

Wind energy pattern factor for Bangladesh and estimation of the wind energy availability

M. SARKAR, M. HUSSAIN and S. ALAM
Department of Physics, Univ. of Dhaka, Dhaka, Bangladesh
 and
 K. A. REZA

Department of Physics, Bangladesh Univ. of Engineering & Technology, Dhaka, Bangladesh

(Received 8 March 1983)

सारा — बंगलादेश के मौसम विभाग द्वारा एक घंटा और आधा घंटा के अंतरालों पर चिटगांव, कोक्स बाजार, ढाका, इशुर्दी और जैसोर के दैनिक रूप से प्रेक्षित आंकड़ों को एकत्रित किया गया है। इन आंकड़ों से औसत और बारंबारता बंटन निकाले गए हैं। इसके बाद इन पांच स्टेशनों के लिए कुल उपलब्ध पवन ऊर्जा की गणना की गई है। पवन चालों के मासिक माध्यों एवं गणना की गई ऊर्जा का उपयोग करके ऊर्जा पैटर्न गुणांक ज्ञात किया गया है। K के मानों का उपयोग करके 14 अन्य स्टेशनों पर जिनके लिए पवन चालों के केवल मासिक माध्य उपलब्ध हैं, उपलब्ध ऊर्जा का आकलन किया गया है।

ABSTRACT. Wind speed data for the period 1978-80, recorded daily at half-hourly or hourly intervals for stations Chittagong, Cox's Bazar, Dhaka, Ishurdi and Jessore have been collected from the Meteorological Department of Bangladesh. The data were averaged and the frequency distributions were obtained. Total available wind energy was then calculated for these 5 stations. Using the monthly mean wind speeds and the calculated energy, the energy pattern factor K , was determined. The energy available at other 14 stations for which only monthly average wind speeds are available has been estimated using the values of K .

1. Introduction

To estimate the availability of wind energy for a particular location, the frequency distribution of wind speed for each month is required and for this one needs half-hourly or hourly wind speed data over the different months for many years. For stations which do not have such detailed data one can calculate the available energy with a fair accuracy using the monthly means of the daily average wind speed and its corresponding wind energy pattern factor, K , which is defined as (Golding 1976) :

$$K = \frac{\text{Total energy available in the wind}}{\text{Energy calculated by cubing the mean wind speed}}$$

Of all the 37 or so meteorological stations in Bangladesh, only 5 stations have half-hourly or hourly wind speed data and the rest have either data at an interval of 3 or 8 hours or daily average data. Hence to obtain the available wind energy at all these stations, an attempt has been made to find the value of this K factor for different wind speeds all over Bangladesh. The K factor for countries like the USA or the UK

have been determined but it is not unlikely that for Bangladesh the K factor will be somewhat different as this depends on the statistical nature of wind speeds.

2. Data collection and handling

Wind speed data for the period 1978-80 recorded daily at half-hourly or hourly intervals for the stations Chittagong, Cox's Bazar, Dhaka, Ishurdi and Jessore have been collected from the Meteorological Department of Bangladesh. All these measurements were taken with the help of vertical cup anemometers with an error of around ± 1 knot. The half-hourly or hourly data were averaged over all the days of a particular month for individual hours. The hourly averaged values were then again averaged to obtain the mean wind speeds for a particular month. The data for the years 1978-80 for these 5 stations were handled in this way to obtain the monthly mean wind speed used to determine the K factor. Monthly means of the daily data evaluated by the Meteorological Department for the years 1931-60 for 14 stations were also collected.

3. Analysis and results

Theoretically the power available from a moving stream of air with a velocity V and of cross sectional

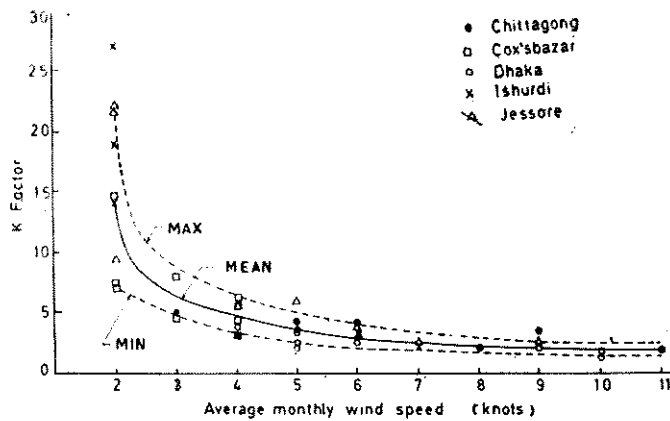


Fig. 1. Wind energy pattern factor K versus the monthly mean wind speed \bar{V}

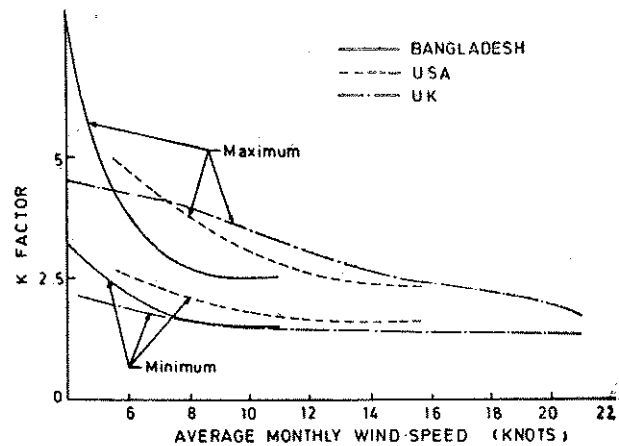


Fig. 2. Comparison of wind energy pattern factor K for Bangladesh with those of the USA and UK

TABLE 1

Annual available wind energy for different stations in Bangladesh using the mean value from Fig. 1

Station	Annual energy output (kWh m ⁻²)	Station	Annual energy output (kWh m ⁻²)
Barisal	83	Ishurdi	135
Bogra	42	Jessore	180
Brahmanbaria	52	Khulna	71
Chittagong	420	Mymensingh	36
Comilla	107	Narayanganj	73
Cox's Bazar	64	Noakhali	182
Dhaka	348	Rangpur	40
Dinajpur	28	Satkhira	40
Faridpur	97	Sirajganj	65
		Srimangal	34

area A is proportional to the cube of the velocity and is given by :

$$1/2 (\text{mass}) \times (\text{velocity})^2 = \frac{1}{2} \rho AV^3$$

where ρ is the density of air. The maximum power that can be obtained (Golding 1976) is :

$$.2795 \times D^2 V^3$$

where D is the rotor blade diameter expressed in metres and V in metre/sec. Expressing V in knots

$$\text{Power} = 0.1368 \times 0.2795 D^2 V^3 \text{ watts} :$$

Hence the total energy available for a month is :

$$\text{Energy (kWh)} = 3.826 \times 10^{-5} D^2 \Sigma V^3 h \quad (1)$$

where h is the duration in hours corresponding to the wind speed V for each month. The duration (h) for different wind speeds (V) was obtained from the half-hourly and hourly data for Chittagong, Cox's Bazar, Dhaka, Ishurdi and Jessore. Taking each value of V into consideration, the corresponding value of $\Sigma V^3 h$ was calculated to obtain an estimate of the monthly available wind energy.

The total available energy can also be expressed as Energy (kWh) = $K \times 3.8236 \times 10^{-5} D^2 \bar{V}^3 H$ (2)

where \bar{V} and H are the average wind speed and the number of hours in a particular month and K is the wind energy pattern factor as defined earlier. From the relation (1) it is clear that the available wind energy is directly proportional to the cube of the wind speed. As the mean of the cube of different wind speeds is always higher than the cube of the mean, the K factor simply measures the correction factor which is to be used when one calculates the available energy from the mean wind speed. Using half-hourly or hourly data in relation (1) and monthly mean wind speed in relation (2) and equating relations (1) and (2), the values of the K factor in respect of 5 stations have been calculated.

A plot of K versus the monthly wind speed \bar{V} is displayed in Fig. 1. It is observed that the factor has a large uncertainty at lower velocities and lies between certain maximum and minimum values. The values of K for the UK (Golding 1976) and the USA (United States Department of Energy 1978) are displayed in Fig. 2 along with the values for Bangladesh. It is observed that these values are fairly consistent with our findings. A curve for the mean value of K has also been drawn (Fig. 1). Using the mean values of K , the yearly available wind energy in kWh m⁻² year⁻¹ for the 5 stations and for other 14 stations for which only monthly average wind speeds are available has been worked out and shown in Table 1. From Table 1 it is clear that Chittagong station (which is situated near the sea) has the highest wind energy availability. The next important station is Dhaka. At the stations Noakhali and Jessore, the annual energy output is a factor of 2 less than that of Chittagong and Dhaka.

Acknowledgement

The authors acknowledge the help of the Meteorological Department of Bangladesh for collecting the meteorological information. The research was financed by the Centre for Policy Research, University of Dhaka.

References

Golding, E., 1976, The generation of electricity by wind power.
United States Department of Energy, 1981, Home wind power.