Wind Power Technology Schemes as Renewable Energy in Bangladesh

M. A. Parvez Mahmud, Shahjadi Hisan Farjana

Abstract - Wind energy is one of the renewable means of electricity generation that is a part of the worldwide discussion on the future of energy generation and use. Usage of wind energy has been increased in recent times especially because it is a running demand to use alternative energy sources and reduce fossil fuels consumption. This paper presents the schemes to use this technology in Bangladesh because it has a 724 km long coastline and many small islands in the Bay of Bengal, where strong southwesterly wind and sea breeze blow in the summer season and there is gentle northeasterly wind and breeze in winter months. It could produce 2,000 MW of power in the coastal belt installing 30 windmills per square km. The windmills that can be installed in the coastal belts can sustain 250 km per hour cyclonic storm. The scope of setting large scale power plant in coastal areas will be discussed in this paper.

Keywords: Wind Power, Renewable Energy, Wind Turbines, Pressure Difference, Alternative Energy Sources, Cost Analysis, Wind Farm

I. INTRODUCTION

Bangladesh faces a severe crisis of electricity in the recent time due to increasing demand of it in every day. We have a good probability to increase our economic condition by utilizing our resources in a well manner. But we can't keep pace with others due to shortage of electricity. So it is a vital issue to increase our production of electricity as soon as possible. In spite of high running cost (about 18TK. per unit electricity), we are bound to use diesel power plant due to high demand. But it is a matter of pleasure that per unit electricity has a role of 32Tk. in GDP. Therefore if we can generate electricity in a large scale with minimum cost it will be very profitable to us. Wind power technology is such a scheme that produces electricity with a very low running cost, in fact no fuel cost.

Wind power technology is one of the renewable energy which provides electricity using wind. Usage of wind energy has been increased in recent times especially since government bodies have suggested using alternative energy sources and reducing fossil fuels consumption. In fact out of all renewable energies, wind power energy has increase with more ratio than any other technology for past two decays with growth rate of 30 % percentage per year.

Sun is predominately the factor involved in providing solar power and wind power. Everyone knows that solar energy is provided by sun. Wind power is also form of solar energy because sun is reason for developing winds in atmosphere. When winds are produced it blows in different direction around, then these winds can be used to produce electricity which can be used for consumption. What actually happens is that sun's heat causes the air to warm up in patches, in result some patches of air becomes warm and some patches remain cold. Therefore a pressure difference is created. Hot air gets lighter in weight hence leaves it place and move towards upside, colder air patches are bit heavier there for they rushes to fill up the space which is left empty by hot air. This rapid movement of air around us produces winds which can be felt as movement of leaves on trees etc.

Wind turbine or motor with blades are installed on the lengthy tower. When wind passes through these blades it makes blades rotate and produce kinetic energy. Due to movement of blade, turbine is rotated which in result produces electricity. Electricity produced can be directly supplied to consumers or can be stored in batteries for later use. To produce more electricity with wind power, multiple wind turbines are installed in wind farm which produce more and more electricity in result.

II. MATERIALS AND METHODS

A. Working Principle of Wind Turbine:

Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetation.

The terms wind energy or wind power describes the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity.

So, to produce electricity a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity. The electricity is sent through transmission and distribution lines to homes, businesses, schools, and so on.

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M. A. Parvez Mahmud, Lecturer, Department of Mechatronics Engineering, World University of Bangladesh, Dhaka, Bangladesh

Shahjadi Hisan Farjana, Lecturer, Department of Mechatronics Engineering, World University of Bangladesh, Dhaka, Bangladesh.

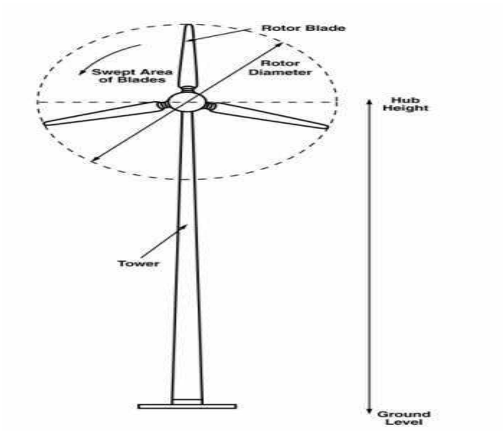

Fig. 1: Wind turbine schematic.

B. Design of Wind Turbine power plant:

There are few considerations which should be taken care of while developing wind power plant. To produce more electricity, increased number wind turbines are required in wind farm. Bigger blade size can also help in increasing the electricity generation capacity; therefore always choose to have bigger blades. Only those places are suitable for building up wind power plants where strong and steady winds are present in most of the time in a day, more wind cross through propellers, more rotation it will take hence produce more electricity. Coastal areas, higher areas, top of the mountain are best areas for developing wind power plant as it will encounter more wind at such altitudes. To receive satisfactory performance from wind power plants it should be located where it faces about minimum of 25 Km/p wind speed. Lower wind speed can also provide electricity however performance with consistency may suffer. Grid should not be build far from wind far, as this will increase costs of wire to provide electricity produced by wind grid station. Wind plant should keep closer to grid station for cost effectiveness.

There are two basic types of wind turbines: horizontal axis wind turbines and vertical axis wind turbines (shown in Fig. 2). Horizontal axis turbines (more common) need to be aimed directly at the wind. Because of this, they come with a tail vane that will continuously point them in the direction of the wind. Vertical axis turbines work whatever direction the wind is blowing, but require a lot more ground space to support their guy wires than horizontal axis wind turbines.

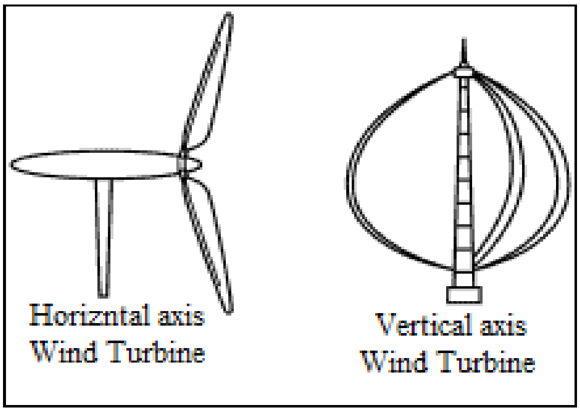

Fig. 2: Two basic wind turbines, horizontal axis and vertical axis

C. Factors in Designing Wind Turbine

An important factor in how much power that the wind turbine will produce is the height of its tower. The power available in the wind is proportional to the cube of its speed. This means that if wind speed doubles, the power available to the wind generator increases by a factor of 8 (*Fig 3*). Since wind speed increases with height (*Fig 4*), increases to the tower height can mean enormous increases in the amount of electricity generated by a wind turbine.

It has been recommended that towers be 24-37 m (80- 120 ft) high. Installing a wind turbine on a tower that is too short is like installing a solar panel in a shady area. At a minimum, mount a wind turbine high enough on a tower that the tips of the rotor blades remain at least 9 m (30 ft) above any obstacle within 90 m (300 ft).

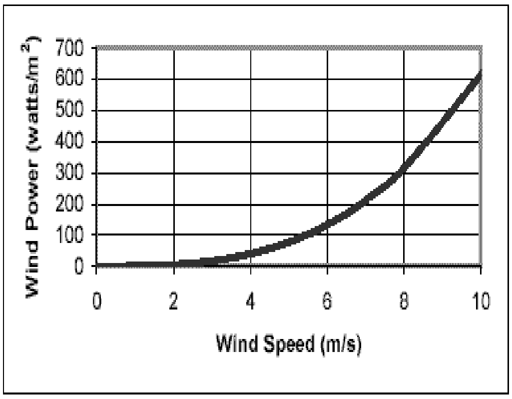

Fig. 3: Relationship between wind speed and wind power.

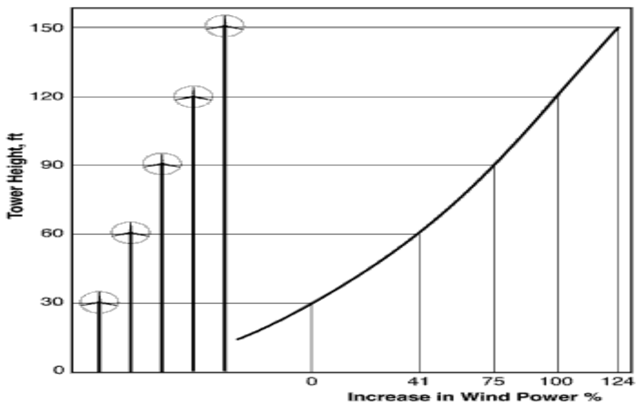

Fig. 4: Wind speeds increase with height.

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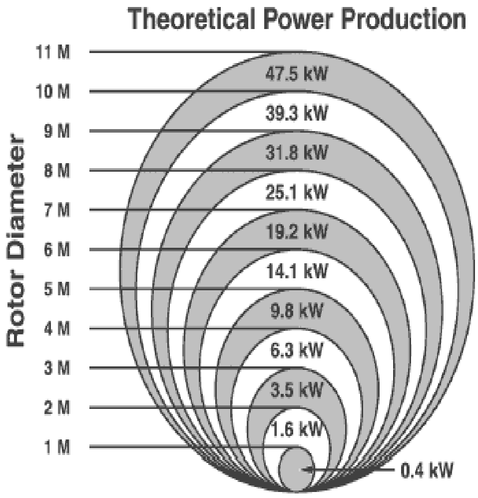

Fig. 5: Theoretical power production for small wind turbines when the wind speed is 10 m/s.

A modest increase in the rotor diameter will lead to significant increases in both the swept area of a turbine and the amount of electricity that the turbine can generate (Figure 5). The values for power production shown on *Figure 5* are theoretical values, and only intended for illustrative purposes. The actual power production from a wind turbine will be influenced by many other factors, such as: the efficiency that the wind turbine is able to extract energy from the wind; the elevation at which the turbine is located; and other design characteristics of the wind turbine.
To get a preliminary estimate of the performance of a particular wind turbine, use the formula below:
AEO = 1.64 D2 V3

Where
AEO = Annual energy output, kWh/year
D= rotor diameter, meters
V = Annual average wind speed, m/s

D. Supplying power to the grid

The tower is connected to an underground metal object to ground the tower in case of a lightning strike. A disconnect switch is needed that can electrically isolate the wind turbine from the rest of the wind energy system. An automatic disconnect switch is necessary to prevent damage to the rest of the system in case of an electrical malfunction or a lightning strike. It also allows maintenance and system modifications to be safely made to the turbine. It may need batteries to store excess energy generated by the wind turbine. Because energy is stored in batteries as DC power, an inverter is needed to convert power from the batteries to the AC power.

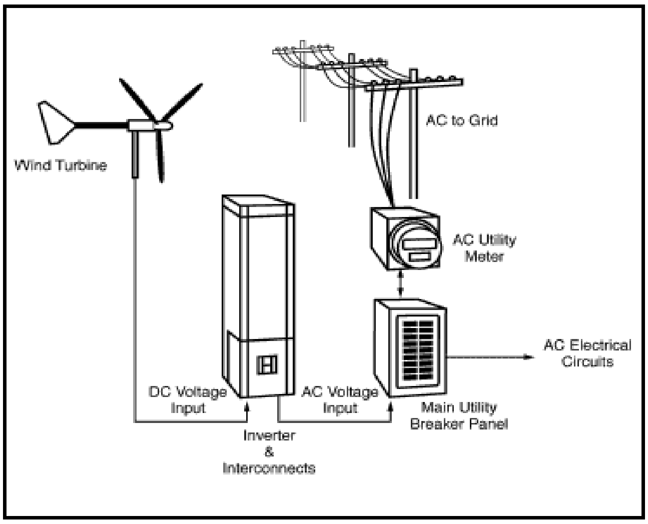

Fig. 6: Diagram of a grid-tied wind electric system.

To connect the wind turbine to the grid, it will require a transfer switch between the wind turbine and the utility line as well as a two-way meter to keep track of the energy that have stored in and taken from the power grid. It is very important that the wind generator meets certain standards and that it does not pose a risk to utility's personnel or equipment. It is also important that the quality of power coming from the turbine adequately matches the electrical characteristics in utility's power grid.

E. Proposed Schemes:

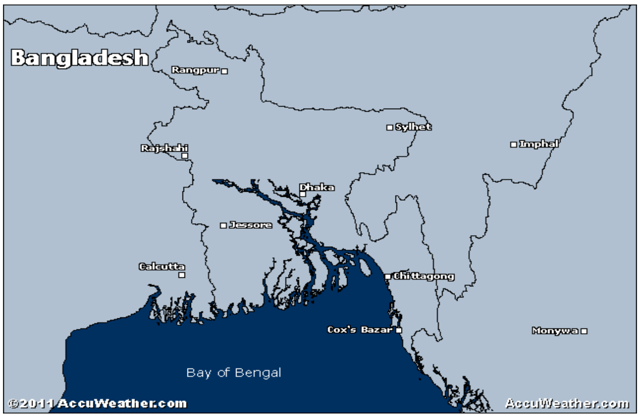

Fig. 7: Position of Bangladesh

Bangladesh is situated between 20°34'- 26°38' North Latitude and 88°01'- 92°41' East Longitude. The country has a 724 km long coast line and many small islands in the Bay of Bengal, where strong south-westerly tradewind and sea-breeze blow in the summer months and there is gentle north-easterly tradewind and land breeze in winter months. Wind speeds are higher in coastal areas. Wind speeds exhibit strong seasonal cycle, lower in the September to February period and higher in summer (March to August).Wind speeds exhibit a diurnal cycle, generally peaking in the afternoon and weakest at night.
Wind speed has been measured in Patenga, Cox's Bazar, Kuakata, Moheshkhali, and Noakhali by the computerized anemometers. The wind computers have been installed at 20 meters height.

According to this study annual average wind speeds in the coastal regions of Bangladesh are greater than 6.5 m/s at the height of 20 meters. It has been observed that during day times (8 a.m. to 7 p.m.) wind speeds are about 30 to 40% higher than the average values. The value of the power exponent α has been determined in the above sites and it is 0.139. So, at 40 meters height the annual average wind speed is about 7.15 m/s. So, wind speeds in the coastal regions of Bangladesh are suitable electricity generation.

F. Implementation:

Spacing between adjacent turbines needs to be at least several times the length of the turbine blades to prevent lowering the efficiency of the turbines due to one stealing wind from or causing turbulence for another. One rule of thumb is that placement between turbines should be about 3 to 7 diameters between adjacent turbines in a direction perpendicular to the wind, and 10 diameters spacing in a direction of the wind.

It is difficult to accurately measure the costs of wind plants. The costs for a commercial scale wind turbine ranged from $1.2 million to $2.6 million, per MW of nameplate capacity installed. Most of the commercial-scale turbines installed today are 2 MW in size and cost roughly $3.5 Million installed. Wind turbines have significant economies of scale. Smaller farm or residential scale turbines cost less overall, but are more expensive per kilowatt of energy producing capacity. Wind turbines under 100 kilowatts cost roughly $3,000 to $5,000 per kilowatt of capacity.

Fig. 8: Placement of Turbines

If we use the rotor of diameter 8m then we can be able to obtain 25.1 kW from per turbine. We have long coastal areas of about 724km.

Therefore, a scope of setting [(724000/ (5*8))] = 18100 turbines per row, assuming space between the poles are five times of their diameter.

If the sea shore has a width of two hundred meters on an average, then the number of row are = 200/ (10*5) = 4.

Total number of turbine = 18100*4
=72400.

So total energy produced = 72400*25.1
= 1817240kW or 1817.24MW

i.e. we can easily generate about 1820MW from our sea shore using wind turbine.

The total cost would be about (1820000*4000) or 7280 million US dollars (5100 crore Tk.) approximately.

G. Cost Comparison:

Table 1: Fuel, Transmission and Distribution Costs

Energy Technology	Share of Fuel Cost in the Each kWh	Initial Investment, O&M Costs for Each kWh	Transmission and Distribution Costs for Each kWh	Total cost for Each kWh
Coal (at mine mouth)	Tk. 0.75	Tk. 1.25	Tk. 1.25	Tk. 3.25
Coal (imported)	Tk.7.00	Tk. 1.25	Tk. 1.25	Tk. 8.50
Oil	Tk. 17.89	Tk.1.50	Tk. 1.25	Tk. 20.64
Gas	Tk. 1.11	Tk. 1.10	Tk. 0.85	Tk. 3.06
Wind Energy (11KV, AC)	Tk. 0.00	Tk. 5.91	Tk. 1.75	Tk. 7.66
Solar PV (11KV, AC)	Tk. 0.00	Tk.79.18	Tk. 1.50	Tk.80.68

We have seen from the above table that in case of wind energy we need not any fuel cost whereas it would require about 18 Tk. when using oil as fuel. Though total cost for each kWh is 7.66 Tk. in wind energy plant due to high investment but actual running cost is about 1.18 Tk. (2 US cent) only.

The comparison is shown on the following figure:

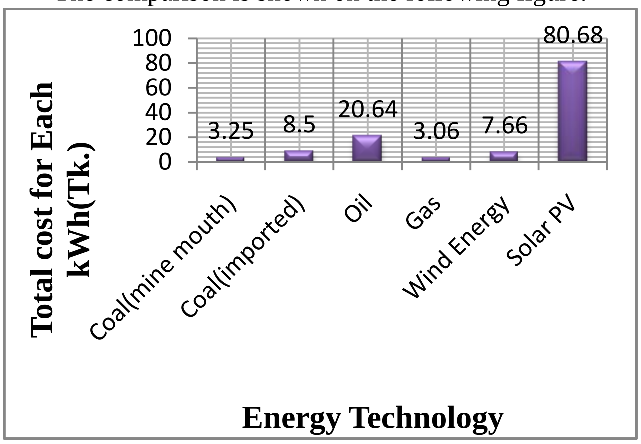

Fig. 9: Comparison of costs

III. CONCLUSIONS

In the near future, wind energy will be the most cost effective source of electrical power. In fact, a good case can be made for saying that it already has achieved this status. The major technology developments enabling wind power commercialization have already been made. There will be infinite refinements and improvements, of course. So the government body should come forward to set up the project of setting this type of power plant and remedy the crisis of power. The government can distribute the total work among different private companies so that the total project could be run within short periods. At the same time they must be sincere to proper maintenance of the ground equipments (especially from flood water) as from the past stories it has been found that due to lack of maintenance the wind turbine cannot give its maximum output.

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