ASSESSMENT OF THE SPACE-TIME CHARACTERISTICS OF WIND POWER AVAILABILITY IN KENYA

BY

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ABSTRACT

Energy availability, production, distribution and consumption has a tremendous influence on the socio-economic, industrial development and environmental impact. The availability of clean, uninterrupted and cheap energy has been a major concern in many countries of the world since the early seventies. This concern has been due to the ever-increasing prices of conventional fossil fuels which marked the beginning of the global energy crisis. The other concern has been on the future availability of the exhaustible fossil fuels whose quantity is finite coupled with the accompanied negative effects on the natural environmental. Cheaper and environmentally friendly renewable energy alternatives are therefore more beneficial than the fossil based fuels.

The major objective of this study was to assess the space-time characteristics of the wind power availability in Kenya and to determine the locations best suitable for use in small, medium or large scale power units for either domestic or commercial purposes. The data sets used in the study were from 25 synoptic stations well distributed over Kenya and comprised of wind speed and direction taken at three hourly intervals between January 1976 to December 1987. Similarly, data sets that included actual wind power outputs from a 150 kW and 200 kW wind machines operating in Ngong Town in the outskirts of Nairobi, and from a 200 kW wind machine as well as the fuel consumption rates in Marsabit Town were also used in the study.

To achieve the objectives of the study, various empirical and statistical methods including the Weibull method were used in the estimation of the wind speed, available and extractable wind power densities at the various wind locations over Kenya. Other empirical methods for assessing the suitability of the various wind locations in terms of small, medium and large wind power units using capacity and energy pattern factors were similarly utilized.

The vertical extrapolation of the 10 m mean wind speeds and available power densities to heights of 15, 20, 25, 30, 35 and 40 m were also determined. The method of Bins which is universal for testing the performance characteristics of an operating wind energy machine was applied in order to determine the behaviour of a wind machine after installation. Finally, the cost-benefit analysis for using wind powered machines or generators were similarly examined.

The results of the study indicated that both the wind speeds and the derived wind power outputs had significant temporal and spatial variations with unique 3-hourly, daily, seasonal and inter-annual variations in the wind patterns for the standard seasons of the year, namely Winter, Summer, Autumn and Spring. Significant large inter-annual variations in wind speeds and power densities, particularly with the observed maximum wind speeds/wind power densities, were observed over many locations during years of anomalous weather and climate (e.g. El-Niño and La-Niña years).

In general, Marsabit region, with observed maximum mean wind speeds in excess of 12.0 ms^{-1} and wind power densities above 850 W/m^2, depicted the overall best wind power potential throughout the entire period of study. Regions represented by Eldoret, Garissa, Embakasi, Lamu and Malindi depicted maximum wind speeds of slightly more than 6.0 ms^{-1} with maximum power densities mostly below 200 W/m^2. However, regions represented by Meru, Nakuru and Makindu depicted the lowest magnitudes of the maximum wind speeds (less than 4.5 ms^{-1}) and power densities (below 50 W/m^2). Results from wind speeds/power duration analysis generally indicated that Marsabit had the most favourable wind energy potentials since it had highest duration of wind speeds above 3.5 ms^{-1} with a total duration close to 8600 hours a year.

The results from the seasonal variations of the Weibull scale parameter (c), which may be used to determine the type of wind regime and its causative mechanism, showed variations that were proportional to the mean wind speeds of the area. The results from Capacity and Energy Pattern Factors indicated that Marsabit was a region most suitable for all types of wind machine sizes, i.e. small, medium or large wind machines. The remaining regions, however, indicated power options for small or medium sized wind machines. Higher/Lower values of Capacity/Energy Pattern Factors occurred during El-Niño/La-Niña years with the largest inter-annual variations being evident over areas such as Moyale, Eldoret and Garissa.

Results from the vertical extrapolation of wind speeds and power densities showed that the most convenient height for wind energy utilisation is 25 m above the ground while the results from the performance testing of the two wind powered machines in Ngong Town showed that wind machines of such magnitudes or even larger capacities can successfully be operated in Kenya. The economic aspects of fuel savings made from using the Windmaster generator in Marsabit indicated that substantial amounts of money could be saved from using the wind turbine generator.

This study concluded that many parts of the country have wind energy potentials capable of driving wind machines for small to medium power applications. Large wind power applications were however concentrated around Marsabit region, parts of north-eastern Kenya, the coastal region and some parts of western Kenya. Detailed wind assessment is, however, still required for Marsabit area and other regions with wind energy potentials in order to determine the viability of Wind Farming (a gridded system of wind machines) in any area due to the significant influence of the regional factors such as topography, large inland lakes and many thermally induced meso-scale systems.

The results from this study are considered crucial in the planning, development, harnessing and utilisation of wind energy resources in Kenya. These results can also be used to test the performance of various sizes of wind machines at potential regions. The use of wind power to generate energy is meant to minimize over-dependence on fossil fuels through provision of this abundant and relatively cheaper energy to rural areas. Utilisation of this renewable energy resource will undoubtedly reduce environmental degradation, is cost-effective and hence would boost the socio-economic development more so in the rural areas and also help minimize the national contribution to the global greenhouse gas emissions.