Renewable and Sustainable Energy Reviews 38 (2014) 296–308

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Assessment of wind power generation potential in Perlis, Malaysia

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ARTICLE INFO

Article history:
Received 27 September 2011
Received in revised form
18 May 2014
Accepted 20 May 2014

Keywords:
Wind speed
Weibull distribution function
Wind power generation

ABSTRACT

This paper presents analysis of the wind speed characteristics at Chuping and Kangar in Perlis, Malaysia. The characteristics consist of daily, monthly and annual mean wind speed. The Weibull distribution function is applied to analyze the wind speed characteristics and used to calculate the wind power generation potential. The wind power and energy as functions of tower height are presented and analyzed in this paper. The result shows that during 2005–2009 the mean wind speed at Chuping is 1.12 m/s, and during 2012–2013 the mean wind speed at Kangar is 2.50 m/s. Based on the analysis of the Weibull distribution function, the wind speed and probability density are, respectively, 0.97 m/s and 73% at Chuping, also 2.5 m/s and 45% at Kangar. They are important information to choose a suitable wind turbine for a wind power generation. The monthly mean wind power and energy density in the beginning (January–March) and the end (December) of year are higher than in the middle of year. The analysis result of the wind power and energy density as functions of tower height shows that higher tower height will produce higher wind power and energy density.

Contents

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http://dx.doi.org/10.1016/j.rser.2014.05.075
1364-0321/

1. Introduction

Energy is one of the essential inputs for economic development and industrialization. Fossil fuels are the main resources and play a crucial role to supply world energy demand. However, fossil fuel reserves are limited and usage of fossil fuel sources has negative environment impact. Therefore, management of energy sources, rational utilization of energy, and renewable energy source usage are vital [1].

Renewable energy has an increasing role in achieving the goals of sustainable development, energy security and environmental protection. Nowadays, it has been recognized as one of the most promising clean energy over the world because of its falling cost, while other renewable energy technologies are becoming more expensive [2].

Wind energy is a renewable energy produced by continuously blowing wind and can be captured using wind turbines that convert kinetic energy from wind into mechanical energy and then into electrical energy [3]. Today, wind energy is widely used to produce electricity in many countries such as Denmark, Spain, Germany, United States, and India [4].

It is necessary to carry out long-term meteorological observation to accurately assess the wind power generation potential and its characteristics. Data of wind speed is needed to assess the potential. The wind speed is a random variable and variation of wind speed over a period of time is represented by probability density function. Wind speed frequency distribution has been represented by various probability density functions such as gamma, Rayleigh and Weibull distribution. However, in recent years Weibull distribution has been one of the most commonly used, accepted, recommended distribution to determine wind energy potential [1].

A lot of researchers have been studying the wind speed characteristics and its potential as a wind power generation in many countries worldwide. The potential and the feasibility basis of the wind energy resources was analyzed by [1] in some locations of coastal regions of Turkey (Canakkale, Balikesir, Istanbul, Takirdag, Izmir, Mugla, Antakya, Mersin, Antalya, Sinop, Bartin and Ordu). The result showed that Balikesir and Canakkale among annual averages show higher value of mean wind speed. The mean annual value of Weibull shape parameter k is between 1.54 and 1.86 while the annual value of scale parameter C is between 2.52 m/s and 8.34 m/s. Analysis of the wind speed characteristics was done by [4] in Ras Benas city located on the east coast of Red Sea in Egypt using measured data (wind, pressure and temperature) and Weibull function. The result showed that the annual mean wind density is 315 kW/m^2 at a height of 70 m above ground level. The monthly and seasonal variations of the wind characteristics were investigated by [2] in term of wind energy potential using the wind speed data collected between 2002 and 2008 for four meteorological stations in Liguria region, in northwest of Italy, namely Capo Vado, Casoni, Fontana Fresca and Monte Settepani. The results showed that Capo Vado is the best site with a monthly mean wind speed between 2.80 and 9.98 m/s at a height of 10 m and a monthly wind power density between 90.71 and 1177.97 W/m^2, while the highest energy produced may be reached in December with a value of 3800 MWh. Six kinds of numerical methods for estimating Weibull parameters were reviewed by [5]; i.e. the moment, empirical, graphical, maximum likelihood, modified maximum likelihood, and energy pattern factor method. The result showed that the maximum likelihood, modified maximum likelihood and moment methods present relatively better ability throughout the simulation test. From analysis of actual data it is found that if wind speed distribution matches well with Weibull function the six methods are applicable, but if not the maximum likelihood method performs the best followed by the modified maximum likelihood and moment methods, based on double checks including potential energy and cumulative distribution function. Wind speed and direction at 20 m and 30 m above ground level and in the Gulf of Tunis were studied by [6] during 2008. The obtained results can be used to run wind park project and confirm that the Gulf of Tunis has promising wind energy potential. A new formulation for the turbine-site matching problem was presented by [7], based on wind speed characteristics at any site and the power performance curve parameters of any pitch-regulated wind turbine as well as turbine size and tower height. The results revealed that higher tower heights are not always desirable for optimality.

This paper presents analysis of the wind speed characteristics at Chuping and Kangar in Perlis, Malaysia. The characteristics consist of daily, monthly and annual mean wind speed. The Weibull distribution function is applied to analyze the wind speed characteristics and used to calculate the wind power generation potential. The wind power and energy as functions of tower height are presented and analyzed in this paper.

2. Assessment of world wind energy

This following section will provide a brief overview of the wind energy potential for wind power generation around the world at the end of 1999 and 2013. The overview of wind energy potential follows the country division (Africa and Middle East, Asia and Pacific, Europe, Latin America and Caribbean, North America). Data of wind energy and installed wind power from some representatives of the country division are explained briefly.

2.1. Global cumulative installed wind power capacity in the world

Global Wind Energy Council (GWEC) reports a bar graph of global cumulative installed wind power capacity in the world for the year 1999–2013 as shown in Fig. 1 [8]. The graph shows that every year, the addition of installed wind power capacity is done continuously. Its average annual additional is 25.31%; thus it can be predicted that an installed wind power capacity in 2020 is 563,643 MW.

Each country division (Africa and Middle East, Asia and Pacific, Europe, Latin America and Caribbean, North America) gives a contribution of installed wind power total capacity at the end of 1999 and 2013 as shown in Figs. 2 and 3, respectively [8,9]. Significant additions of installed wind power total capacity with multiple factors are 32.18, 85.40, 13.05, 54.13 and 27.07 for Africa and Middle East, Asia and Pacific, Europe, Latin America and Caribbean, and North America, respectively. The installed wind power total capacity in the world at the end of 2013 is 23.64 times that at the end of 1999 as shown in Table 1. It indicates that the wind power generation is very interesting as a friendly alternative energy source.

2.2. Overview of wind energy potential in selected countries

The overview of wind energy potential in selected countries following a top 10 countries installed wind power cumulative capacity at the end 2013 is shown in Fig. 4 [8]. Every year, these countries always do additional works of installed wind power capacity. At the end of 2013, the installed wind power total capacity in the world from the top 10 countries is 318,137 MW. China, USA, Germany, Spain, India, UK, Italy, France, Canada, Denmark and Rest of the world have installed, respectively, 91,424 MW; 61,091 MW; 34,250 MW; 22,959 MW; 20,150 MW; 10,531 MW; 8522 MW; 8254 MW; 7803 MW; 4772 MW and 48,352 MW of wind power capacity.