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Feasibility of Wind Power Technology Schemes in St. Martin's Island of Bangladesh

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Abstract

Renewable energy is one of the most important alternative energy sources to extenuate the demand for energy and reduce fossil fuels consumption. Wind energy is one of the renewable means of electricity generation that is a part of the worldwide discussion on the future energy generation. In case of isolated island, it is very difficult to transmit power from the land area because of excessive cost. This paper presents the schemes to use this technology in St. Martin's Island in Bangladesh which is about 9km apart from the southern part of main land. It has an eight square km area in the northeastern part of 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. The scope of setting small scale wind turbine power plant in isolated areas will be discussed in this paper.

Keywords: Renewable Energy, Wind Power, Wind Turbines, Alternative Energy Sources, Wind Farm.

1. 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.

The St. Martin's Island is one of the islands located at the eastern Bay of Bengal. It is one of the beautiful tourist spots of the country. But this Island suffers from chronic shortage of electrical energy due to non-availability of grid quality power. The People of this island depend on the expensive and often erratic supply of kerosene for their lighting needs. There are few small diesel generators supplying electricity to the markets of some villages, but the diesel delivery mechanism is not reliable. As the region has the characteristic of sensitive ecosystem, remoteness, inadequate infrastructure for transport sector, distributed demand for electricity and dependency on petroleum products imported from main land, there is an absence of diesel based grid systems set up by state electricity board. In this background the Renewable Energy Technologies can play a very effective role for electrification. Wind energy has been very promising in Bangladesh which varies at a speed form 4 m/s to 5.5 m/s at the height between 25m to 50m. This speed is enough to generate electricity requiring some design change from the windmill of other countries.

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2. Working principle of wind turbine:

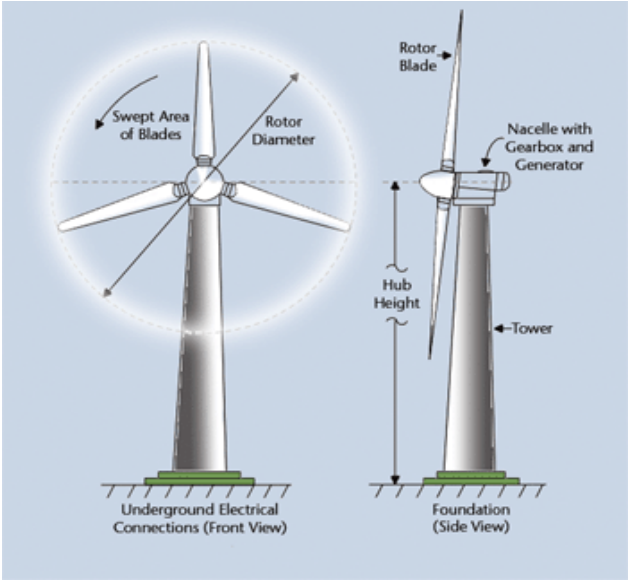

Fig. 1: Wind turbine schematic.

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.

3. Design of wind turbine power plant:

3.1. Considerations for designing wind 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 5 m/s 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.

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3.2. Selection of Wind Turbines:

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

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.

3.3. 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 wind speed is varied in St. Martins Island throughout the year (Fig. 3).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 4). Since wind speed increases with 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).

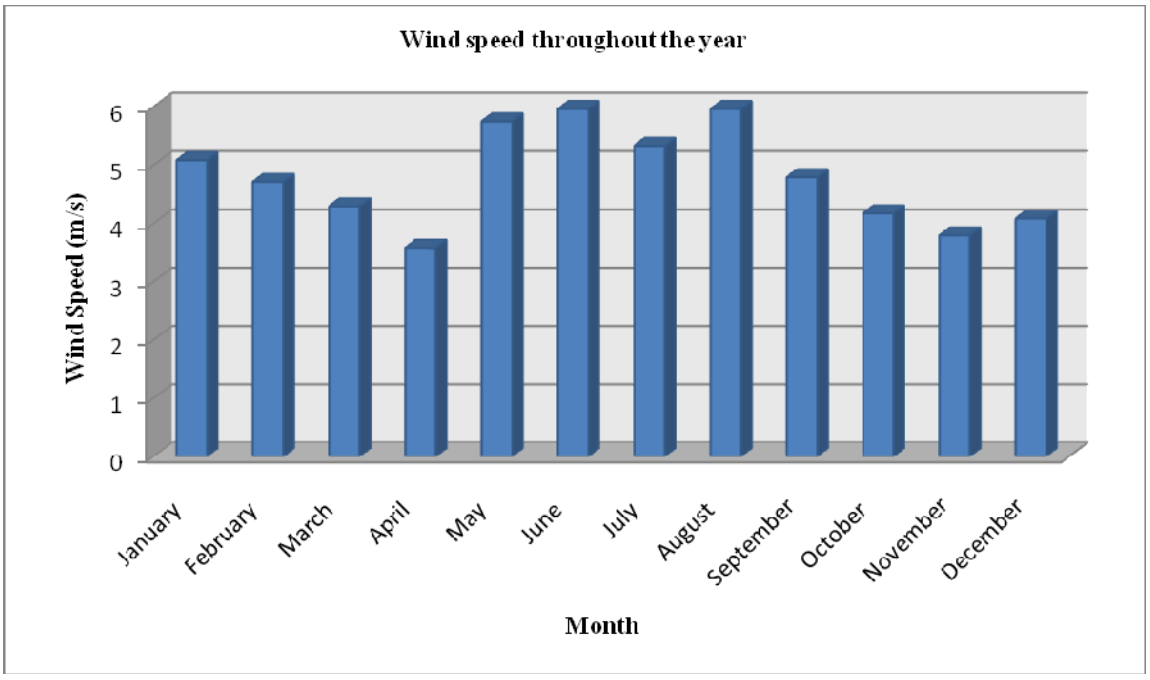

Fig. 3: Wind speed variation in St. Martin's island.

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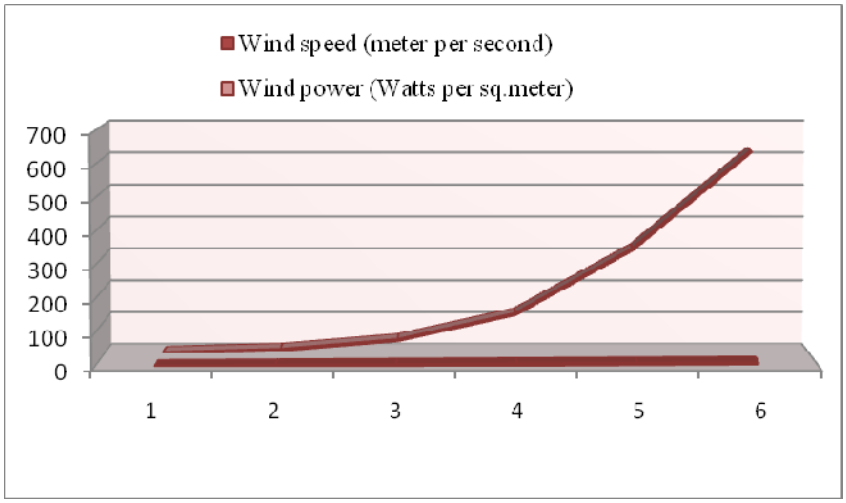

Fig. 4: Relationship between wind speed and wind power.

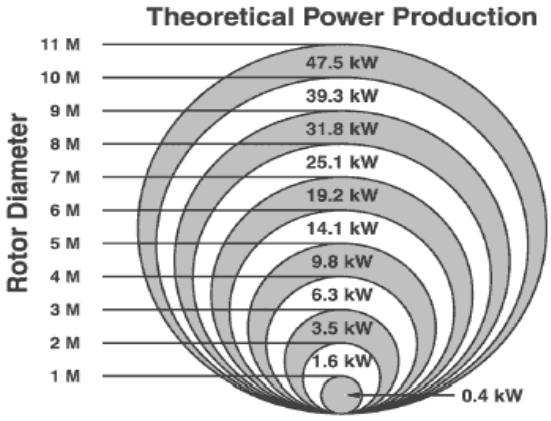

Fig. 5: Theoretical power production for small wind turbines when the wind speed is 10 m/s.

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 (Fig. 5). The values for power production shown 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

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4. Proposed schemes:

Fig. 6: Placement of Turbines

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.

If we use the rotor of diameter 8m then we can be able to obtain 31.8 kW from per turbine. As the periphery of Saint Martin's is about 20 km, Therefore a scope of setting [(20000/ (4*8))] = 625 turbines per row, assuming space between the poles are four times of their diameter.
If the number of row is doubled then the total number of turbine = 625*2=1250
So total energy produced = 1250*31.8
= 39750kW or 39.75MW
i.e. we can easily generate about 40MW from the island using wind turbine.
The total cost would be about (40*1.5) or 60 million US dollars (4800 million TK.)

5. 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	Tk.1.00	Tk. 1.00	Tk. 1.25	Tk. 3.25
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

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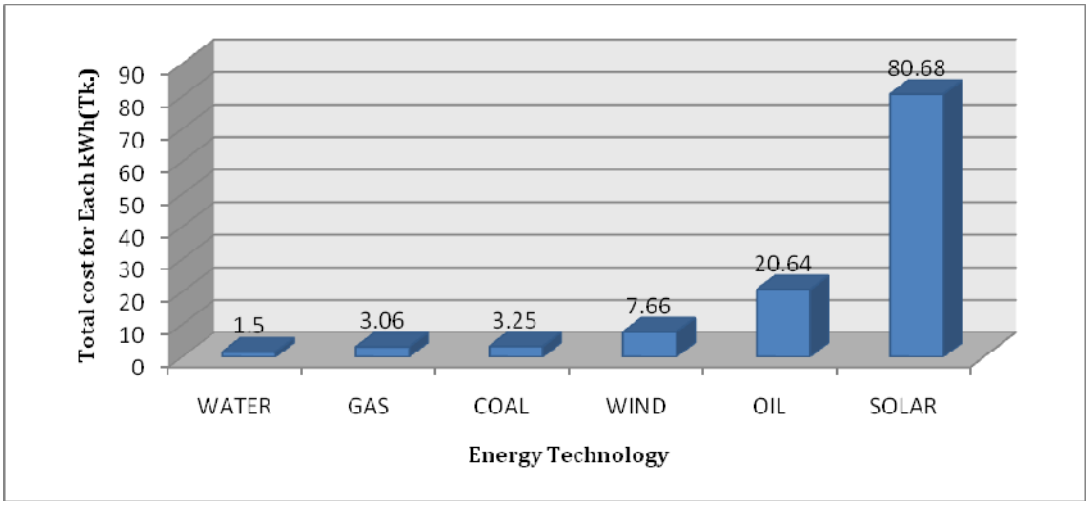

Fig. 7: Comparison of costs

The comparison is shown on the above figure. We have seen that in case of wind energy we need not any fuel cost whereas it would require about 20.64 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.

6. Conclusion:

In Saint Martin Island, Wind Energy is one of the replacements of Solar Energy and it reduces a lot of cost. 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 project and remedy the crisis of power in this island. 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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