Assessment of Wind Energy Potential for Small Scale Power Generation at Thatta, Sindh, Pakistan

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Abstract: In this paper, the wind characteristics and wind Power potential for south coast of Thatta, Sindh province, Pakistan are presented. The variation of monthly wind speed at the height of 10m, 20m, 30m, 40m, and 50m are presented. The power density for these heights are calculated employing coefficient of performance C_p as 0.40 and 0.45. Season wise classification of wind speed and power density at these heights indicates a fairly reasonable prospect of wind energy utilization for small scale power generation.

Keyword: Power Density, Coefficient of Performance, Wind Machine.

INTRODUCTION

With the ever increasing growth in energy consumption and rapidly depleting fossil fuel resources, it is feared that the World will soon exhaust its fuel reserves. This situation has resulted in search of alternate energy resources especially by developing countries whose progress and economic growth heavily leans on the energy use.

Among the alternate energy resources, Wind Energy has emerged as clean, abundant, affordable, inexhaustible and environmentally benign source of energy. In the recent past wind energy is getting worldwide attention. USA, China, Denmark, Germany, Spain and India are the leading countries today in the efficient utilization of this source [1, 2]. Wind energy has the advantage that it can be utilized independently for the areas, far away from the main national grid. It is unfortunate that wind energy has almost no share in the energy mix of Pakistan, although this source of energy can be utilized for electricity generation and pumping water for irrigation purpose [3].

The earlier research [4-6] has shown very high wind potential for coastal and mountain areas of Pakistan. This paper investigates the prospects of harnessing and useful conversion of wind energy potential for Thatta, the coast of southern Sindh, Pakistan. Thatta is located 65 miles from the mega city Karachi with latitude 24.75^0N and longitude 67.92^0E. Along with Gharo (Sindh), this place has been considered as the wind corridor with high prospects & feasibility for efficient utilization of wind energy for power generation [7].

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METHODOLOGY

The generation of power from a wind machine requires wind velocity data and a continuous flow of wind at rated speed. The speed of wind is dependent on the height as well. For estimation of wind speed at any height, we employ Hellman exponent law [8].

$$\frac{V(h)}{V_{10}} = \left(\frac{h}{10}\right)^{\propto} \quad (1)$$

Where V (h) is the wind speed at height h and v_{10} is the wind speed at 10m height and α is the Hellman exponent. For flat open areas α ≈ 1/7.

The available power in the wind per unit area at any wind speed may be estimated as [3].

$$P = \frac{1}{2}\rho V^3 \quad (2)$$

Where ρ is the air density which is assumed to be 1.225 kgm^{-3} and v^3 is monthly wind speed in ms^{-1}.

The available wind power cannot be totally extracted by the wind machine. The maximum extractable power from any wind machine is limited by Betz's relation [9] which assigns the power coefficient c = 16/27, being the maximum performance of a wind

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Table 1: Monthly Wind Speed Variation at Different Heights for Thatta

Months	Wind Speed (V) at Different Heights (ms^{-1})				
	10meters	20meters	30meters	40meters	50meters
January	0.81	0.89	0.94	0.98	1.01
February	1.06	1.17	1.23	1.29	1.33
March	1.76	1.94	2.05	2.14	2.20
April	2.81	3.09	3.28	3.41	3.52
May	3.93	4.32	4.58	4.77	4.92
June	3.35	3.68	3.90	4.07	4.19
July	5.01	5.51	5.84	6.08	6.28
August	4.05	4.45	4.72	4.92	5.07
September	3.44	3.78	4.01	4.18	4.31
October	1.49	1.64	1.74	1.81	1.87
November	0.56	0.61	0.65	0.68	0.70
December	1.14	1.25	1.33	1.38	1.43

machine. The maximum extractable power per unit area is given as

$$P_{max} = \frac{1}{2} C_p A V^3 \ wm^{-2} \quad (3)$$

Where C_P is coefficient of performance.

RESULTS AND DISCUSSIONS

From the available wind data it is observed that the wind speed varies throughout the year. The months of April, May and monsoon months (June, July, August, September) exhibits high wind speed while for the rest of the months the wind speed is low. Table **1** shows the available wind speed at the height of 10m, 20m, 30m, 40m, and 50m for Thatta. This is also shown in Figure **1**. The highest wind speed during July is 5.01ms^{-1} at 10m height and 6.28 ms^{-1} at 50m. The useful wind potential is available from April to September with a variation of wind speed from 2.81ms^{-1} to 5.01 ms^{-1} at 10m height and from 3.52 ms^{-1} to 6.28 ms^{-1} at 50m height for the same months.

As far as the wind power density is concerned it is observed that useful wind power is available during the month from April to September and varies from 10.69 Wm^{-2} to 60.57 Wm^{-2} with c_p=0.40 which is varies from 12.03 Wm^{-2} to 68.24 Wm^{-2} with c_p=0.45 at 50m height. This is given in Table **2** and represented in Figure **2**.

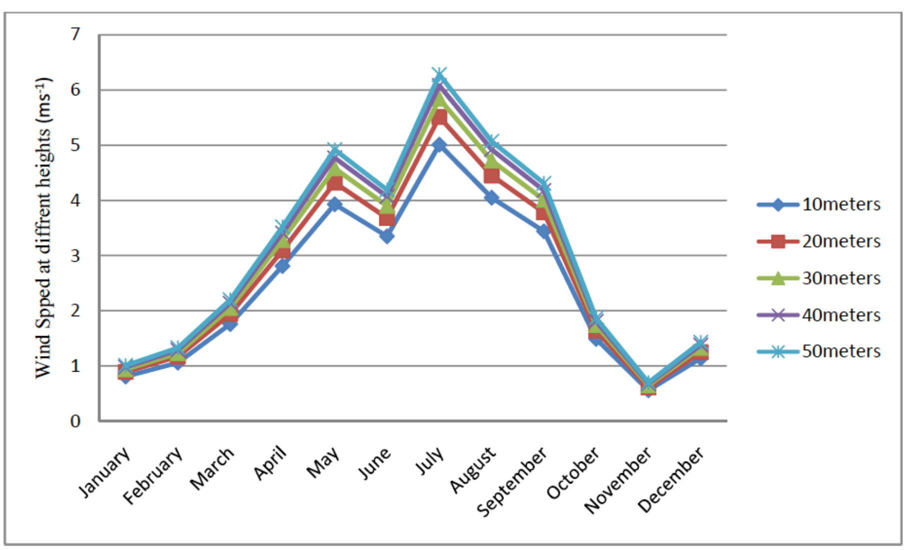

Figure 1: Monthly average wind speed variation at different heights for Thatta.

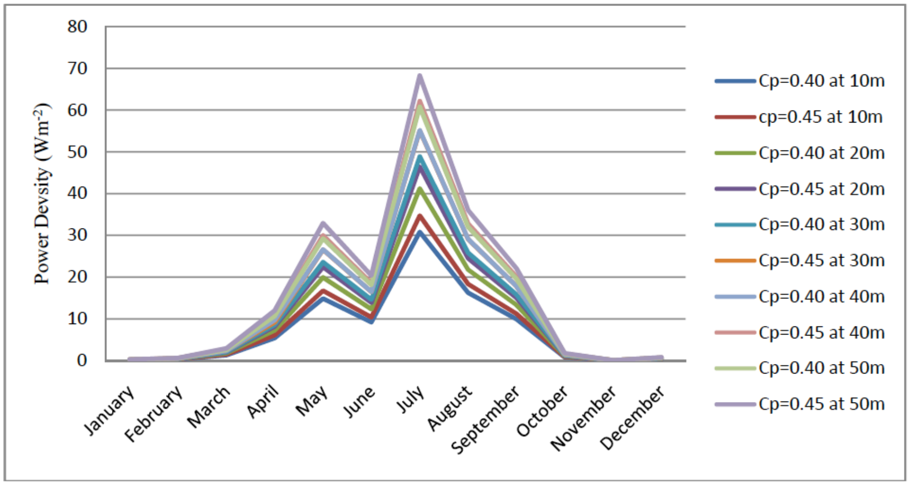

Figure 2: Monthly average Power Density at different heights for Thatta.

Table 2: Monthly Power Density Variation at Different Heights for Thatta

Month	Power density at different heights (Wm^{-2})									
	10meters		20meters		30meters		40meters		50meters	
	C_p=0.40	C_p=0.45	C_p=0.40	C_p=0.45	C_p=0.40	C_p=0.45	C_p=0.40	C_p=0.45	C_p=0.40	C_p=0.45
January	0.13	0.15	0.17	0.20	0.21	0.24	0.23	0.27	0.26	0.29
February	0.29	0.33	0.39	0.44	0.46	0.52	0.52	0.59	0.57	0.65
March	1.33	1.5	1.78	2.0	2.11	2.38	2.38	2.68	2.61	2.95
April	5.44	6.12	7.28	8.19	8.63	9.17	9.74	10.95	10.69	12.03
May	14.87	16.75	19.9	22.41	23.58	26.56	26.62	29.98	29.23	32.93
June	9.21	10.37	12.32	13.87	14.61	16.45	16.49	18.56	18.11	20.39
July	30.81	34.71	41.22	46.44	48.86	55.05	55.15	62.13	60.75	68.24
August	16.28	18.33	21.78	24.52	25.82	29.07	29.14	32.80	32.00	36.04
September	9.97	11.24	13.34	15.04	15.81	17.83	17.85	20.12	19.6	22.12
October	0.81	0.91	1.08	1.22	1.28	1.44	1.45	1.63	1.59	1.79
November	0.04	0.05	0.05	0.07	0.06	0.08	0.07	0.09	0.08	0.10
December	0.36	0.41	0.48	0.55	0.57	0.65	0.64	0.73	0.71	0.81

Table 3: Seasonal Power Density Variation at Different Heights for Thatta

Season	Power density at different heights (Wm^{-2})									
	10meters		20meters		30meters		40meters		50meters	
	C_p=0.40	C_p=0.45	C_p=0.40	C_p=0.45	C_p=0.40	C_p=0.45	C_p=0.40	C_p=0.45	C_p=0.40	C_p=0.45
Winter 1 Jan, Feb, Mar (Mean)	0.58	0.66	0.78	0.88	0.93	1.01	1.04	1.18	1.15	1.13
Spring Apr, May (mean)	10.15	11.43	13.59	15.30	16.10	18.13	18.18	20.46	19.95	22.48
Moonsoon June, July, August (Mean)	18.77	21.14	25.11	28.28	29.76	33.53	33.59	37.83	36.89	41.56
Winter 2 Sept, Oct. Nov, Dec (mean)	2.79	3.15	3.74	4.22	4.43	5.00	5.00	5.64	5.49	6.20

The availability of wind energy and wind power density has been categories on the basis of seasonal variation as shown in Table **3**. This is shown that the year is divided as winter 1 (January, February, March), winter 2 (September, October, November, December), spring (April, May) and monsoon (June, July, August). The availability of wind energy during spring and monsoon period is evident.

From the analysis of the wind energy availability at Thatta, the situation is very encouraging for efficient utilization. Through wind energy is a clear limitless source of energy, few major limitations has to be addressed. This includes energy storage, proper engineering design, site selection and proper height. With abundant sunshine and strong wind potential it is the need of the hour to develop the WECS (wind energy conversion system) for optimum utilization to compensate for the energy gap which will widen in the coming years with increased population and ever growing energy demand.

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