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Prospects of Wind Energy at Sitakunda and a Proposal for Hybrid Power System for Remote Areas

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Abstract- Wind is most probable future fuel for production of electricity. Due to the fact that power production using nonrenewable fuel is become costly and they are diminishing day by day. Weibull distribution which is a good statistical tools for analyzing characteristics of wind and power probability of wind. So by using Nordex N80 wind turbine we get power which is supplied to the remote sites of local areas. We got few hundred kilowatt power. Here, We proposed a new hybrid power system. Where wind power, solar power and Hydrogen power are connected. Wind power supplied to electric load but when more power is generated, it supplied to electrolyzer. Electrolyzer produced Hydrogen from water. A battery is used for power smoothing of electrolyzer. Hydrozen then stored in a Hydrogen storage tank. A fuel cell is used to produced power. This then connected to ac and supplied to local electric load. A solar power system is also connected in this system. The solar power goes to electrolyzer or with the output of fuel cell when needed. In this way we generated power easily for local areas.

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Md. Ahsan Habib [α], Md. Mijanur Rahman [σ] & Md. Motaher Hossain [ρ]

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I. Introduction

Wind is the flow of gases on a large scale. On the surface of the Earth, wind consists of the bulk movement of air. In outer space, solar wind is the movement of gases or charged particles from the sun through space, while planetary wind is the outgassing of light chemical elements from a planet's atmosphere into space. There are different places of Bangladesh where there are strong wind is available. But we select only one site for this work.

II. Site Selection

Sitakunda is one of most important the places of Bangladesh where there is a possibility of production of wind energy. The geographical position of sitakunda is 22°35.68' North Latitude 91°42.52'East Longitude. [1] Twenty years monthly wind speed of sitakunda is given below.

Table 7.1 : Monthly variation of wind speed at Sitakunda from 1988 to 2007

EAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1988	5.88	6.58	6.16	8.13	10.65	7.29	7.99	6.87	6.02	9.11	5.18	5.6
1989	5.46	7.43	8.27	8.41	6.44	5.6	4.34	4.48	3.92	3.78	2.94	2.8
1990	5.04	3.64	6.3	7.57	6.44	7.43	7.29	6.16	5.32	9.11	8.69	3.78
1991	5.32	7.15	6.73	6.44	9.39	6.87	6.58	5.46	5.04	5.18	3.22	3.5
1992	6.16	7.29	7.43	8.27	5.88	4.62	5.6	3.78	4.9	4.76	3.36	3.78
1993	5.74	8.13	5.6	5.32	6.44	6.02	5.32	4.62	3.92	3.22	3.08	4.2
1994	4.62	4.48	5.74	4.62	4.34	5.46	4.06	4.62	4.2	3.22	2.94	2.8
1995	3.08	4.06	4.62	5.04	6.44	4.34	3.92	3.92	4.62	3.08	4.06	2.24
1996	3.36	3.78	5.6	6.16	7.85	4.76	5.04	3.5	3.22	9.81	2.8	3.92
1997	4.62	5.6	7.01	5.88	7.29	7.15	4.76	5.32	4.2	2.8	2.8	3.5
1998	3.08	4.2	5.46	5.46	6.44	5.04	4.76	4.48	4.06	4.2	2.24	2.66
1999	3.22	2.94	6.73	6.02	5.6	6.73	5.18	4.62	4.62	3.64	2.8	3.64
2000	3.64	3.64	6.02	5.6	5.32	4.48	6.16	4.48	4.06	3.64	2.52	2.94
2001	2.66	3.08	2.38	5.88	3.92	5.74	4.06	5.74	5.18	3.36	1.96	2.52
2002	2.8	3.36	3.78	5.04	5.74	3.92	4.06	4.34	3.22	3.5	7.43	2.24
2003	2.94	3.36	2.8	4.9	4.76	5.04	6.44	4.06	2.8	2.66	1.54	1.82
2004	1.82	3.08	6.16	7.85	4.48	5.74	6.44	8.55	7.15	8.42	2.66	3.08

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2005	3.92	8.41	9.81	7.57	7.85	8.13	6.44	6.16	4.48	5.04	2.24	2.52
2006	3.5	6.73	6.73	6.44	6.44	7.15	6.16	6.02	5.32	2.8	2.24	2.1
2007	4.06	3.78	5.32	7.01	5.46	5.88	6.44	5.18	5.32	7.29	4.62	1.96

III. Weibull Distribution

Weibull distribution function which has recently been proposed by some researchers. This is due to its greater flexibility and simplicity, as well as good agreement with experimental data. In other words, this analytical distribution for fitting wind speed data is generally accepted for energy assessment analyses and wind load studies. [2]

Weibull distribution function is written for wind speed [3][4]

$$Q(v) = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} exp\left[-\left(\frac{v}{c}\right)^{k}\right] \qquad (1)$$

Where Q(v) is the probability of observing wind speed v, k the dimensionless Weibull shape parameter (or factor), and c reference value in the units of wind speed (so-called: Weibull scale parameter).

The k values range from 1.55 to 3.10 for most wind conditions.

The generalized cumulative distribution function is [4][5]

$$Q(v) = 1 - \exp\left[-\left(\frac{v}{c}\right)^{k}\right] \qquad (2)$$

Determination of the parameters of the Weibull distribution requires a good fit of Equation (2) to the recorded discrete cumulative frequency distribution. Taking the natural logarithm of both Sides of Equation (2) twice, gives

$$\ln\{-\ln[1 - Q(v)]\} = kln(v) - kln(c)$$

So, a plot of ln $\{-\ln[1 - Q(v)]\}$ versus lnv presents a straight line. The k is the gradient of the line and the intercept with the y-axis is -k lnc.

The relation between k and c for wind speed v_m is [2]

$$v_m = c\Gamma(1 + \frac{1}{k})$$

Where gamma function is Γ( )

Weibull distribution is a good statistical tool for analyzing wind speed. It shows the power probability and weibull distribution of a site. Two important parameters Weibull's shape factor k and Weibull's scale factor c have been obtained from the data.

The power probability, weibull distribution, shape factor and scale factor helps to determine the charactерristics of wind wave and potential of wind power.

We know, the cumulative distribution function is given as

$$Q(v) = 1 - \exp\left[-\left(\frac{v}{c}\right)^{k}\right]$$

Rearranging and taking ln two times we gets

$$\ln\{-\ln[1 - Q(v)]\} = k\ln(v) - k\ln(c)$$

So, a plot of ln {-ln[1-Q(v)]} versus lnv presents a straight line. The gradient of the line is k and the intercept with the y-axis is -klnc.

So the graph is shown below:

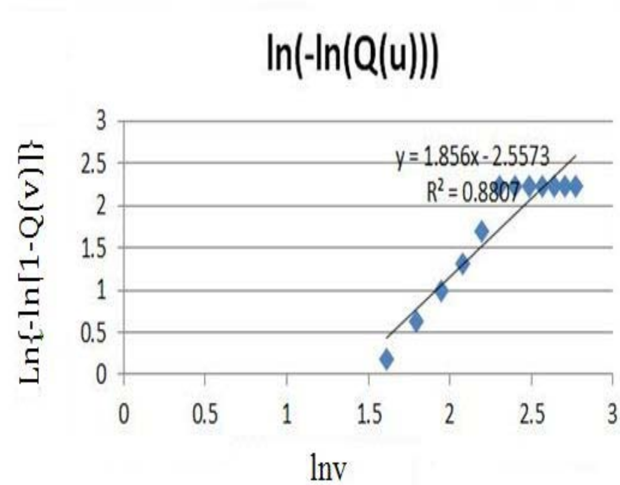


Figure 7.1 : Curve of ln $\{-\ln[1 - Q(v)]\}$ versus lnv

We get the value of scale factor c=3.97 and the value of shape factor k=1.86 which is the appropriate value for most wind conditions.

Now, we draw a curve of probability and weibull distribution versus wind speed.

The curve is shown below.

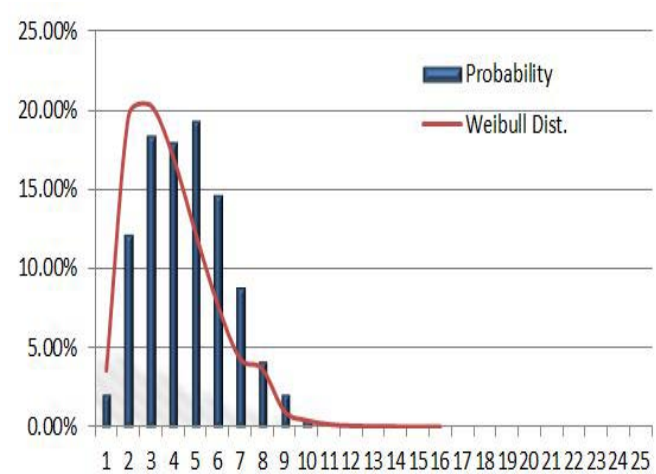


Figure 7.2 : Histogram for monthly mean speed with probability and weibull distribution of wind speed

Histogram represents 20 years of monthly mean wind data at sitakunda plotted together with the weibull probability distribution. This figure illustrates that the weibull distribution is a good representation of the wind resources of a site. The imperfectness of the weibull distribution compared with the histogram may be a significant source of error.

IV. Power Calculation

Here, we calculate theoretically available power for twenty years from 1988 to 2007 for yearly speed.
For 1988, speed, v=7.12, Cp=.410

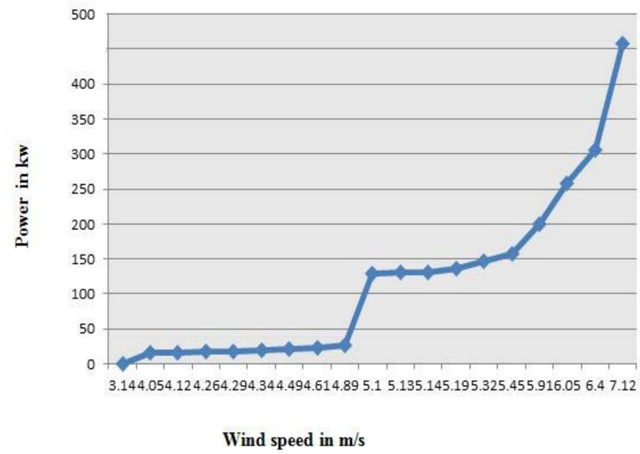
$$P_{avail} = \frac{1}{2} \rho A \, C_p \, v^3$$

$$= \frac{1}{2} \times 1.23 \times 5026 \times .410 \times 7.12^3$$

$$= 457.426 \text{ Kw}$$

The SI unit for magnetic field strength H is A/m. However, if you wish to use units of T, either refer to magnetic flux density B or magnetic field strength symbolized as $\mu 0H$. Use the center dot to separate compound units, e.g., "A·m^2."

YEAR	SPEED,V in m/s	Cp	POWER, Pav in Kw
1988	7.12	.410	457.426
1989	5.32	0.314	146.137
1990	6.4	.377	305.477
1991	5.91	.314	200.350
1992	4.49	.076	21.264
1993	5.13	.314	131.352
1994	4.26	.076	18.161
1995	4.12	.076	16.428
1996	4.89	0.76	27.469
1997	5.1	.314	128.747
1998	4.34	.076	19.203
1999	4.61	.076	23.015
2000	4.29	.076	18.547
2001	4.05	.076	15.605
2002	4.12	.076	16.428
2003	3.4	00	00
2004	5.45	.314	157.114
2005	6.05	.377	258.050
2006	5.14	.314	131.800
2007	5.19	.314	135.684



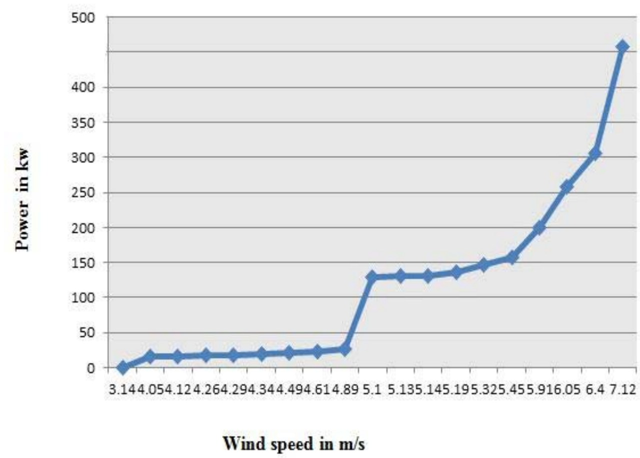


Figure 7.3 : Power for corresponding wind speed that obtained in sitakunda

Table shows the power which is produced over twenty years at sitakunda. Wind speed varies from 3 m/s to 7 m/s and power varies 16 kw to 457 kw. This power is obtained from one turbine. So if we place a few numbers of wind or make a wind farm we get certain MW power from them. This power is supplied to the remote areas. This helps the people of the remote areas is on the under of electricity.

If we want to cover a larger area which is greater than the area covered by the wind farm, we need more power .So for this reason, we here design a new combined power system. This power system consists of wind, hydrogen and solar. The combination of this will produce large power. The combination is make in such a way that if one parts of this system is falls there is a continuity of supply.

V. Proposed System

The combined power system shown in below:

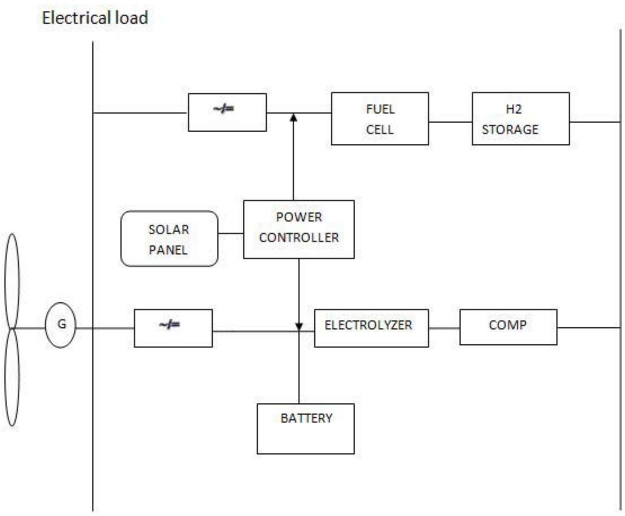


Figure 7.4 : Proposed power system consisting of wind, hydrogen and solar

When wind blows, turbine rotates and power is generated. This power is supplied to electric load. But when speed of wind is high, more power is generated. If this power is larger than the load which is connected, excess power is goes to eletrolyzer. An electrolyzer is an electrochemical apparatus which is used to perform electrolysis. Here, electrolyzer is used to splitting water into hydrogen and oxygen. The hydrogen is stored in hydrogen storage tank. The battery is used to smooth the turbulent wind power to protect the electrolyzer from wear due to rapid and large wind power variations. This hydrogen then passed to fuel cell where it used as fuel. Now, we get dc power from fuel cell which is converted to ac. This ac power is supplied to the electric load. A solar panel is connected whose electricity is goes to electrolyzer or to the point where fuel cell out is obtained. The hydrogen which is obtained from electrolyzer is also used for mobile applications when more power is not needed i.e from fuel cell.

VI. Conclusion

In future, wind energy will be the most cost effective source of electrical power. Most probably it reached this state. The major technology developments enabling wind power commercialization have already been made. This paper analyze the characteristics of wind and power probability of wind at sitakunda. This site is able to produce huge power. This papers also introduce a new power production model. If it is possible to implement with proper knowledge, equipment and sincere to proper maintenance of the ground equipments (especially from flood water), it takes a great role to improve power crisis of Bangladesh.

There is huge power crisis in Bangladesh. Only 50% people get electricity. So there many remote areas in Bangladesh specially hilly area where this power production system is very suitable. Here, we proposed this system theoretically. There are many equipments associated this model such as electrolyzer, battery, hydrogen storage tank, controlling device and fuel cell. The final power output depend on the performance of all this device. So sizing of fuel cell, battery and electrolyzer is very important. In future we size all of this equipment so that optimum output is obtained.

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