# The Prospect of Wind Energy Application in Bangladesh

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**Abstract:** The wind data obtained by meteorological department show a prospective source of wind energy in many places of Bangladesh. Appropriate wind turbines may be designed and selected for the purpose of driving irrigation pumps. The performance of Savonius rotor coupled to a diaphragm pump is found to be satisfactory.

**Keywords** : *Savonius rotor, Diaphragm pump, Wind energy.*

## INTRODUCTION

With the development of technologies the commercial sources of energy are being exhausted, and people are applying the technologies for extracting wind energy more effectively. The financial budget for research in the area of wind energy is increasing every year in many developing and developed countries of the globe. But Bangladesh is neither rich in commercial sources of energy nor progressing satisfactorily in the area of wind energy. It is the appropriate time to expand research and development in the area of wind energy. Appropriate technology will be very helpful to extract available energy from wind in a very efficient way for the daily uses. In the countries like Bangladesh, this available source should be explored in a very effective way to meet the multi-dimensional demand of energy as they are not rich in the other conventional commercial forms of energy. On the other hand the wind energy is available at every door, and it needs only a device for extracting useful energy.

The possibilities of windmills as power source for water supply for irrigation has the following advantages.

a. The possibilities of local production and creation of employment.
b. Savings of foreign exchange by using locally available materials.
c. Conservation of fuel.
d. Promotion of self reliance of villages.
e. Does not create environmental pollution.

When installing a wind powered machine in an area some specific information about wind of that area has to be known. The meteorological department can give the preliminary information for the suitability of installing a wind machine. The design or selection of a rotor will depend upon the availability of wind speed, power and its frequency. These variables should be measured throughout the year in an area to know the distribution of energy.

However, experiences with windmill projects in the past have proven that it is of great importance to select a proper windmill. Many windmills were destroyed or did not come up to the expectations. This is mainly because of the following reasons [1,2].

i. The windmills were not properly exposed to the wind due to poor siting, resulting in too low energy yields.

ii. Against high winds or storms, the windmills were not properly protected by safety devices.

iii. Trained personnel and materials were seldom available to guarantee a proper operation of a windmill. Windmills needing frequent maintenance or having complicated mechanisms were in many cases not adapted to the situation in rural areas.

iv. Energy calculations have to be based on detailed information of the local situation and not merely on mean yearly wind speeds. Lack of a proper analysis of the wind regime often led to disappointments on the water yields.

v. The delay of the repair of a windmill due to the unavailability of spare parts, often resulted in a gradual process of dismantling of the windmill.

At present, there are many types of wind turbines for extracting energy from the wind. Among them, horizontal axis wind turbines are used for pumping water and for generation of electricity. In early 1960, attention was given to vertical axis wind turbines such as Savonius rotor, Darrieus rotor, Sailwing rotor etc. However, the performance of rotors depends on the design and the ratio of the rotor tip speed to the wind speed.

## WIND DATA

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 too low to be of any use by a windmill. Except for the above mentioned period of four months a windmill if properly designed and located, can supply enough energy.

The peak rainfall occurs in the country during the months of June, July and August. But the peak wind speed occurs one to two months and in some cases three months before the peak rainfall occurs. So one of the advantages is that the peak winds are available during the hottest and the driest months of March, April and May. During this period windmills may be used for pumping water for irrigation if it had been previously stored in a reservoir during the Monsoons. During the operating seasons, subsoil water from shallow wells can also be pumped up by low lift pumps run by windmills. Wind power can be incorporated into electricity grid on a substantial basis and could add reliability and consistency to the electricity generated by the Kaptai Hydro-Electric Power station during the dry season. This is due to the fact that during the dry season required water head becomes rather low for total utilization of all the generators. Thus power generation has to be curtailed during this period. So this deficit power could be compensated with the help of wind power plant.

Among the 15 locations analyzed from all over Bangladesh, some locations have been found suitable for wind power generation as shown in Table 1. Wind power of an area determines the size and shape of the rotor appropriate to that location. Raw wind data from the meteorological stations give an estimation of available wind power. The wind data analyzed here are the average of the data recorded during the period 1976 to 1986. Figure 1 shows the annual average wind velocity

**Table 1 :** Average Wind Speed of Different Location in Bangladesh.

| Locations | Potential Months for Extracting Wind Power | Average Wind Speed (m/s) | Theoretical Available Power ($W/m^2$) |
|---|---|---|---|
| Chittagong | March to September | 3.53 | 26.39 |
| Comilla | March to September | 2.78 | 12.89 |
| Cox's Bazar | May to August | 2.00 | 4.80 |
| Dhaka | March to October | 3.19 | 19.48 |
| Dinajpur | March to August | 2.03 | 5.02 |
| Hatiya | April to July | 1.89 | 4.05 |
| Jessore | April to September | 2.11 | 5.64 |
| Khepupara | February to September | 3.11 | 18.05 |
| Rangamati | April and May | 1.88 | 3.99 |
| Teknaf | February to September | 3.11 | 18.05 |

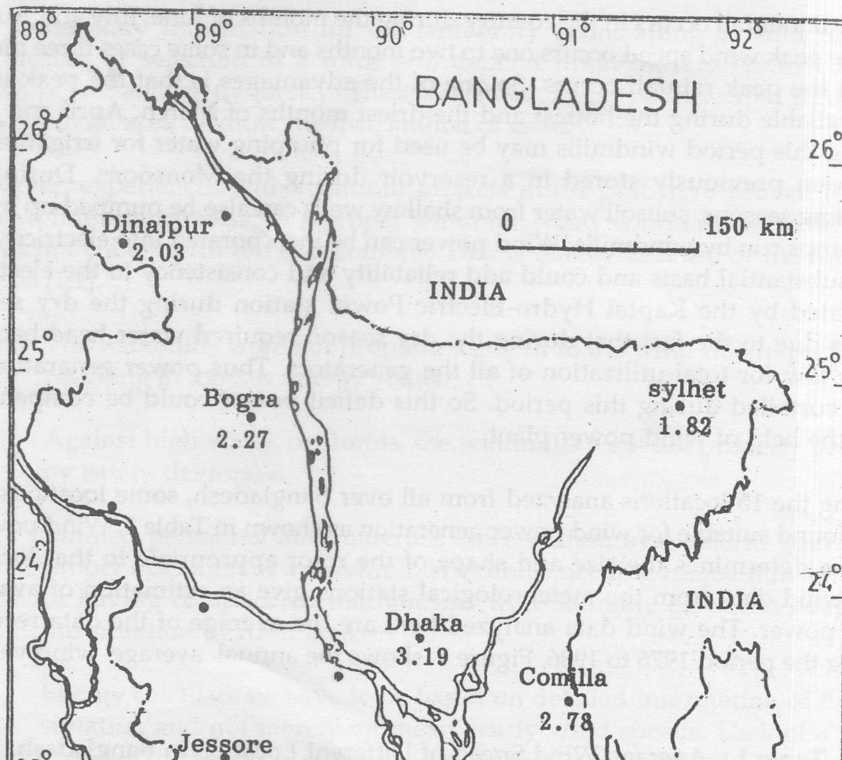


**Fig. 1** Map of Bangladesh showing annual average wind speed in meter per sec.

in different regions of Bangladesh. Figure 2 shows the wind speed duration curve for six different locations in Bangladesh. The wind speed in Chittagong is 2.57 m/s (5 knots) or more for 4000 hours a year. At this available speed a wind plant can be operated both for generation of electricity and for driving pumps. Whereas at Cox's Bazar the wind speed is 2.57 m/s (5 knots) or more for about 2000 hours a year. This speed may not be recommended for generation of electricity.

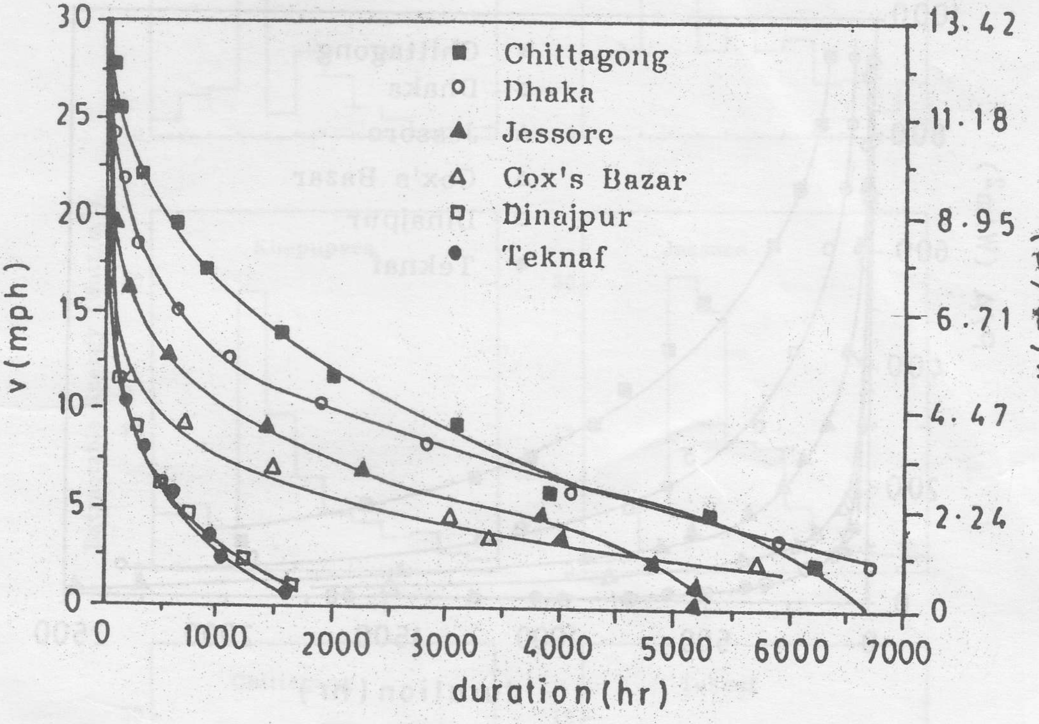


**Fig. 2** Velocity duration curve.

The wind power per unit area of approach is proportional to the cube of wind speed [2] and it can be expressed as $P/A = 0.6V^3$ where P/A is in watt/$m^2$ and V is in m/s. This wind power represents the strength of wind, and theoretically maximum 59% of this power can be extracted. The wind power P/A is plotted in Fig. 3 to show the strength of wind in six locations of Bangladesh. It shows that in Chittagong the wind power is nearly 150 watt/$m^2$ for 2000 hours in a year. Choosing suitable rotor size useful amount of energy can be harnessed both for electricity and for driving pumps. Figure 3 also shows that in Cox's Bazar the wind power is about 50 watt/$m^2$ or more during 1000 hours in a year. This may be useful for driving shallow tubewells for lifting water. Power extracted by windmill can be written approximately as [2,3], $P_e = 0.1 AV^3$ (Watt), where A is the total swept area of the rotor blades and V is the wind speed (m/s).

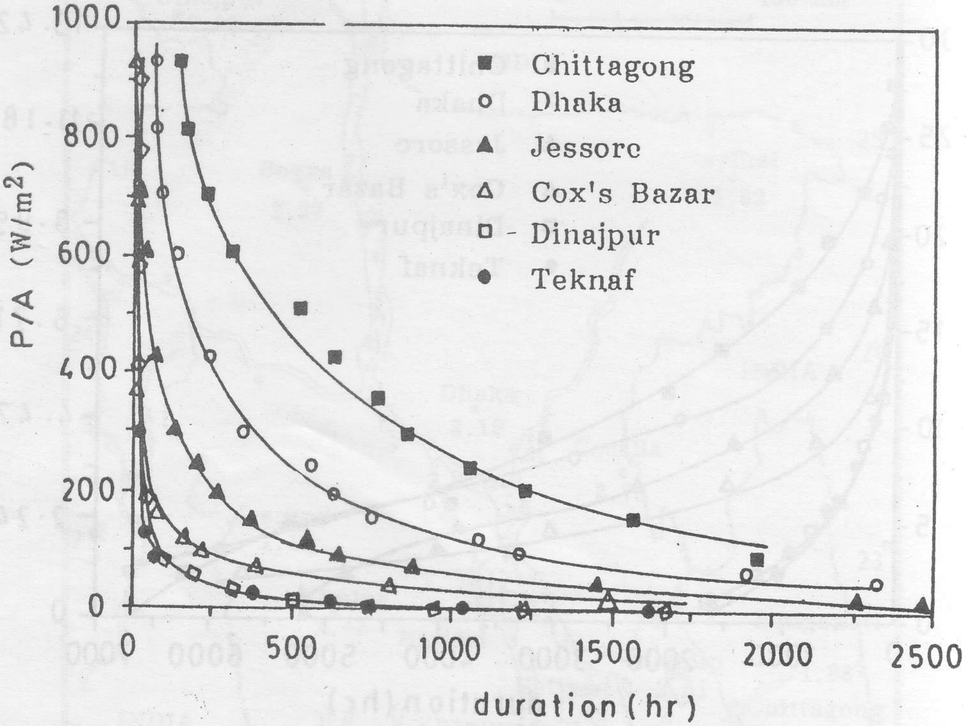


Fig. 3 Wind power in six regions of Bangladesh.

Extracted power per square meter of swept area for different months for six locations in Bangladesh is shown in figure 4. From this figure it can be seen that wind energy potential rises in the dry months i.e. March, April, and May, which is favorable for irrigation purposes.

The wind data at other locations also show similar strength of wind energy. The installation of wind powered machines at the coastal and island areas will be useful for lifting water and for generation of electricity. However, Savonius rotor is found to be useful for irrigation considering manufacturing with locally available materials and the cost.

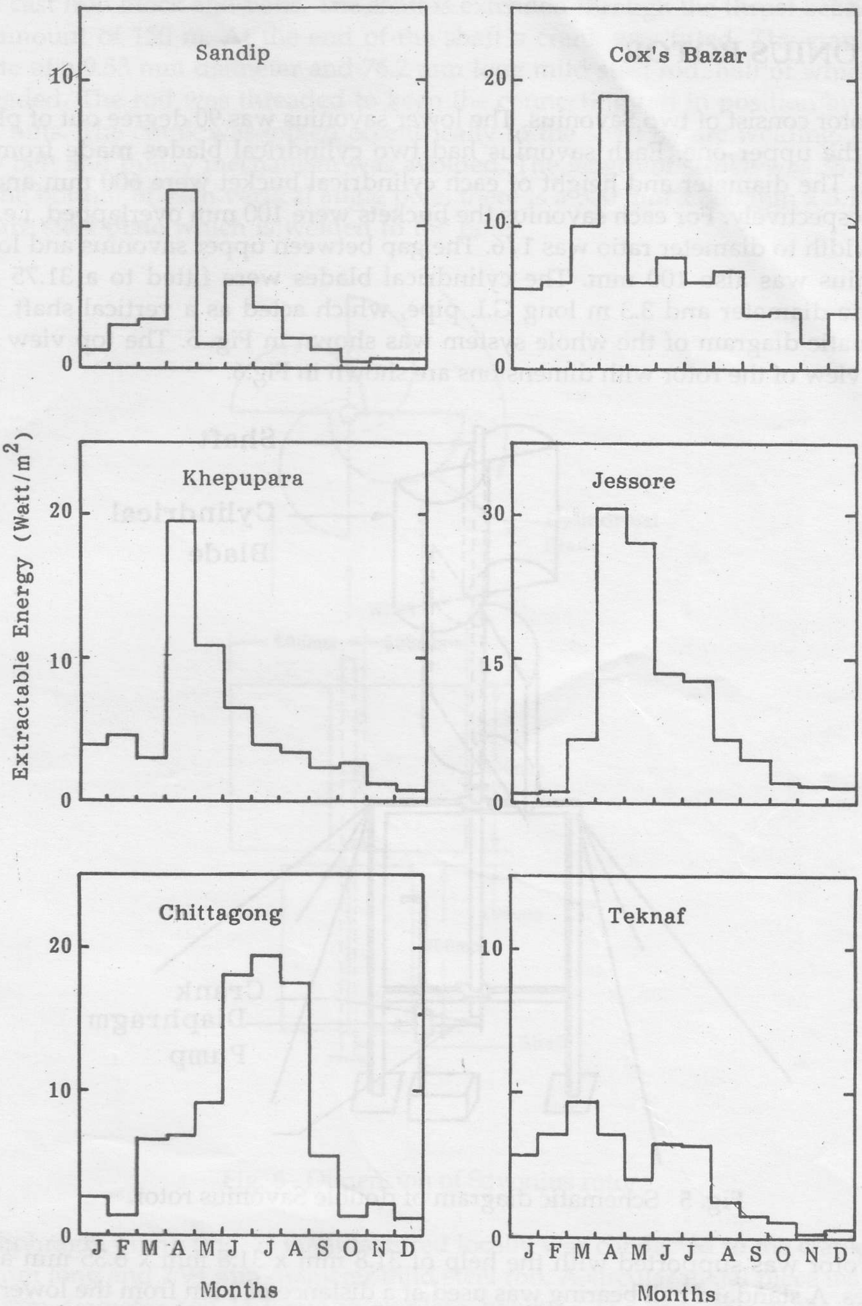


**Fig. 4** Monthly extractable energy for six stations (1986).

## SAVONIUS ROTOR

The rotor consist of two Savonius. The lower savonius was 90 degree out of phase with the upper one. Each savonius had two cylindrical blades made from oil drum. The diameter and height of each cylindrical bucket were 600 mm and 90 mm respectively. For each savonius the buckets were 100 mm overlapped, i.e. the gap width to diameter ratio was 1/6. The gap between upper savonius and lower savonius was also 100 mm. The cylindrical blades were fitted to a 31.75 mm outside diameter and 3.3 m long G.I. pipe, which acted as a vertical shaft. The schematic diagram of the whole system was shown in Fig. 5. The top view and front view of the rotor with dimensions are shown in Fig.6.

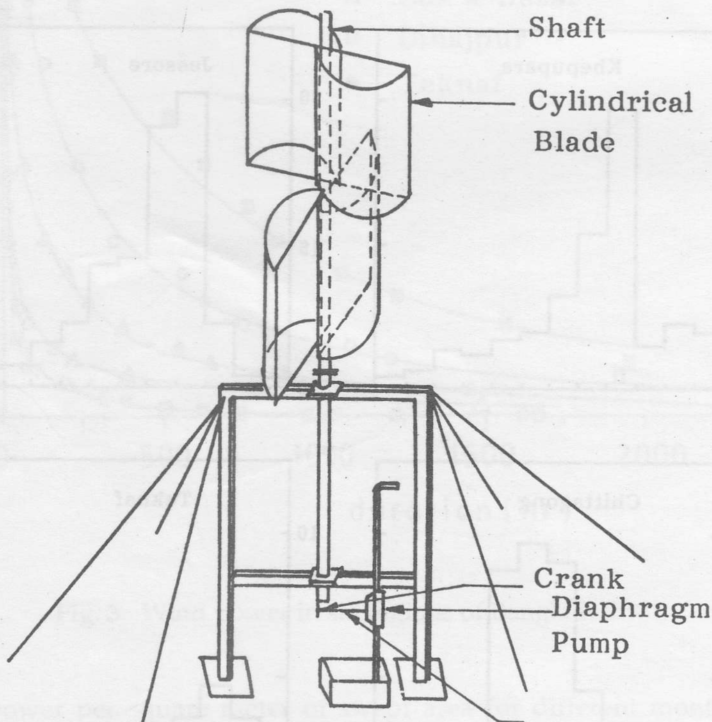


**Fig. 5** Schematic diagram of double Savonius rotor.

The rotor was supported with the help of 31.8 mm x 31.8 mm x 6.35 mm angle frames. A standard ball bearing was used at a distance of 1.2m from the lower end of vertical shaft which was fastened to the cross angle frame by bearing casing and bolts. The lower portion of the shaft was supported by a standard thrust bearing which was fitted to the cross angle frame by a 101.6 mm x 101.6 mm x 9.35

mm cast iron block and bolts. The shaft is extended through the thrust bearing by an amount of 150 m. At the end of the shaft a crank was fitted. The crank was made of a 9.53 mm diameter and 76.2 mm long mild steel rod, half of which was threaded. The rod was threaded to keep the connecting rod in position by using two nuts. The crank was joined eccentrically to the shaft by arc welding. In this way belt and pulley mechanism was avoided. The length of stroke was 38.1 mm. At the bottom of each vertical angle pole, there is a 300 mm x 300 mm x 3.18 mm square steel plate which is welded to the pole.

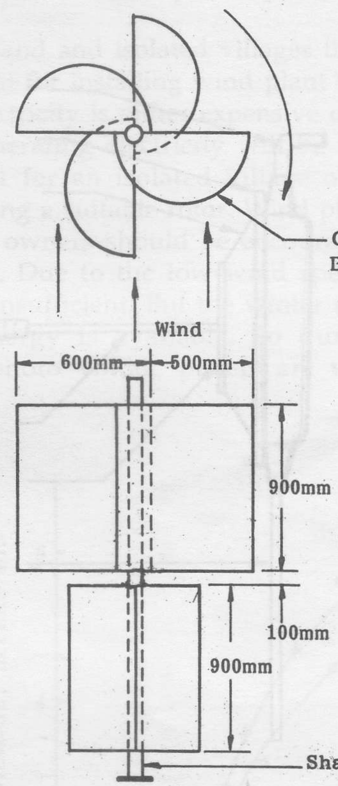


**Fig. 6** Dimension of Savonius rotor.

A diaphragm pump (Fig. 7) manufactured locally was connected to the crank by a 600 mm long and 7.94 mm diameter mild steel rod. A circular metal piece made of 25.4 mm diameter and 11.1 mm thick plate, having a 11.1 mm hole at the center, is fitted at one end of the connecting rod. This end was connected to the crank and the other end was welded to a 127 mm diameter and 6.35 mm thick mild steel plate. This plate was fitted to the diaphragm by bolts. Instead of usual preshaped rubber diaphragm, leather diaphragm was used which had greater strength and longer life than the rubber diaphragm. Anybody can replace the leather diaphragm without going to manufacturer by the ordinary shoe making soft leather. The diameter of the diaphragm was 190 mm. The pump was fixed to the lower cross frames by steel angles and bolts. The whole structure was kept in position by 2 mm diameter galvanized iron wires.

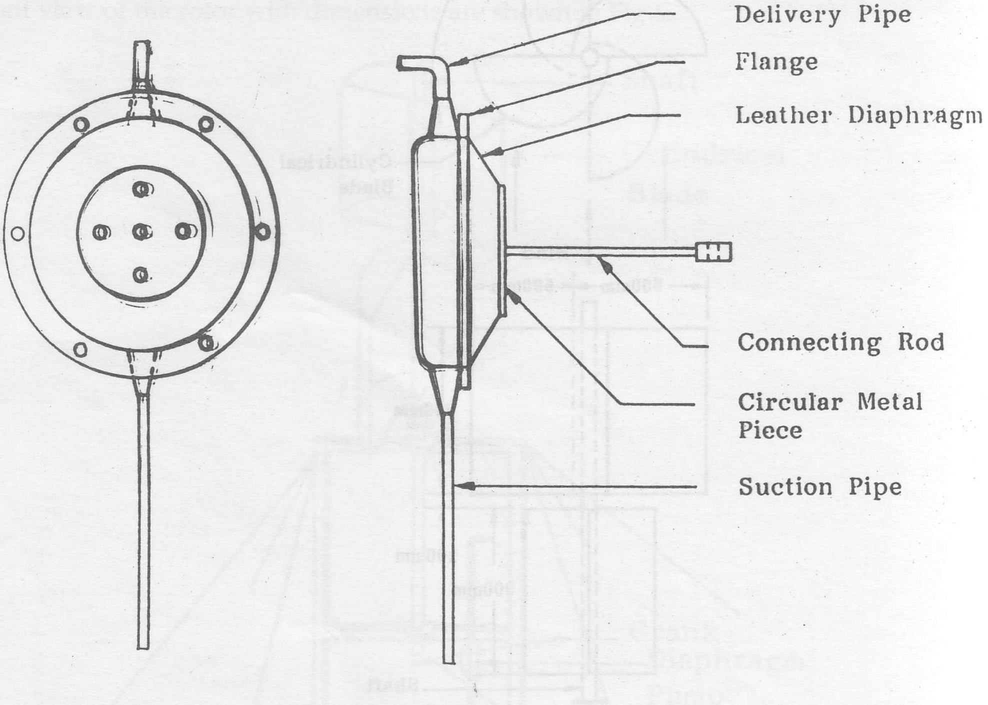


Fig. 7 Schematic diagram of diaphragm pump.

## DISCUSSION AND CONCLUSION

The wind data presented here are may be prospective in some regions for lifting water and for generating electricity to solve energy problem in the country to some extent. In most of the areas in Bangladesh, the pumping head is less than 6 m which is appropriate for using diaphragm pumps and the man-powered pumps. For these pumps the available wind power in the country can produce good results with a suitable rotor. The use of locally available materials and technology can produce satisfactory wind pumping unit for lifting water.

In coastal areas, island and isolated villages the wind speed is expected to be reasonably sufficient for installing wind plant for electricity. In many areas the transmission of electricity is either expensive or impossible. The installation of wind plant for generating electricity will be very useful for such areas. The power requirement for an isolated village or island may be calculated for selecting or designing a suitable rotor. Wind plants should be made popular to the users, and the owners should be encouraged to make it with the locally available materials. Due to the low wind speed in winter, the generation of electricity may be insufficient. But the winter months are nearly cloudless and sufficient solar energy is available. So during winter season, it will be advantageous if photo voltaic panels are used for hybrid generation of electricity.

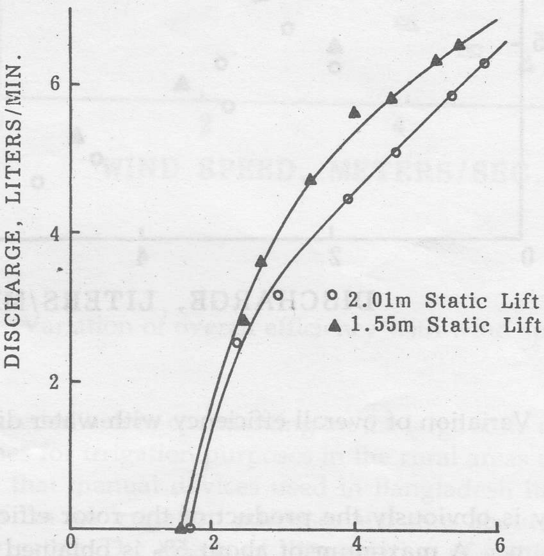


**Fig. 8** Variation of water discharge with wind speed.

The variations in the discharge of the diaphragm pump with wind speed are shown in Fig. 8. The static lift is changed by changing the suction lift only. It is observed that for this system the starting speed is about 1.5 m/s (3.53 mph). This is encouraging from the point of view that most areas of Bangladesh, especially the areas far away from the coast, have in general low wind speed. The discharge is found to be higher for lower lift at a given wind speed. With the increase in the wind speed, the discharge increases for both the lifts; but the rate of increase is lower at higher wind speed.

The overall efficiency of the system, η, is plotted against the water discharge rate, Q (Figure 9). Overall efficiency is defined as

$$\eta = \frac{gHQ\rho_W}{\frac{1}{2}\rho AV^3}$$

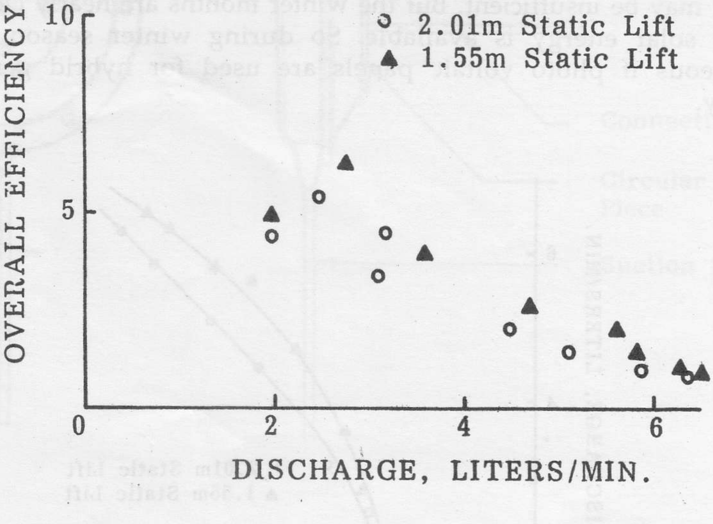


**Fig. 9** Variation of overall efficiency with water discharge.

Overall efficiency is obviously the product of the rotor efficiency, $\eta_r$, and the pump efficiency. $\eta_p$. A maximum of about 6% is obtained at Q of about 2.8 lit./min. Recalling that the efficiency limit for the rotor as given by Betz [3] is 59.3% and considering that h is the product of $\eta_r$ and $\eta_p$ and that the diaphragm pumps in general are of lower efficiency, 6% overall efficiency is quite encouraging. Again, attention may be drawn to the fact that the maximum value of h occurs at lower values of Q i.e. at lower wind speeds. This observation is important from the view point of low wind speed inside the country for a good period of the year. It is also found that for the same discharge overall efficiency is in general higher for the lower lift. Now from the definition of $\eta$, $\eta$ is proportional to $H/V^3$, indicating the relative effects of the variables on the overall efficiency. Figure 10 shows that the product of Q and H at a given wind speed remains more or less same.

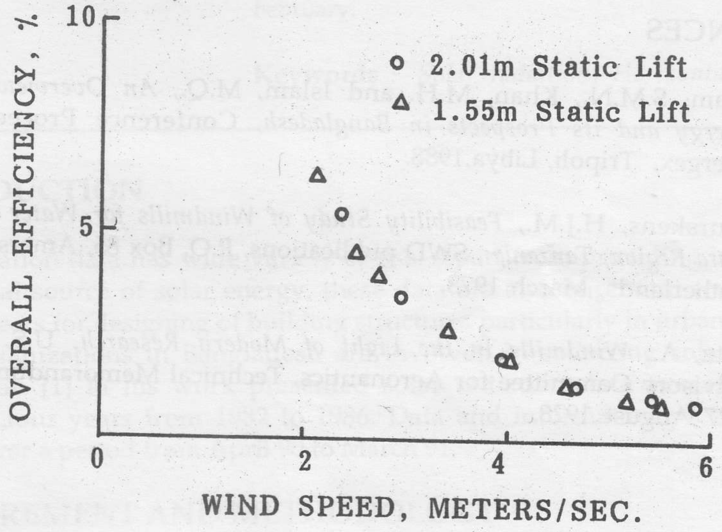


Fig. 10 Variation of overall efficiency with wind speed.

Further works are needed before commenting on the large scale utilization of this type of wind turbines for irrigation purposes in the rural areas of Bangladesh. It may be mentioned that manual devices used in Bangladesh lift water up to a maximum height of 2m for irrigation purposes and thus about 30% of the total irrigated area is irrigated. The effects of the variation of suction and delivery head on the discharge are to be investigated, keeping in mind that in most cases of power irrigation, pumping height is 6m or less. Other types of positive displacement pump may be tried.

## NOMENCLATURE

H : Total head, m
Q : Water discharge rate, $m^3/s$
V : Wind speed, m/s
$\rho$ : Air density, $kg/m^3$
$\rho_w$ : Density of water, $kg/m^3$
$\eta$ : Overall efficiency
$\eta_r$ : Rotor efficiency
$\eta_p$ : Pump efficiency

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