demand of electricity, Indian Government has prepared a master plan to promote the non-conventional energy sources. A target is set to generate 10% power from renewable energy sources by the year 2012, which is only 1% today. Wind energy is at the top of the plan. So far, wind power projects of 1345 MW are commissioned and feeding the power to the utility grid in the country. A rapid growth of wind power sector is seen in the country. The estimated technical potential of wind power is around 45000 MW. India ranks amongst the top five wind power production countries in the world. Various state governments in the country have also declared the promotional policies to encourage the wind power sector [4].

The water pumping windmill, reciprocating type being of low efficiency has an economic performance inferior to that of an electric motor pump and even to that of a diesel engine pump [7]. It is suggested that the technical performance of the wind water pump can be significantly improved if a centrifugal pump is used in place of the reciprocating type [2].

2. WIND DATA ANALYSIS

Bangladesh farming needs adequate supply of irrigation water at right time and in right quantities for maximum agricultural production. About 50 % of irrigation pump operate at a head of 6 m or less, depending on the terrain of the country. For driving these pumps, either diesel engine or electric motors are used. These pumps can be driven with the help of wind turbine.

Bangladesh is situated between $20^0 34'$ to $26^0 38'$N latitudes and $88^0 01'$ to $92^0 41'$ E longitudes with nearly 130 million people living on 1,44,000 sq. km. of area. It has 724 km long coastal belt, around 200 km hilly-coast-line and about 50 islands in the Bay of Bengal. The strong south/south-westerly monsoon wind, coming from the Indian Ocean, after traveling a long distance over the water surface, enter into the coastal areas of Bangladesh. This trade wind blows over the country from March to October. This wind speed is enhanced when it enters the V-shaped coastal regions of our country [6].

In this study, an attempt has been made to investigate the application of wind energy for

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water pumping in coastal and rural areas of Bangladesh. For this purpose, 16 years wind speed data of 20 meteorological stations have been studied and the wind velocity is estimated at 20 meters height by using power law expression (Table 1). The meteorological department of Bangladesh collects 3-hourly wind speed data with the help of vertical axis cup type anemometers. These wind data for the period 1981-1996 of 20 stations were taken and monthly average speeds were computed for all the 20 stations.

Wind velocity changes with height. The rate of increase of velocity with height depends upon the roughness of the terrain. The variation of average wind speed can be determined from the following power law expression [8],

$$\frac{V_Z}{V_{ref}} = \left(\frac{h}{h_{ref}} \right)^{\alpha} \quad (1)$$

where, V_Z and V_{ref} are the average speeds at height h in meter and at the reference height of $h_{ref} = 10m$ above the ground respectively and α varies from 0.1 to 0.4 depending on the nature of the terrain.

Table-1: Average Wind Speed (m/s) at 20 Meters Height at Different Locations in Bangladesh

Locations	Months												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Mean
Barisal	2.90	2.57	2.57	3.56	3.23	2.90	2.71	2.64	2.57	2.11	2.07	2.05	2.66
Bogra	1.95	2.20	3.05	4.03	4.15	3.66	3.42	3.05	2.56	2.20	1.83	1.71	2.82
Chittagong	3.64	2.88	4.95	5.01	5.51	6.89	7.09	6.83	4.64	2.82	3.39	2.20	4.65
Comilla	2.26	2.70	2.57	5.45	3.83	3.20	2.88	2.95	1.82	2.38	1.63	1.70	2.78
Cox'sBazar	3.76	3.83	4.51	5.58	3.83	4.14	3.83	3.95	3.20	3.26	2.57	3.26	3.81
Dhaka	3.39	3.26	4.39	5.77	6.33	5.71	6.01	5.89	4.39	3.45	2.64	2.95	4.52
Dinajpur	2.68	2.44	4.88	2.44	2.93	2.68	2.56	2.44	2.44	3.54	2.44	2.44	2.83
Hatiya	3.04	2.64	4.16	3.97	4.82	6.47	5.75	2.64	2.96	2.77	3.06	2.57	3.74
Jessore	2.88	2.95	4.95	8.34	8.34	6.27	6.15	4.95	4.33	3.45	3.32	3.20	4.93
Khepupara	4.20	4.39	3.83	7.09	5.83	4.71	4.14	3.95	3.57	3.70	2.95	2.57	4.24
Khulna	2.96	1.65	3.04	3.05	4.16	3.89	3.31	2.44	2.51	1.98	3.31	2.38	2.89
Kutubdia	1.77	1.82	2.32	2.70	2.77	3.65	3.61	3.14	2.11	1.45	1.19	1.29	2.32
Mongla	1.07	1.25	1.72	2.51	2.92	2.63	2.48	2.35	1.83	1.27	1.02	1.01	2.20
Rangamati	1.45	1.65	4.42	3.10	2.11	3.23	1.72	2.24	1.45	1.45	1.39	1.59	2.15
Sandip	2.32	3.01	3.20	4.83	2.44	3.83	3.39	2.70	2.32	1.63	1.70	1.70	2.76
Sylhet	2.20	2.93	3.29	3.17	2.44	2.68	2.44	2.07	1.71	1.95	1.89	1.83	2.38
Teknaf	3.70	4.01	4.39	4.01	3.32	3.89	3.83	2.88	2.44	2.20	1.57	1.76	3.17
Patenga	6.22	6.34	7.37	7.92	8.47	8.69	9.20	8.54	7.48	6.93	6.71	5.91	7.48
Sathkhira	4.21	4.40	3.84	7.10	6.11	4.76	4.27	4.03	3.62	3.78	3.54	2.81	4.37
Thakurgaon	4.15	5.06	7.93	8.43	8.66	8.05	7.93	6.59	6.34	5.98	5.25	4.76	6.59

Attempt would be made to give a detailed idea about various kinds of presentation of the wind data at different sites at 20 m height. This would provide information to make decision whether that site has reasonably potential for the operation of wind machine. Table 2 shows the monthly variation of average wind speed for several places in Bangladesh. It can be seen that wind speeds are higher from March to August for all places. A wind turbine, if properly designed and located, can supply enough wind energy. The peak rainfall in Bangladesh occurs during the months of June, July and August. But peak wind speeds are available during the hottest and driest months of March, April and May. During this period wind turbine may be used for water pumping for irrigation, if the water is previously stored in a reservoir during the monsoon season. From September to February the velocities are not at all promising for harnessing power. It may be noted that there is wide variation of wind velocity in the coastal areas throughout the year. Patenga, Chittagong, Thakurgaon, Jessore, Khepupara etc. are relatively prospective site for extraction of wind energy.

The wind power per unit area of approach is proportional to the cube of wind speed [2] and can be expressed as $P/A = 0.6V^3$(watts), where P/A is in W/m^2 and V is in m/s. The available wind power represents the strength of wind and theoretically 59% of this power is extractable but practically only 30-40% can be extracted.

Practically, extractable power by any type of windmill can be written as [3], $P_e=0.1AV^3$ (watt), where A is the total swept area of the rotor blades and V is wind speed (m/s).

Extracted power per square meter of swept area for different months for 20 locations in Bangladesh is shown in Table 2. From this table, it can be seen that wind energy can be used in the hottest months i.e., March, April and May for irrigation purposes.

Table-2: Theoretical Available Power of Different Locations at 20 Meters Height in Bangladesh

Locations	Potential Months For Extracting Wind Power	Average Wind Velocity (m/s)	Theoretical Available Power (W/m^2)
Barisal	April to May	2.66	11.27
Bogra	April to June	2.82	13.40
Chittagong	March to September	4.65	60.49
Comilla	March to September	2.78	12.90
Cox'sBazar	May to August	3.81	33.17
Dhaka	March to October	4.52	55.26
Dinajpur	March to August	2.83	13.55
Hatiya	March to July	3.74	31.29
Jessore	April to September	4.93	71.84
Khepupara	February to September	4.24	45.88
Khulna	April to July	2.89	14.47
Kutubdia	April to August	2.32	7.49
Mongla	May to August	2.20	6.39
Rangamati	April to May	2.15	5.97
Sandip	April to July	2.76	12.55
Sylhet	April to July	2.38	8.13
Teknaf	February to September	3.17	19.06
Patenga	February to November	7.48	251.11
Sathkhira	March to September	4.37	50.16
Thakurgaon	March to August	6.59	172.04

The wind energy can be used in the following prospective resources of Bangladesh.

Shrimp cultivation: There is more than 0.2 million hectres of shrimp cultivated land in the coastal regions of Bangladesh. But due to shortage of electricity it is not possible to apply the modern methods of shrimp cultivation. Shrimp cultivation season in Bangladesh begins from March and ends by September. By applying the semi-intensive methods of shrimp and other fish cultivation, which requires electricity, production can be increased by 25-30 times. Electricity is essential for semi-intensive and intensive methods of shrimp cultivation. But it is difficult and expensive to take the national grid or transport fossil fuels to those remote areas and the off shore islands. On the other hand there prevails strong trade winds in those regions from which electricity generation and supply it through localized grid is possible. This electric power will be cheaper and pollution free.

Fish Preservation: About 15 million people live in the coastal regions and the off shore islands of our country. More than 80% of these people live on fishing. The fishing season in the Bay of Bengal is from July to October. During this season, tends of thousands of fishes are netted in the Bay. Due to scarcity of ice, a large portion of these netted fishes are rotten and are thrown into the sea. Running the ice mills by wind generated electricity in those remote areas; this problem can be solved to some extent.

Boro Paddy Cultivation: Boro Paddy cultivation in Bangladesh is from March to May. During this driest season, there prevails a very strong flow of the North-Westerly Trade Wind in the country, specially, in the northern districts. High yielding varieties of paddy are cultivated in this season.

So, irrigation is the must. Wind generated electricity and the wind pumps can help irrigation.

Social Benefits: The application of wind energy may result in significant improvement of the quality of life in the remote rural areas and off shore islands. This development may prevent the tendency of the people to migrate to the cities. Wind energy can help growing small industries in the remote areas and thus can create many jobs and self-employment opportunities.

Wind energy can convert millions of idle night hours into effective working hours in the rural area where people stop working before sunset and start working after 6 or 7 a.m.

Sizing the Wind Pump for Patenga, Bangladesh:

An empirical equation developed for wind pump rotor sizing for Patenga, Bangladesh is given below [1]:

$HQ = C \times D^2 \times V^3$ (2)

Where, C = Constant (here, 8.47)

HQ = Volume-Head product (m^4/day)

Q = Water requirement per day (m^3/ day)

H = Water tank height (m)

D = Diameter of the rotor (m)

V = Average wind velocity (m/s)

Sizing of the wind pump for Patenga, Bangladesh can be calculated using equation (2), or more easily from the nomogram given in Figure-1 by following steps.

Step-1: Locate the volume-head product along the Y-axis on the graph on the left side.

Step-2: Move horizontally right to intercept the line for the average wind velocity 5.91 m/s.

Step-3: Move downward to intercept the X-axis referring to the rotor diameter.

Another way of sizing of the wind pump for Patenga, Bangladesh could be carried out using equation 2 or more easily from the nomogram given in Figure-2, if the average wind velocity (m/s) is known.

Step-1: Locate the average wind velocity along the X-axis on the graph on the right side. In the case of the example, average wind velocity is taken as 5.91 m/s.

Step-2: Move upwards to intercept the line for D =1 m^2.

Step-3: Move horizontally left to intercept the Y-axis referring to the volume-head product. This results in HQ = 1748.42 m^4/day. The diameter of the pump could be established from the supplier's catalogues, depending on the stroke adjustment scale and standard pump diameters.

3. CONCLUSION

There is a prospective site of wind electricity generation in many places of Bangladesh, namely, Patenga, Thakurgaon, Jessore etc. The wind data at different locations also show similar strength of wind energy. The installation of wind power machines at the coastal and island areas will be useful for lifting water and for generation of electricity. Wind pumping could play a significant role in the supply of water for irrigation and drinking in the rural areas of developing countries.

Bangladesh is neither rich in commercial resources of energy nor progressing satisfactorily in the area of wind energy. Since, the prospects of wind energy in Bangladesh look promising we should engage international and national resources to harness energy from this renewable energy source. It is the appropriate time to expand research and development in the area of wind energy utilization for daily life.

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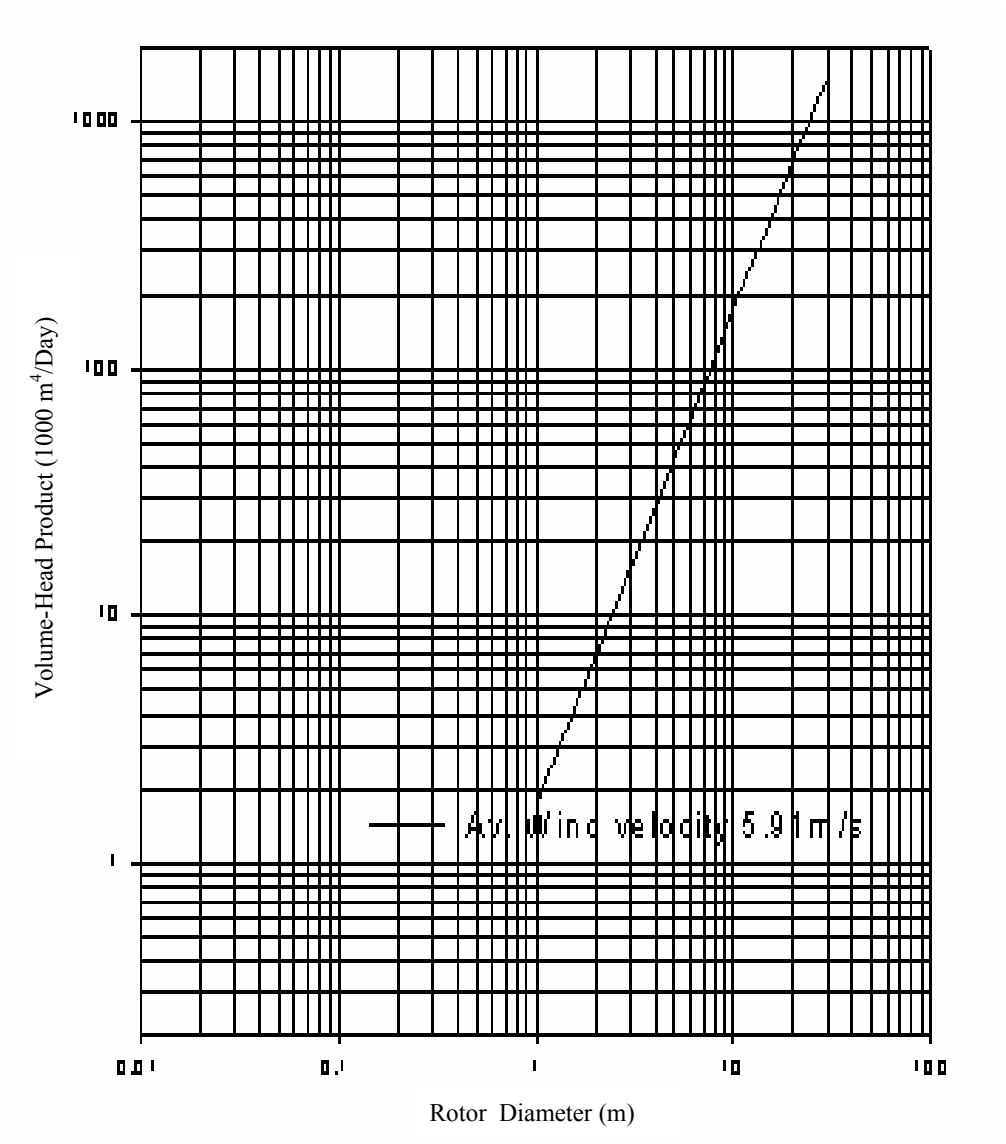

Figure 1: Wind Pump Rotor Sizing Nomogram for Patenga, Bangladesh

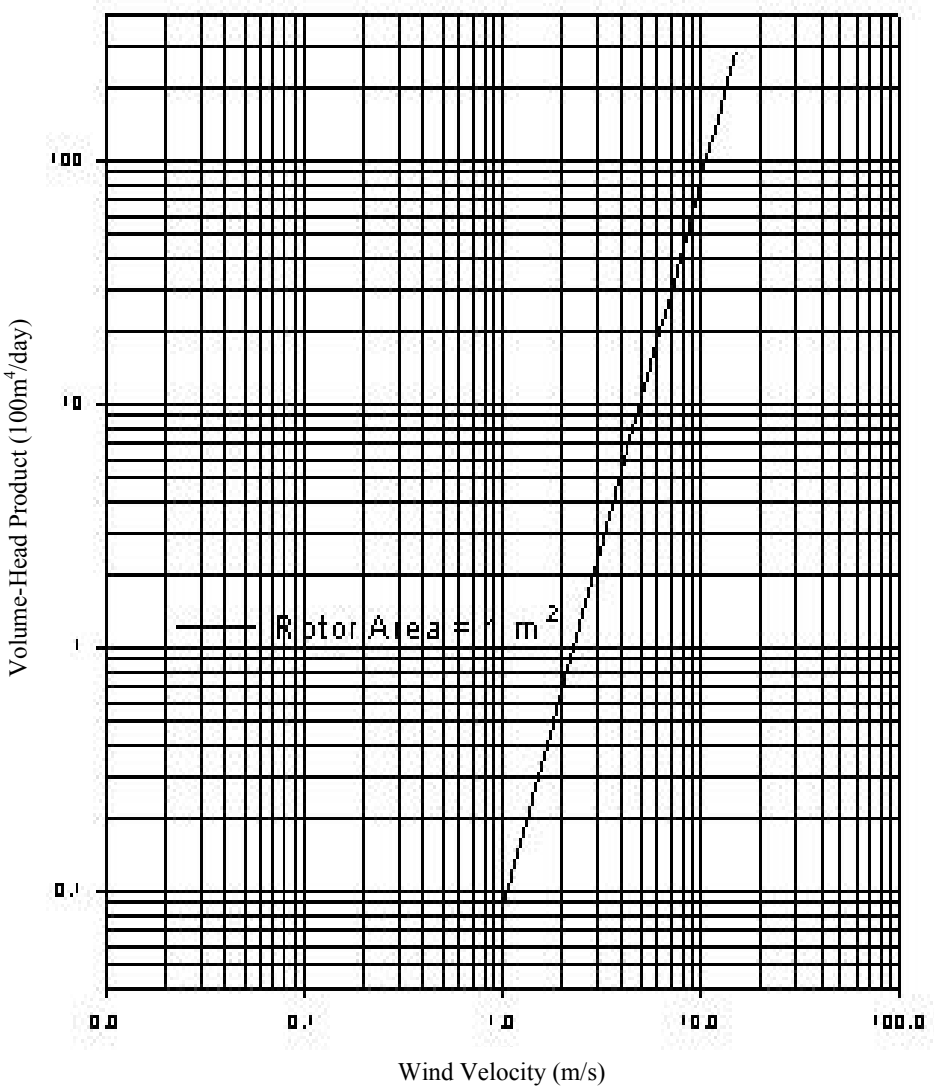

Figure 2: Nomogram for Wind Pump Rotor Sizing