Renewable Energy xxx (2017) 1–10

Contents lists available at ScienceDirect

Renewable Energy

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

Validation of wind resource in 14 locations of Nepal

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ARTICLE INFO

Article history:
Received 21 February 2017
Received in revised form
11 September 2017
Accepted 23 October 2017
Available online xxx

Keywords:
Wind speed
Wind measurement
Calibration
Validation
Statistical analysis

ABSTRACT

In the highly traditional and inefficient energy dependent countries like Nepal effective exploitation of renewable energy need serious attention. In this context, identification of potential locations for wind energy production is the particular interest of Nepal. Wind speed is the most important indicator for assessing the wind energy resource. Wind resource assessment is carried out either by microscale modeling or dedicated masts or by means of both. Measuring wind energy potential by establishing masts demands high cost and longer time period. Hence it is important to validate the available modeled wind speed with the observed data. The modeled wind data produced by High Asia Refined Analysis dataset are validated based on the observed data of 14 locations in this research. Statistical analysis is computed and also wind speed hourly data of all study sites are compared by presenting both sources data graphically. The statistical analysis supports that the two sources of data do not differ significantly and there is moderate correlation between these data sources. The validation result shows that the modeled wind dataset represents moderately the actual wind speed situation of the studied locations. Thus this modeled dataset is useful for preliminary assessment of wind in Nepal.

1. Introduction

Deployment of wind energy started in the decade of 1970s; partially in response to the oil crisis, and environmental and climate change problems. Theoretically the potential supply of earth's wind energy substantially exceeds global energy demand. However, the irregular nature of wind resources is the major hurdle to exploit wind power [1]. Despite the first wind power plant installed in Mustang back in 1987, the utilization of wind energy in Nepal was first envisioned only in its eighth periodic plan (1992–1997). The wind energy was especially focused for the purpose of lift irrigation while the plan gave equal emphasis on research and development including resource assessment of wind energy [2].

The renewable energy subsidy policy 2000 highlighted the importance of wind energy for meeting nation's energy demand. The policy also highly prioritized the need for data collection and wind map preparation including financial support to attract investors [3]. The Rural Energy Policy 2006 aims preparing Wind Energy Master Plan for effective deployment of potential wind energy resources [4]. The Solar and Wind Energy Resource Assessment pointed out the need of further analysis and research for a complete assessment to identify micro-level potential of the wind resource in Nepal [5,6]. Renewable energy technologies are in first priority of the Government. Micro/mini hydro power and solar photovoltaic are disseminated through existing renewable energy policy in off-grid areas of Nepal for rural electrification, and operating enterprises and income generating activities. Around 30 MW of electricity has been generated from micro hydropower, 15 MWpp from solar PV system and only 20 kW from wind energy [7]. Despite the policy support, endowment of wind resource is not explored in Nepal.

In order to assess the actual potential, measuring the wind data at least over one year at the proposed site is essential [8]. For the purpose of *Solar and Wind Energy Resource Assessment* (SWERA) project in Nepal, wind resource was measured in five locations at 10-m height from the ground at the 10-min interval averaging on an hourly basis starting from 2003. Furthermore, wind speed was measured at each meteorological station at 2 m height; however 13 stations measure wind resource at 10 m height since 2009. Alternative Energy Promotion Centre and National Academy of Science and Technology have been measuring wind resource by installing purposeful met masts in some locations of the country at the hub height ranging 10–50 m. However, none of the above organizations

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https://doi.org/10.1016/j.renene.2017.10.068
0960-1481/

have recorded, stored and managed wind data on regular and systematic basis.

The utilization of wind energy, like any other natural resource, requires detailed information on its availability. Continuous wind speed is the most important factor to estimate the wind resource potential at any location. Wind resource assessment is time consuming and resource intensive work. Due to high variability of topography, temperature and altitude, wind energy mapping in Nepal is further complicated and expensive. The past effort neither came up in the complete picture of wind resource of the country nor borrowed the work carried out by the outsiders. Predicted wind energy data collected using atmospheric information through global or regional climate change models are made available by various organizations. The High Asia Refined analysis (HAR), an atmospheric dataset, provides gridded fields such as temperature, precipitation and wind at 10 m height from the ground at 10 km resolution for the Tibetan Plateau and surroundings. This data is available for whole Nepal for the period from July 2000 to September 2014 [9].

Geographical and temporal variability of wind inevitably increases the difficulty to give an accurate prediction of wind [10]. Nepal has contrasting terrain with high local relief in a short cross sectional distance from north to south and also major elevation difference in a short horizontal distance in mountain. Relief map with shaded height of Nepal is presented in Fig. 1.

The maximum temperature of the year occurs in May or June. The sunshine days are about 300 in Nepal [11]. Temperature starts decreasing from October and reaches the minimum in December or January. As the temperature decreases with height, the sharp altitudinal gradients in the topography of the country have resulted in the significant spatial variation in temperature. Due to its unique physiographical and topographical distribution, the climate types of the country ranges from subtropical in the south to arctic in the north [12]. The degree of uncertainty and quality of wind data is therefore dependent on the multiple factors including temperature variation, terrain complexity and the geographical variability of the wind resource.

There are two possible approaches for wind data collection; one is measurement at site and the other is modeling using downscaling atmospheric data using model [25]. Although measuring wind data over one year in the proposed site is essential, it is a cost-intensive and time consuming process; hence, in the early stages of development, pre-feasibility studies are conducted using reference wind data from the adjoining areas [26]. The weather station data is commonly available dataset used in the analysis of wind resources because it objectively measures the wind speed at certain locations [27]. The alternative to using direct observations is to use other long-term wind speed datasets to derive a useful localized wind speed dataset. Long-term global reference datasets are the most commonly used wind speed datasets [28,29].

Fourteen sample sites which have complete one year hourly wind data measured in either purpose built masts or meteorological stations are selected to validate the modeled data. These sites have 90% hours or more data available with maximum 10% missing information. This paper aims to validate modeled data for judging the magnitude and significance of association with the observed wind speed data in Nepal. The best fit equation is also formulated for each sample locations for estimating wind resource supposing modeled data and temperature as independent variable.

2. Material and methods

2.1. Study location

For the purpose of the research, 14 sites were sampled, out of which four sites are from the mountain region, seven are located in the hilly area and remaining three are in the Terai. Five sites are situated in river corridors; six are on hill tops and three in other types of topography (Fig. 2).

The metadata of the study locations are presented in Table 1.

2.2. Data collection

Wind data were collected from both primary and secondary sources. As referenced data sets are required for at least 90% of one year duration [13,16], data from only those sites that meet these criteria are selected for the research. Simikot, Jumla airport and Patan west sites are climatology meteorological stations and remaining 11 sites are purposely established observation posts. The wind speed data were recorded at the height of at least 10 m above

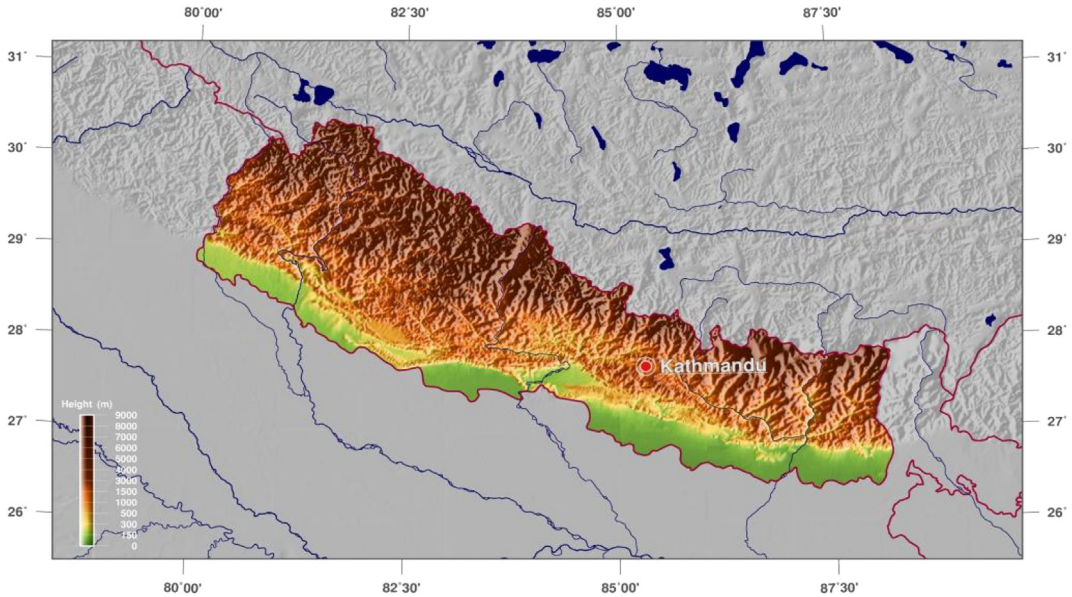

Fig. 1. Shaded height and relief map of Nepal.

Please cite this article in press as: R. Laudari, et al., Validation of wind resource in 14 locations of Nepal, Renewable Energy (2017), https://doi.org/10.1016/j.renene.2017.10.068