DEVELOPMENT AND FUTURE OF WIND ENERGY IN CIRCUMSTANCE OF BANGLADESH

Md. Zahid Hasan, Md. Rakibul Islam, Md. Asad Rahman
Department of Mechanical Engineering
Khulna University of Engineering & Technology, Khulna-9203, Bangladesh

Abstract: Wind energy has been utilized by human society for millennia**;** it is a great source of renewable energy**.** The objectives of this paper are to find out the potential and future development of wind energy in Bangladesh. It is a fact that wind power is a irregular source of energy that can be used to produce electricity**.** The future of wind energy will depend a great deal on the ability of the industry to continue to achieve cost reductions, and ultimately, to achieve cost parity with conventional sources of electricity generation. In this paper wind data have been collected from different journals and websites which actually suggest how to use and develop this kind of renewable energy. Only the theoretical perspectives have been used during the study. However, results show that considering energy consumption and environmental effects wind energy has a great potential in a country like Bangladesh, which have coastal areas.

Keywords: Wind Energy, Coastal Areas, Wind Turbine, Weibull.

1. INTRODUCTION

Renewable energy resources are becoming an increasingly important part of our total energy demands due to the rapid depletion of fossil fuels and the emergence of global warming. Renewable energy is energy that comes from natural resources such as sunlight, wind, tides, geothermal heat etc., which are naturally replenished. About 19% of global final energy consumption comes from renewable sources, with 9% coming from traditional biomass, 3.8% from hydroelectricity, 2.6% from bio-heat and 3.6% from other renewable sources like solar, wind, geothermal, bio-fuels, etc. [1].The worldwide concern about environmental pollution and a possible energy shortage has led to increasing interest in technologies for the generation of renewable electrical energy. Among various renewable energy sources, wind power is the rapidly growing one. Airflows can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5–3 MW have become the most common for commercial use. The power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically up to the maximum output for the particular turbine. Areas where winds are stronger and more constant, such as offshore and high altitude sites are preferred locations for wind farms. Typical capacity factors are 20-40%, in particularly favorable sites. Offshore resources experience average wind speeds of ~90% greater than that of land, so offshore resources could contribute substantially more energy [1]. Recent study and analysis on wind energy assessment in Bangladesh show that some of the coastal areas are potential for small-scale wind electricity generation system.

Access to electricity in Bangladesh is one of the lowest in the world. Energy supply is a major problem for all classes in Bangladesh. The electricity infrastructure is old and badly maintained, breaks down frequently, and is inadequate to meet the demand. Power cuts are frequent and some areas have no power for days at a time Thus, it may be important to check the possibility that a part of the energy needs of Bangladesh can be economically covered from renewable energy sources like wind energy.

2. DEVELOPMENT OF WIND ENERGY

Since antiquity, mankind has been using wind energy; it is thus not a new idea. For centuries, windmills and watermills were the only source of motive power for a number of mechanical applications, some of which are even still used today. The Danes are the pioneers in world wind electricity generation. Professor Poul La Cour, the 'Danish Edison', began experiment with electricity generation from wind energy in his polytechnic of Askov and finally erected one as early as in 1891. Professor La Cour's generator was a standalone DC dynamo because AC was not very popular then. By 1910 several hundred units ranging in capacity from 5 to 25 kW were in operation in Denmark. While the Industrial Revolution replaced water pumping and grinding windmills by steam engines in the nineteenth century, the advent of fossil fuel based power generation censored the growth of wind electricity early in the twentieth century [2].

The wind turbines that generate electricity today are new and innovative. Their success story began with a few technical innovations, such as the use of synthetics to make rotor blades. Developments in the field of aerodynamics, mechanical/ electrical engineering, control technology and electronics provide the technical basis for wind turbines commonly used today. Since 1980, wind turbines have been becoming larger and more efficient at rates [3].

3. THE PHYSICS OF WIND ENERGY

Power is available from the kinetic energy of the mass of air moving in wind. The amount of energy that wind carries increases by a factor of two as its speed increases and is proportional to the mass of air that passes through the plane of the area swept by the rotors. As power is the product of energy (work) within a given period, the power of wind increases by a factor of three as the speed of wind increases. Because of the low density of air ($P_{air} = 1.25\ kg/m^3$), the power density of wind is much lower than that of water power ($P_{water} = 1000\ kg/m^3$), for instance. The power that can be harvested from wind is calculated in terms of the swept area for a horizontal axis wind turbine (HAWT), the area through which the rotor blades pass. As a result, if the diameter of the rotor blades is doubled, the power increases by a factor of four. If the wind speed then doubles, power increases by a factor of eight.

In 1920, Albert Betz demonstrated in his theory of the closed stream tube that a wind turbine can only convert a maximum of 16/27 or 59% of the energy in wind into electricity [4].

WEG (Wind Electric Generators) system is needed for the generation of electricity from wind energy. The WEG comprises a wind turbine (mostly horizontal axis type), a gear for speed matching and an electric generator (mostly induction type) connected to the grid. Wind turbine (WT) is coupled to the electric generator through the gear. The WT can be of stall-regulated type or pitch-controlled type the former being normally used for constant speed operation and the latter for variable speed operation. A synchronous WEG has its generator synchronized to the grid while in operation whereas an asynchronous WEG has an asynchronous interface (a DC link converter-inverter) between generator and the grid.

4. PRESENT CONDITON OF WIND ENERGY IN WORLD

Wind power is growing at over 20% annually, with a worldwide installed capacity of 238,000 MW at the end of 2011. It is widely used in Europe, Asia, and the United States. Several countries have achieved relatively high levels of wind power penetration. As of 2011, 83 countries around the world are using wind power on a commercial basis [5]. The list of top ten wind power generation countries are given in Table 1 [1].

Table 1 Top ten wind power countries [1].

Country	Total capacity end 2009 (MW)	Total capacity end 2010 (MW)	Total capacity end 2011 (MW)
China	26,010	44,773	62,733
USA	35,159	40,298	46,919
Germany	25,777	27,191	29,060
Spain	19,149	20,623	21,674
India	10,925	13,065	16,084
France	4,521	5,970	6,800
Italy	4,850	5,797	6,747
UK	4,092	5,248	6,540
Canada	2,550	4,008	5,265
Portugal	3,357	3,706	4,083
Rest of the World	21,698	26,998	32,446
Total	**159,213**	**197,637**	**238,351**

As of 2012, the Alta Wind Energy Center California is the world's largest wind farm (1,020 MW). As of February 2012, the Walney Wind Farm in the United Kingdom is the largest offshore wind farm in the world at 367 MW, followed by Thanet Offshore Wind Project (300 MW), also in the UK. The London Array (630 MW) is the largest project under construction. The United Kingdom is the world's leading generator of offshore wind power, followed by Denmark.

5. PRESENT CONDITON OF WIND ENERGY IN BANGLADESH

Bangladesh lays between 20'34" and 26'39" North Latitude and between 88'00" and 92'41" East Longitude. It is one of the most densely populated countries with 79% of the population living in rural areas. Over 80% of people depend on traditional energy sources for their energy needs. According to Bangladesh Power Development Board (BPDP), 5823 MW power capacity power plants installed.

Table 2 Installed capacity of BPDB power plants (As on June'2010) [6].

Types of Plant	Installed Capacity (MW)	Percentage (%)
Hydro	230	3.95%
Steam	2638	45.31%
Gas Turbine	1466	25.18%
Combined Cycle	1263	21.69%
Diesel	226	3.87%
Total	5823	100%

Bangladesh is endowed with vast renewable energy resources such as solar, wind and biomass resources. Tackling these resources appears to be a promising solution for improving the quality of the life of rural villagers, who are unlikely to have access to conventional electricity supply in the near future. One of the first actions needed when interested in wind energy in a region is to establish an overview of the available wind resource. This overview should make it possible to identify areas of high and low winds. Local Government Engineering Department (LGED) and Bangladesh Centre for Advanced Studies (BCAS) in 1996-97, have taken initiatives to assess the wind potential in several coastal regions and the reports indicate that the location of Bangladesh fall in a comparatively low wind regime. Since the study was concentrated in the coastal regions only, the LGED has taken an initiative to measure the wind data throughout the country under "Wind Energy Resource Mapping" program funded by United Nations Development Program (UNDP). The study has been designed in a more comprehensive way aiming at systematic observation on wind flow initially at 20 different suitable locations including Hill Tracts region over a longer period of time. Also assessment of the electricity generations at this site and preparation of detail technical and economic analysis have been done [7]. 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 number of previous studies 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 the height of around 10 meter but the seacoast and coastal islands should have a good many locations with prospective wind speed. Data analysis and study show that seasonal effect is very strong in Bangladesh. During monsoon period (May – Aug), when the strong South / South-westerly wind comes from the Bay of Bengal after traveling a long distance over the water surface speed becomes very high. For rest of the month, wind blows from the North / Northeast and comes from the inland; it is of low speed while in Oct – Nov it is minimum. Again hourly wind speed variation is low during the windy months but for rest of the months it is high. As energy depends on the cube of speed, therefore the available energy should be higher for coastal wind in Bangladesh than for locations having the same annual wind speed with a low speed variation [8].

6. PLANNING OF BANGLADESH GOVERMENT

BPDB (Bangladesh Power Development Board) has taken a number of steps in the development of Renewable Energy and implementation of Energy Efficiency Measures. For utilizing wind energy, the current steps are [9]:

- Expand Wind Power (100-200 MW Offshore) in coastal areas at Anowara, Chittagong.
- Expand On-shore Wind Power in coastal areas of, Cox'sbazar.
- Install 12 (twelve) numbers of Wind Monitoring Station of different coastal zones of Bangladesh.

7. STUDY METHODOLOGY

Importance of methodology in conducting any research can hardly be over looked. It needs a very careful as well as sincere consideration. For developing electricity-using wind power the necessary materials needed and their availability is given in this section:

7.1 Data Collection

This research is done by collecting data from different websites and journals. The outcomes of recent research on wind energy are considered for the view point of Bangladesh.

7.2 Equations Required

7.2.1 Power and Energy

Power in the wind is ($\frac{1}{2} \rho AV^3$) watts, where ρ is the air density in kg/m^3, A is the swept area of the wind turbine rotor in m^2 and V is the wind speed in m/s. Therefore the output power of a WEG operating at a wind speed V is

$$P = \tfrac{1}{2} \rho AV^3 \eta(v) \text{ watts} \quad \text{---------- (1)}$$

where η(v) is the overall conversion efficiency of the machine corresponding to V. η(v) is a function of V and therefore not a constant. Then the rated power output of the WEG at a given site is

$$Pr = \tfrac{1}{2} \rho AV_r^3 \eta(Vr) \text{ watts} \quad \text{----------(2)}$$

where V_r is the rated wind speed of the WEG and $\eta(V_r)$ is the corresponding value of overall efficiency. The energy produced per annum by the machine can be expressed as

$$E = P_r \times CF \times 8760 \text{ watt-hours} \quad \text{---------- (3)}$$

Where the capacity factor (CF) of a WEG is defined as the ratio of actual energy output to its rated value on an annual basis.

7.2.2 Weibull Parameters

Wind energy varies with year, season, and time of day and elevation above ground. Proper position of turbine, in windy sites, away from large obstructions, improves wind turbines performance. Usually, the two-parameter Weibull probability density function is used to represent wind speed distributions [10]. Weibull probability distribution is used to determine parameters of the wind speeds. The Weibull distribution is a mathematical expression, which provides a good approximation to many measured wind speed distributions. The Weibull distribution is therefore frequently used to characterize a site. Such a distribution is described by two parameters: the Weibull "scale," parameter which is closely related to the mean wind speed, and the "shape" parameter, which is a measurement of the width of the distribution. It has been widely accepted that the two-parameter Weibull distribution has a good match with the wind regime in most of the places. The Weibull probability density function of a wind speed V is given by

$$f(v) = (k/c)\,(V/c)^{k-1}\, \exp[-(V/c)^k] \quad \text{-------- (4)}$$
$$= F(v) \div 8760 \quad \text{---------(5)}$$

where k is the dimensionless Weibull shape parameter, c is the Weibull scale parameter having the same dimension as that of V and F(v) is the duration for which V is prevailed at the site during the year under consideration. V and c are normally expressed in m/s and the unit of F(v) is hours. The parameters k and c are estimated from the annual average wind speed at the site, V_m and the corresponding annual average value of its standard deviation, σ [11], as

$$k = (\sigma / V_m)^{-1.086} \quad \text{------ (6)}$$

and,

$$c = V_m / \Gamma\,(1 + [1/k]) \quad \text{------- (7)}$$

For determining the factors graphical and standard deviation method can be used. And it can be done by using Wind Energy Assessment tool, developed at the website of IUT [12]

8. RESULTS AND DISCUSSIONS

In general, daily and seasonal changes as well as wind direction are important considerations while citing wind systems. From five LGED stations, it was found that the average annual wind speed values at 10 m, 20 m, 30 m height for the five wind stations vary from 1.73 m/s to 4.17 m/s. The highest average annual wind speed (4.17 m/s) was observed in Kuakata and the lowest value (1.32 m/s) was observed in Khagrachari. The analysis showed that highest wind speed was found during summer at Kutubdia and Kuakata. The annual cycle of monthly average wind speed shows fairly large seasonal variation, the appearance of which is typical for measurement sites, with minimum values in winter (October–March) and maximum values during summer (April–September). Similar variations also observed for BCAS Kutubdia and Kuakata stations [13].

The analysis of the daily cycle of the wind speed at different time instants, however, suggests that the dominance of daytime winds over night winds that is characteristic of mainland measurement sites also contributes to this feature. Also the cost of generating electricity has been established. Let us assume the 1 kilo-watt turbine considering the following specifications:

Price of the turbine is, 2027 USD approximately, Initial installation cost is, 608 USD approximately (30 % of turbine cost), annual operation and maintenance cost, 70 USD approximately (3.5% of turbine cost), rate of interest is, 5%, 10%, 15%, life period of turbine is 25 years (assume). As seen from the yearly data analysis that mean speed is 4.18 m/s at 30 m height and CF=0.23. Then the cost of electricity is 0.175 USD that is 14.35 taka/kwh [7]. So, the cost of electricity can be reduced by utilizing the renewable energy resources. Wind energy does not pollute the air or water with harmful gases and materials not generate Hazardous waste. Being a non-delectable source, extracting energy from wind does not pose the threat of over exploiting the limited natural resources. Hence, wind is considered as one of the cleanest sources of energy available today.

9. CONCLUSION

As Bangladesh is a poor country, it is very important to reduce the cost of electricity. In this country the demand of electricity is increasing, and most of power plants are now depending on natural gas, furnace oil and diesel. Using this kind of fuels the rate of electricity is also increasing. So it is high time to utilize the wind energy for producing electricity. In this paper the system and cost has been analyzed. Though the air speed is not up to the mark, but also using this, the job can be done. Therefore, remote coastal inlands and islands in Bangladesh should be a potential market for wind energy.

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