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WIND ANALYSIS FOR WIND POWER AT JAISALMER

1. Western Rajasthan is spreading in desert. No development of this area is possible unless adequate supply of electrical energy for agricultural and industrial purpose is made available. This region is far away from conventional energy source of coal, oil etc. and again they are limited in the country and elsewhere. Necessity has been felt the world over to harness renewable energy source of solar energy, wind energy etc. Here the huge potential of renewable wind (non-conventional) energy in arid areas of west Rajasthan, comprising the district of Banner, Bikaner, Jaisalmer and Jodhpur, is possible. These areas have good natural wind regime.

Sun is the main source of wind which is a mechanism for dissipating (as kinetic energy) the potential energy accumulated in the air pressure difference called by atmospheric temperature difference. A few countries have gone ahead in the utilization of wind energy into electrical energy by using a proper wind mill generator. Wind turbine generator (wind mill) is a device which converts mechanical energy to electrical energy. A single wind driven generator can generate an output of 25 KW (and more) with a low tower height of 20 m and area swept by a rotor of 20 m diameter.

The power of the wind in kilowatts (*P*) may be given by the formula (Thomas 1981) –

$$P = 0.393\rho D^2 V^3 * 10^{-3}$$

Where,

P = Power in kilowatt.

V = Wind velocity in meter per sec, and

ρ = Air density (kgm^{-3})

Wind generating plant (wind mill) mainly consists of (a) Rotor (blades & hub) (b) Nacelle and (c) Tower. Rotor of wind turbine generator is directly mounted on the flexible coupling of the gear box shaft. The wind power is proportional to the intercept area. Thus an aero turbine with a large swept area has higher power than a smaller area machine. Area is normally circular diameter (*D*) in horizontal axis machine.

The amount of air passing in unit time, through an area (*A*), with Velocity (*V*) is $A*V$; and its mass (*M*) is equal to its volume multiplied by its density (ρ) of air (1.225 kgm^{-3} at sea level and it may vary 10-15% during the year because of pressure and temperature change).

It may be noted here that the power in the wind is proportional to the third power of wind velocity and hence the significant advantage of relatively strong winds. Authors have selected Jaisalmer (Lat. 26° 55′N & Long. 70° 54′ E) where a huge area (land) is under the hillock and sandy dunes which are useless for agriculture and being a hard terrain can be useful for the installation of wind mills. As such a small unit of wind mill (up to 25 KW) can be installed practically anywhere, where there is a fair wind and the power produced can be of use.

The task for optimum benefits is proper planning. The planning under consideration involves the following factors (*i*) Wind data for the locality, (*ii*) The type and design of the wind mill to be installed.

In this study the authors have analysed the winds for Jaisalmer for determining the number of observations when the strength of wind is in the range of light (L = 0 to 9 kmph; 2.5 ms^{-1}) moderate (M = 10 to 14 kmph; 2.78 to 3.9 ms^{-1}), strong (S = 15 to 19 kmph; 4.2 to 5.3 ms^{-1}) and very strong (VS = 20 kmph and above; 5.6 ms^{-1}). For utilization of wind mills, synoptic observation of wind gives more information. Records from the Anemometer reading are ideal for a study of this nature for the following reasons (*i*) it is the surface wind that needs to be considered, the height of the sensor above ground level in the case of this anemometer is such that the winds at that level (8.2 m) are nearly representative of the requirement for wind mills with a tower height of 20 m and diameter of swept area 20 m, the lower end of rotor blade will be 10 m above the ground, (*ii*) the anemometer reading were taken three hourly, (*iii*) the data taken from anemometer are very dependable, because the anemometer installed at the site conforms to a class ‘A’ observatory of India Meteorological Department. The anemometer used is a cup counter anemometer model MK-II, which is designed and developed by the office of DDGM (SI) Pune, as per the specification of WMO. The instrument (anemometer) is annually calibrated by the inspector from Meteorological Centre Jaipur.

There is a slight difference between the height of anemometer installed *i.e.*, 8.2 m above the ground level and the rotor of the wind mill proposed to be installed *i.e.*, 20 m above the ground level. The frictional drag of the ground normally decreases as we move away from the earths surface. Because of this, wind speed tend to increase with height above the ground. In fact at a height of only 10 m (33 ft) the wind is often moving twice as fast as at the surface (C. Donald Ahrens, 1985).

TABLE 1

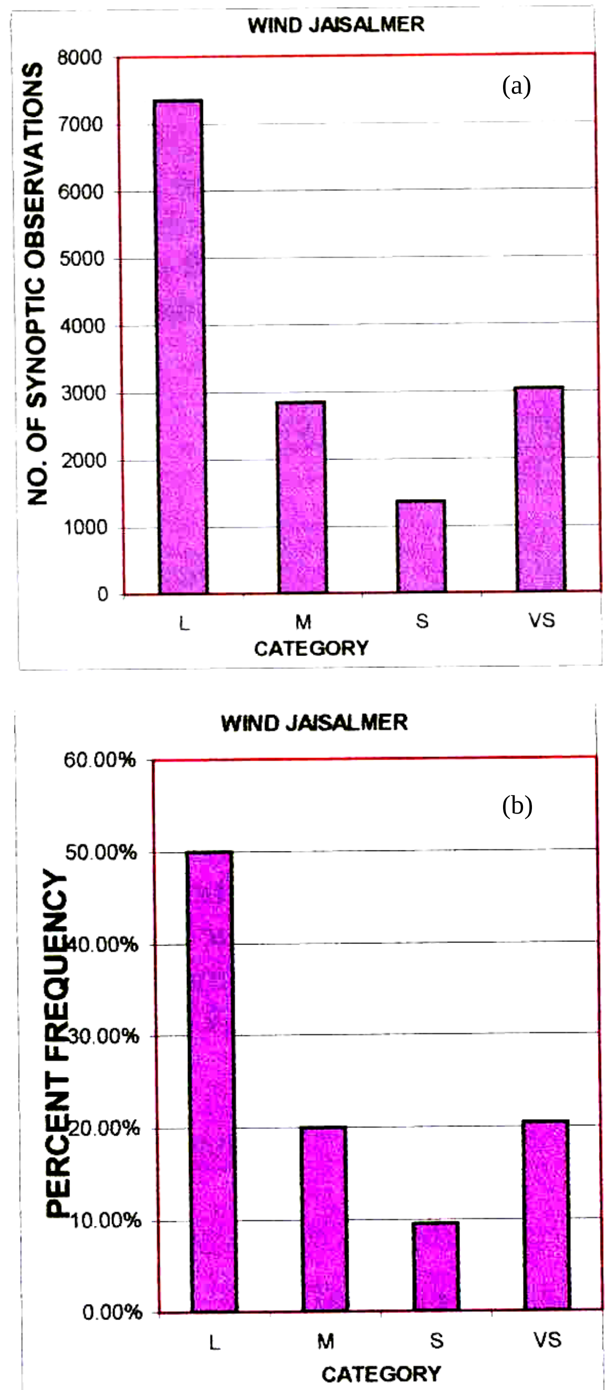
Frequency distribution of winds period : 5 years 1999-2003

Months	Category				Total
	L	M	S	VS	
Jan	959	232	36	13	1240
Feb	735	281	71	41	1128
Mar	801	290	69 —	80	1240
Apr	573	312	162	153	1200
May	185	240	172	643	1240
Jun	121	186	165	728	1200
Jul	242	236	166	596	1240
Aug	268	237	244	491	1240
Sep	380	344	211	265	1200
Oct	1031	176	24	09	1240
Nov	983	178	28	11	1200
Dec	1070	140	25	05	1240
Total	7348	2852	1373	3035	14608
% Frequency	50.0	20.0	09.5	20.5	

2. The cup counter anemometer MK-II is installed at Weather Radar Station campus, class 'A' observatory Jaisalmer. It is installed at a height of 8.2 m (Jain, 1971) above the ground level.

As usual all the synoptic observations from a class 'A' observatory, data has to be sent to Meteorological Centre for correction, forecast & storage purposes. Corrected and recorded data of Jaisalmer station for every synoptic (three hourly) hours are obtained from the Meteorological Centre, Jaipur *i.e.*, from 01 January 1999 to 31 December 2003, and analysed according to the categories. The direction of wind has not been considered because the wind mills can be so designed that they can turn so as to always face the wind.

Rotor of wind turbine generator is directly mounted on the flexible coupling of the gear box shaft and gear box shaft automatically changes over according to the wind speed. Hence the classification of the wind speed has been made accordingly. When the winds are light *i.e.*, 0-9 kmph (2.5 ms^{-1}), wind mills are practically in-operative (cut in wind speed), frequency of occurrence of wind in the other groups will be helpful in deciding upon the type and sturdiness of the wind mills to be employed and in deciding upon the uses for which the wind mills can be installed.



Figs. 1(a&b). Wind speed

The wind speed at each synoptic hour falling in each of the above four groups (Thomas, 1981) were determined. This was done in respect of all (08) synoptic observations per day. Thus the classification was made for one month. In the same manner classification for all the months for all the five years was made.

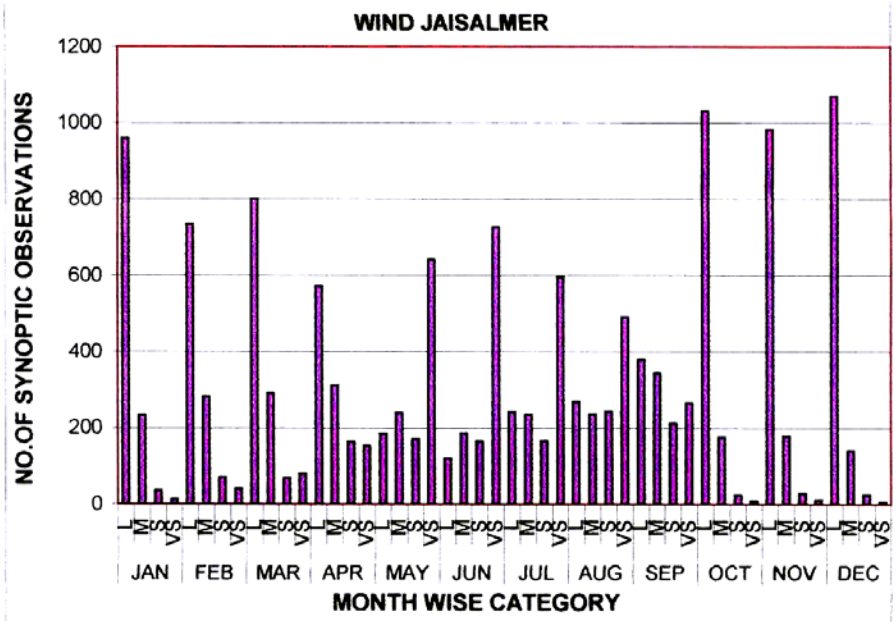


Fig. 2. Graphical representation of wind speed

Thus the frequency distribution according to the four groups L, M, S and VS in respect of each synoptic hours for all the months, for all the five years was prepared. With these groups various kinds of analysis could be made.

3. The first type of analysis made was to find the frequency distribution in the four groups of all the wind for all the synoptic hours, for all the months and for all the five years put together. For this the number of occasions the winds under each group for all synoptic hours for all months and for all the five years were first added up. This gives us an idea of the proportion of each group of wind speed for five years period. It was thus found that there were 7348 synoptic hours of light wind, 2852 synoptic hours of moderate wind, 1373 synoptic hours of strong wind and 3035 synoptic hours of very strong wind during the five years period.

This is graphically indicated in Fig. 1(a). The frequency distribution is expressed as percentage distribution in Fig. 1(b). It can be inferred from Fig. 1(b) that light wind prevails 50%, moderate wind 20%, strong wind 9.5% and very strong wind 20.5% of all the synoptic hours in a year at Jaisalmer. In other words for 50% of the times of synoptic hour in a year the wind is above 9 kmph (2.5 ms^{-1}). That is, broadly speaking, wind mills could be effective and operative for well over more than half the period in a year at Jaisalmer.

The second type of analysis made was to classify the wind speed into the four groups month wise. The result is shown in Table 1. This result is also graphically represented in Fig. 2. These give us useful information as to which are the favourable months when wind mills could be used with the best advantage, it can be seen from Table 1 that the favourable months are May, June, July, August and September and the least favourable month are January, February, March, October, November and December.

This gives useful information as to which are the months when wind mill could be used with the best advantage.

4. Arid area like Jaisalmer where electrical power crisis is always experienced by the farmers and industrialists, power scarcity can be removed by generating the wind power.

(*i*) From Table 1, synoptic observation shows that winds under the category of light are 7348 (50.0%) of the total synoptic hours for a period of five years (1999- 2003) and the rest are under the category of moderate (2852 observations ; 20.0%), strong (1373 observations ; 9.5%) and very strong (3035 observations ; 20.5%) which are good to operate the wind mills for power generation.

(*ii*) From Figs. 1 & 2 it can be seen that, May - August shows moderate, strong to very strong winds at Jaisalmer for continuous power generation. Hence the favourable months for best utilization of wind mill are May, June, July, August and September.

(*iii*) Operative wind speed for wind mill being 10 kmph (2.8 ms^{-1}) (Thomas 1981), nearly half of the period wind mill will be effective in a year.

(*iv*) Wind direction from March to September was observed to be constantly from SW (Climate of Rajasthan 1988). Therefore wind conditions at Jaisalmer are more favorable for the operation of wind mills.

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References

Climate of Rajasthan State, India Meteorological Department, 1988.

C. Donald Ahrens, 1985, "Meteorology Today - An introduction to weather, Climate and the environment", II[nd] Edition, p255.

Jain, P. K., 1971, "Maximum wind pressure over India", *Indian J. Met. & Geophys*., **22**, 571-574.

Thomas, S. I. T., 1981, "Wind analysis for wind power - Pt-I," *Mausam*, **32**, 1, 55-58.

Thomas, S. I. T., 1981, "Wind analysis for wind power - Pt-II," *Mausam*, **32**, 2, 151-154.

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