Chapter 18
Constitutive Modeling of Wind Energy Potential of Selected Sites in Nigeria:
A Pre-Assessment Model

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ABSTRACT

In this chapter, the authors present the result of a study carried out to develop a pre-assessment model that can be used to carry out a preliminary study on the availability of wind energy resources of a site. 21 years' (1987 – 2007) monthly average wind speeds for 18 locations in Nigeria were used to create the simple constitutive model. The locations span across the six geopolitical zones of the nation with three stations from each zone. Various statistical procedures were employed in the development of the model. The outcome gave an empirical model, which if employed, will lead to determining the modest range of wind energy potential of a site. Further, the results from this model were compared with those from the well-established two-parameter Weibull statistical distribution function and found to be reasonably adequate. Thus with this model, decision on site selection for complete assessment can be made without much rigour.

INTRODUCTION

The impact of electricity to a nation cannot be overemphasized. The socio-economic growth of national economies has been proved to depend to a large extent on the balance between demand and supply of electrical energy. Moreover, the level of availability and utilization of energy in a country is reported to be responsible for the increase or decrease in the population of a community, it is also directly linked to the growth of national product (Hermann, 2001). Countries with low

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energy availability and high-energy demand have been found to have correspondingly high proportion of poverty, illiteracy and migration. Also, the principles of the millennium development goals, access to information technology systems and improved telecommunication, literacy programmes and birth control policies will not do well if the current trend of energy shortages experienced by developing nations is not addressed globally (Hermann, 2001).

However, energy production has over the years been dependent to a large extent on fossil fuels in the form of coal, oil and natural gas. An estimate revealed that, 65% of the global sources of energy generation are from fossil fuels (Stiebler, 2008; Ajayi et al., 2010). It is reported. In Nigeria for instance, that major telecommunication systems and masts depend majorly on electricity produced from diesel generators on a daily basis. The emissions from this source have been found to include various gases, which have direct or indirect effects on the ozone layer. This creates a depleting effect of the layer and also in the process interferes with the self-cooling of the natural atmosphere (Ajayi et al., 2010).

Recently, concerns over the environment's quality have become subjects of global discussion, prompting various legislations, debates and declarations. Majority of the arguments have favoured the reduction of anthropogenic emissions that are deleterious to the environment and promotes the utilization of renewable energy resources for power generation (Ajayi et al., 2010). However, utilization of renewable energy resources, such as wind, for power generation in a given location requires the first step of resource assessment. This is in order to have adequate information on the intensity and viability of its prospects at the location (Fadare, 2009; Islam et al., 2009). The development of wind as a source of renewable electricity in developing countries, especially Africa, has been hindered by the absence of adequate measurements and/or assessment studies (Ajayi et al., 2013b). It is worthy of note that, before embarking on wind energy investments, the investors would first want to know the magnitude of likely wind energy output from a site's wind speed. A complete resource assessment therefore ranges from site selection and preparation, installation of wind speed measuring equipment, data gathering, analyses, and modelling to decision making. The analyses and modelling stage is critical to the study as it exposes the site's potential and degree of viability for a wind-to-power project. Various means exist for modelling wind energy potential of a site.

Based on the aforementioned, modelling can be explained to mean a process of creating suitable and qualified approximations which could be used to replace real life systems, repetitive or fluctuating data, or phenomena. However, without appropriate models, foretelling climatic variables, such as wind resources, will be a process that becomes expensive and could be frustrating. Several studies have been conducted and published on using statistical probability density functions to describe wind speed frequency distributions. Some of those that have been used in time past (pre-1970 analyses) range from using standard parametric distributions to distributions that relate to applying the principle of maximum entropy. Some authors have also suggested the use of univariate and bivariate distributions, unimodal, bimodal, bitangential and hybrid distributions (Justus, 1978; Auwera, 1980; Koeppl, 1982; Ozerdem, 2003; Shata & Hanitsh, 2006; Ramirez & Carta, 2006; Akpinar & Akpina, 2007; Tar, 2007; Chang & Tu, 2007; Shamilov et al., 2008; Carta et al., 2009).

In the post-1970 analyses, better statistical models surfaced. The use of the gamma distribution function of two parameters (scale and shape parameters), normal and lognormal, Rayleigh, Weibull and other statistical distributions were proposed (Ozerdem, 2003; Akpinar & Akpina, 2007; Ngala et al., 2007; Carta et al., 2009). According to Carta et al. (2009), the Rayleigh distribution function of one parameter corresponds to the chi-distribution for two degrees of freedom.