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FREQUENCY DISTRIBUTION OF WIND SPEED OF QUETTA, PAKISTAN

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Abstract: Wind data of twelve years have been analyzed for Quetta, Pakistan to produce the probability distributions. Data for Quetta station is recorded on hourly basis and converted into m s^{-1}. Distributions are considered on monthly and annual basis: final results are compared and show 70-80% probability of hourly wind speed greater than 2.0 m s^{-1}. The probability for occurrence of wind speed at any location in Quetta will help designing the diverse engineering parameters for wind turbines like Darrius or Savonius such as angle of attack on rotors, suitable gear system to make wind machines work even in clean spells, generators, length of rotors; cut-in, cut-out and rated wind speeds of rotors.

Keywords: Angle of attack, diverse engineering parameters, wind speed, turbine

INTRODUCTION

In Pakistan a large number of people are living in rural areas which are not accessible to the notional grid. The absence of electricity in these areas causes the people to migrate from rural to urban areas for better social amenities. In order to reverse this trend, it is necessary to provide energy and other infrastructural facilities in rural areas.

Wind is the alternative source of energy that can be exploited to meet some of the needs. It is necessary to evaluate the wind energy potential areas for Wind Energy Conversion Systems (WECS). In the previous work on wind [Nasir and Ayub 1989, Nasir and Raza 1991, Nasir *et al.* 1992] the data on wind speed and frequency distribution were used to analyse wind energy characteristics and availability in Pakistan.

ANALYSIS OF DATA

The speed of the wind, which is continuously changing, makes it desirable to describe wind by statistical methods. Wind speeds are normally measured in integer values, so that each integer value is observed many times during the recording and the number of observations of specific wind speed v_i will be defined as m_i.

The average wind speed is then calculated as [Justus 1985, Johnson 1984]

$$\overline{V} = \frac{1}{n}\sum_{i-1}^{w} m_i v_i \qquad (1)$$

where w is the number of different values of wind speed and n is the total number of observations. The probability of wind speed is

$$P(v_i) = \frac{m_i}{n} \tag{2}$$

And the sum of all probabilities (cumulative) is always equal to unity so we have:

$$\sum_{i=1}^{w} P(v_i) = 1 \tag{3}$$

The total number of observed frequencies during a month or year is accumulated as:

$$M_1 = \sum_{i=1}^{k} m_i \tag{4}$$

where *k* is the number of last required interval. In a similar way the cumulative percentage of hourly wind speed per year is determined and given in Table 1.

Table 1: Cumulative Frequency in Percentage Hours per Year Hourly Wind Speed (m s^{-1}) for Quetta.

Wind Speed	Quetta
1	75.2 (6592)
2	70.0 (6145)
3	55.3 (4843)
4	43.0 (3804)
5	33.1 (2602)
6	22.0 (1925)
7	15.8 (1384)
8	11.0 (1001)
9	07.4 (0647)
10	03.0 (0301)
11	02.0 (0165)
12	01.0 (0103)

RESULTS AND DISCUSSION

Table 2 shows the cumulative frequency distribution in m s^{-1} for Quetta station in Pakistan, yields the hourly wind speeds during each month and the final column gives the annual cumulative frequency. The observed frequency or the total number of hours corresponds to the wind speed (u_i).

Fig. (1) gives the cumulative frequency expressed as a percentage of the total frequency, which is useful for comparing the different frequency distributions. Here, we represent the distribution of wind speeds in Quetta as regards to the requirements of the energy for lighting, drinking and irrigation particularly in rural areas.

CONCLUSIONS

The result of analysis of wind speed data shows better prospects for Wind Energy Conversion Systems (WECS) in Pakistan, that 80% probability of hourly wind speed is greater than 2.00 m s^{-1} for Quetta.

Table 2: Cumulative Frequency of Wind Speed (m s^{-1}) at Quetta.

Wind Speed	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
00	744	672	744	720	744	720	744	744	720	744	720	744	8760
01	480	482	573	558	588	567	647	636	559	540	479	483	6592
02	442	445	544	517	545	527	626	614	523	501	432	429	6145
03	338	353	459	411	433	427	530	515	405	372	297	303	4843
04	262	284	392	335	353	337	428	414	306	276	197	220	3804
05	199	213	322	267	282	264	344	316	213	194	125	160	2902
06	132	146	238	199	213	180	234	192	114	113	068	096	1925
07	097	113	190	155	168	128	157	118	074	076	046	062	1384
08	072	082	153	123	123	091	116	073	051	051	025	041	1001
09	045	054	112	085	080	058	069	046	030	027	014	027	0647
10	021	026	066	044	046	031	032	022	014	009	007	013	0301
11	009	013	038	024	027	016	014	011	005	003	002	003	0165
12	005	008	024	015	018	011	010	008	001	002	001	001	0103
13	003	002	018	008	011	006	008	006	001	-	-	-	0067
14	002	005	011	005	006	001	006	005	-	-	-	-	0041
15	001	001	006	002	003	-	004	003	-	-	-	-	0020
16	-	-	001	001	001	-	001	001	-	-	-	-	0005
17	-	-	001	-	001	-	001	-	-	-	-	-	0003
18	-	-	-	-	-	-	001	-	-	-	-	-	0001
19	-	-	-	-	-	-	001	-	-	-	-	-	0001
20	-	-	-	-	-	-	001	-	-	-	-	-	0001

Strong wind speeds are prevalent on high altitude (Quetta) regions. Economic analysis [Nasir and Raza 1993] also shows that utilization of the available wind power potentials in Quetta can be realized at a cheaper cost in relation to other renewable energy sources like solar energy, biomass, etc.

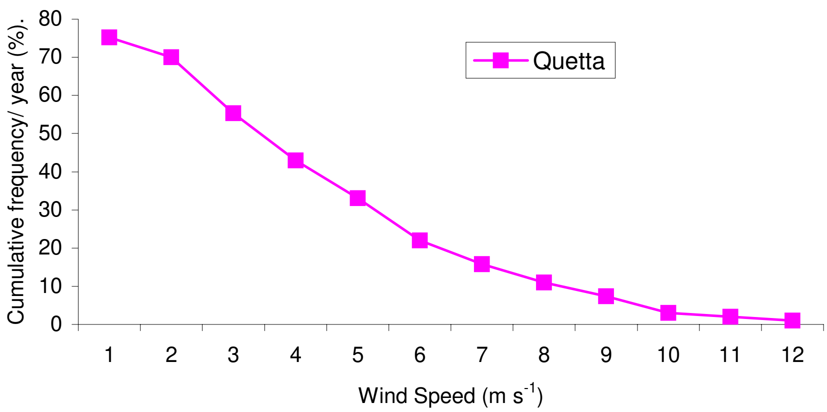

Fig. 1: The cumulative frequency expressed as a percentage of the total frequency.

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