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Wind Shear Coefficients and their Effect on Energy Production

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Abstract

Generally wind shear coefficient is used to estimate the wind speed at higher elevations, while the local meteorological anemometers monitor one elevation. The well-known equation for estimating wind shear coefficients is a power law. This paper assesses wind shear and its effects on annual energy production from wind speed data on Phangan island, collected from December 2011 to November 2012 at locations 65 and 120 m above ground level (agl). The annual, monthly, and diurnal variations of wind shear coefficient were investigated. The annual energy production was assessed by using the wind turbine power curve. The results show that the difference between wind energy production from extrapolated wind data and the measured energy production may be up to 35%.

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Keywords: Wind Shear Coefficients, wind speed, wind energy, power law, Phangan island;

1. Introduction

The modern wind turbines have a very tall hub height while most meteorological anemometers in developing countries have only one position below 50 m above ground level (agl). In order to estimate the wind speed at the higher position, a wind shear coefficient is needed. This parameter directly impacts the wind energy obtained, and it relates to the wind speed data from the two positions, atmospheric stability, and terrain type. [1] The wind shear

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coefficients were found to be higher during nighttime and smaller during daytime [2]. It was also found [3] that estimates of wind speed at the higher position based on wind shear coefficient may differ from measured wind data by up to around 50 percent. In general the value 0.143 for wind shear coefficient is used to predict the wind at the higher elevation, which gives good results over smooth surfaces such as at sea [4]. The objective of this work was to compare the energy production estimates from power law extrapolation of 65 m data to 120 m agl with the measured data for 120 m agl.

2. Study area and data description

The wind speed at two positions above ground level, 65 m and 120 m agl, were obtained from the inland Phangan station affected by complex terrain. Khao Ra is the highest peak with 627m elevation from sea level. The number of data points is 52,192, recorded every 10 minuites from December2011 to November 2012, and they were used to calculate the wind shear coefficient.

3. Methods

The vertical wind profile is widely assumed to follow a power law, as shown in the equation 1.

$$\frac{v_2}{v_1} = \left(\frac{h_2}{h_1}\right)^{\alpha} \tag{1}$$

Here v_1 [m/s] and v_2 [m/s] are the measured wind speeds at elevations h_1 [m] and h_2 [m], respectively. α is the wind shear coefficient. The wind shear coefficient can be calculated if wind speed measurements at the two elevations are available by fitting the data with equation 2. [5]

$$\alpha = \frac{\ln(v_2) - \ln(v_1)}{\ln(h_2) - \ln(h_1)} \tag{2}$$

4. Results and discussion

4.1. Frequency distribution

The wind speed data were sorted from minimum to maximum and binned into 1 m/s intervals. The frequency distribution of wind speed in Fig. 1 shows that speeds exceeding 3 m/s occur about 54 and 67 % of the time at 65 m and 120 m agl elevation respectively.