Renewable Energy 91 (2016) 1–10

Contents lists available at ScienceDirect

Renewable Energy

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

Reliably model of microwind power energy output under real conditions in France suburban area

H. Ramenah, C. Tanougast*

LCOMS-ASEC, Universite de Lorraine, Metz, France

ARTICLE INFO

Article history:
Received 5 March 2015
Received in revised form
28 July 2015
Accepted 5 November 2015
Available online xxx

Keywords:
Wind energy
Weibull distribution function
Wind speed
Rural and urban wind powers

ABSTRACT

Micro-wind turbine are now specially designed for rural or urban environment and one of the main advantages of such turbine is that it can be propelled by a wind speed as low as 3 m/s. However, due to terrain roughness in urban environments wind flow is reduced compared to open spaces reducing power output and increasing payback time on capital investment. Well mounting turbines in urban areas may provide the perfect opportunity for onsite generation from wind power. In this paper, we investigate the performance of a micro-wind turbine in a complex urban area and show that due to long time period and very subtile onsite measurements the ideal position for the wind turbine can be determined. Well measured data, wind speed, power output at this particular location are approximated by the Weibull function. The considered model is tested and validated at an urban landscape location in Metz City, France, where an anemometry is positioned at adjacent to the turbine and the instrumentation is positioned specific to its surrounding location and, record wind turbine data thanks to real time wireless communications. Technical data including wind speed and output power were analyzed and reported allowing to provide an reliable estimation of the wind energy potential in an urban location.

1. Introduction

Wind power is one of the fastest grows form of renewable energy in the world. Most of significant research assessing the wind energy resource in rural locations around the world, and in some research, this work has been extended to apply to the potential for wind energy conversion systems. Therefore, several micro wind installations were carried out and demonstrate benefits and possibility of producing an adequate amount of power required to a rural area even at lower wind speed with most cost effective way [1–7]. Nowadays, new form of wind power is designed to work in an urban environment. Small and micro wind turbines can meet the electricity needs of individual homes, farms, small businesses and villages or small communities and can be as small as 0.2 kW. They can play a very important role in urban electrification schemes in mini-grid applications and off-grid application for urban applications and even be complement to solar photovoltaic systems in off-grid systems or mini-grids.

In contrast, there is few significant research assessing the wind energy resource in urban environments where wind energy potential can be explored and warranted as civil populations are increasingly concentrated and thus increasing energy demand. Some researchers have ascertain the potential of building mounted turbines by providing the on-site measured data for design and assessment of micro-wind turbines installed in building blocks [8–14]. Similarly, the specific technology and design issues in the use of wind energy in buildings have been described in [15]. However, in the most case studies and although the potential of integrating wind turbines into buildings is vast, turbines were individually placed and fixed into the roof level in order to reduce shading effect due to surroundings and grabbing intensified wind speed providing high electricity output.

Actually, there are many challenges to incorporate wind generation into urban areas where the impact of wind generation on power system performance should be assessed for wind power contribution and providing a reliably meet peak load while assuring energetic security [16]. Indeed, in the micro-grid network, generated micro-wind power is extracted under varying wind speed and then it is difficult to support the critical load without uninterrupted power supply. That is why, micro-wind energy conversion systems with battery energy storage is used to maintain the power quality norms [17]. Indeed, higher participation levels of

* Corresponding author.
E-mail addresses: Harry.Ramenah@univ-lorraine.fr (H. Ramenah), Camel.Tanougast@univ-lorraine.fr (C. Tanougast).

http://dx.doi.org/10.1016/j.renene.2015.11.019
0960-1481/© 2016 Published by Elsevier Ltd.

wind power in power systems will increase the need for flexible back-up generation to balance the differences between predicted and realized wind power production [18]. Consequently, major countries in the European Union (EU) have developed strategies to promote the growth of renewable sources of electricity (RES-E) but French renewable output has lagged that of neighbors countries. The recent France's Energy Transition bill is encouraging householders to utilize micro renewable generation through financial incentives. Siting urban wind power needs preliminary resources assessment such as wind characteristics and wind profile, topography of the terrain with respect to the roughness class, near-by obstacles. These parameters of a specific location are essentials for power output prediction and estimation to reduce payback time on capital investment.

In considering where these technologies are likely to be installed, little is known of the wind resource in these environments and due to the very rough and heterogeneous landscapes, turbines close to the urban surface will experience site-specific [19]. Consequently, the wind field undergo significant changes in urban areas compared to rural areas due to the channeling effect of the urban buildings. Therefore, most research works used numerical models needed to predict power output of urban micro wind power and assess this particular effect. Hence, some researchers have employed computational fluid dynamic modeling to indicate that turbines installed in urban environments are subject to wind particular effect. These works demonstrates the significance of turbine position and mounting height facing the building, such that small changes in location can have dramatic effects on the power generated. Accordingly, these installations appear to underperform when compared to installations in wind field undergo or rural environments. Another approach is based on an appreciation/quantification of how turbulence affects the productivity of a wind turbine is required so that installers can be informed on the basis of installation location [16]. However, such analysis requires intensive computation resources and validation of results is very difficult to achieve owing to the requirement of the turbulence intensity modelization. Therefore, a genetic algorithms to wind farm performance evaluation and optimization for wind turbine placement has been applied [20,21]. Furthermore, an algorithm simulating the power output from the wind turbine based on wind average speed, the electrical load, and the power curve has been developed [22]. A numerical wind speed data to estimate energy yields as well as analysis of financial payback periods under various scenarios applicable to micro-wind devices and the urban environment has been considered in [22]. Wind distribution functions and power evaluation models for optimization of wind farm configurations by genetic algorithms have been used in [23].

The objective of this paper is to investigate the performance of a micro-wind turbine in a complex urban area and show that due to long time period and very subtile onsite measurements the ideal position for the wind turbine can be determined. The originality of our study is that the model arising from the well mounting turbines in such urban areas may provide the energy output prediction and estimation of payback time on capital investment. In contrast with previous works, this paper focuses on the decision pertaining to installation so that optimal performance can be achieved; hub height with respect to proximity/influence of adjacent buildings/obstructions, with the goal of predicting turbine productivity in the urban environment based on evaluation of roughness coefficient and Weibull distribution. This paper presents a methodology to evaluate the power output of a micro wind turbine for the period 2012 to 2014 based on a long time period and very subtle onsite measurements to determine the ideal position for the wind turbine in an urban environment.

The following section introduces the Microwind turbine as well as wind power parameters and data location. In this section, roughness coefficient is determined proving that the experimental site correspond to a turbine urban siting. The wind power output for the urban siting is presented in the section 3 where the measurement power output performance during three years are detailed. Next, the modeling wind speed and power output methodology for the case study is presented in section 4. In this section, the experimental data have been compared with simulation results to validate a Micro Wind turbine output power prediction model, and proving the reliability micro wind power estimation in a specific urban siting. Finally, section 5 draws appropriate conclusions.

2. Wind power parameters and location

2.1. Wind observation location

Since 2010, University of Lorraine is equipped with a 200 m^2 designed GREEN platform where several renewable energy technologies are implemented for modeling, managing and optimisation of energy consumption. All technologies are monitored, including real weather conditions data are recorded, processed and implemented on Field Programmable Gate Array (FPGA) chips for prediction analysis. For this study, the GREEN platform is equipped with a residential Skystream three blades 2.6 kW horizontal axis wind turbine, which is at 12 m above the ground level. Installing a domestic micro wind turbine in France is usually subject to planning permission and total height must not exceed 12 m. The blades are constructed from two halves of compression molded fiberglass. The curve of the blade helps to more efficiently capture the energy in the wind and to reduce the sound of the blades as they move through the air. The turbine is a downwind design so that the blades of the turbine are downstream from the nacelle, which is quieter and inherently better at finding the wind direction than upwind designs. The GREEN platform scheme and the associated 3 blades Wind power Skystream in an urban area are represented in Fig. 1.

The inverter constantly monitors the turbine and the electrical connection to assure that the electric energy generated by the turbine synchs with the frequency and voltage of the building's electrical system. Table 1 indicates the Skystrean technical specifications. The inverter actually draws about 5–7 W to operate the monitoring system. Because of this, the turbine will not generate electricity when the electrical grid to the building is down.

Wind speed is measured by a 3-cup rotor anemometer at the same height as the wind power. The anemometer is part of a meteorological weather station and wireless computer interface allows direct communication with the anenometer. It displays the current weather station data in a real-time report on the computer. Fig. 2 presents the block diagram of the considered wind turbine system. Thus, a wireless wind monitors allows to save large quantities of data for download (2 Megabytes of internal memory) and use a Zigbee wireless link to computer for data acquisition. Indeed, the wind turbine has a built in 2.4 GHz wireless radio that sends performance data to a desktop computer in the GREEN platform monitoring with a wireless receiver. More precisely, the Wireless Wind Monitor measures wind speed, direction data every minute and stores wind statistics once per minute. Skyview software track the generation of the turbine displaying the data wind turbine in a defined sample time [33]. Thus, from data acquisition we can calculates histogram data.

The GREEN platform is located in building at the University of Lorraine, Metz, France. The investigation site location is given in the Table 2. Fig. 3(a) gives a map specifying isobaric and wind curves, temperature and nebulosity. The climate of localization platform