ASSESSMENT OF WIND ENERGY POTENTIAL FOR ELECTRICITY GENERATION IN SETCHET, HANANG, TANZANIA

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ABSTRACT

Tanzania depends heavily on hydropower for her electricity demand and experiences power shortage during the dry seasons. Wind energy is proposed as an alternative source of electricity to fossil fuel generators during the dry season, the latter are normally used to supplement the shortfall in hydro-electricity generation. Fossil fuel generators produce emissions that are toxic and as such degrade the environment. Wind speed data from a site called Setchet is used to illustrate that the available wind energy can be harvested to generate electricity that can supplement the shortfall of electricity. The windy season, which is from July to November, coincides with the dry season. The annual average wind speed is 8.3 m/s, a value that is sufficient to generate electricity. Wind energy that can be harvested from this annual average wind speed is $2.30X10^3$ *kwh per year. It is suggested that by generating electricity from wind, the already limited hydrological resources in the country could be used for irrigation schemes instead of channeling them for developing new hydropower plants.*

INTRODUCTION

Hydropower plants are the main source of electricity in Tanzania. During severe droughts and prolonged dry seasons, hydrological sources are depleted and as such Tanzania faces electric power shortage. In such seasons therefore, rationing of electricity has been necessary. While 90 % of the electricity generated in Tanzania is from hydropower, 10 % is from fossil fuels (Kainkwa 1999). The fossil fuel generators are often used to supplement the shortfall of electricity that arises during the dry seasons. In the process of generating electricity, the fossil fuels are burnt thus producing a lot of harmful emissions to the environment. Such emissions include airborne particulate, carbon monoxide, hydrocarbons, hydrochloric acid, solid ash and waste, ionization radiation and trace elements. Burning of fossil fuel for energy production has been estimated to contribute about 80 % of the total gases responsible for the green house effect of the atmosphere. Renewable energy sources such as wind, if thoroughly investigated, could be used to reduce the dependence on fossil fuels for electricity generation.

Although wind energy is one of the most efficient renewable energy sources, it is very variable compared to other sources of energy. It is also more sensitive to variations with topography and weather patterns compared to solar energy. Wind energy can be harvested at an economical level if the wind turbine is sited in a windy area and a careful choice of the type of wind turbine that matches the wind pattern of the site is made. Thorough knowledge on the wind speed characteristics at a site of interest is very important in planning to harvest the wind energy.

A study on wind speed pattern and the available wind power in Tanzania was conducted by Kainkwa and Uiso (1989). The research revealed that a large part of the country has high wind potential. Some sites that had steady and strong winds were identified. It was suggested that further detailed studies should be conducted to investigate the actual wind power at those specific sites. The Setchet site was chosen for the present study because preliminary studies indicated that wind speed there is relatively high and constant compared to the other sites.

The site

In an attempt to search for a suitable site where wind energy is significantly high and worth harnessing, a prospective site called Setchet was identified at the Hanang Wheat Complex. Setchet Wheat Company Limited (04° 22' S, 35° 14' E, 1740 m altitude) is one of the seven farms of the Hanang Wheat Complexes is in Hanang district, Arusha region. Interviews with residents of Hanang Wheat Complex revealed that Setchet was the windiest location in the complex (Kainkwa 1992). For a period of thirteen months (June 1987 to June 1988) primary data were collected from this site.

Analysis of wind speed data

A mechanical wind recorder (Woelfle type), mounted at 2.0 m above ground level (a.g.l.), was used to collect the data at 2 m a.g.l. (V2). The data were then extrapolated to a height of 20 m a.g.l. (V20) using the extrapolation model

$$V(20) = \frac{V(2)}{0.77} \quad \text{(1)}$$

derived by Kisamo and Stitger (1972) where 0.77 is a correction factor for Tanzanian conditions. The data were from June 1987 to June 1988 and were based on hourly observations. Mean monthly wind speeds were determined from the daily values and plotted (Figure 1) to investigate the monthly variation of wind speed. Series1 and Series2 in Fig. 1 display the monthly average and the mean annual wind speed, respectively.

Evaluation of electric power and energy from wind speed

The power, P, (in Wm^{-2}), that is available from the given wind speed, V, can be computed from the relation:

$$P=0.5\rho V^3 \quad \text{(2)}$$

where ρ is the average air density, which for this site has been found to be 1.027 kg/m^3 (Kasasi 1998). The available wind energy, E, (Whm^{-2}) in a specified period (say a year) is found by taking the product of the power and the number of hours in a year. This energy can be converted to standard units of electricity namely the kWh by multiplying the available energy E by a factor of 0.001.

RESULTS AND DISCUSSION

Wind Speed Patterns

The mean annual wind speed during this measuring session was 8.3 m/s (Fig. 1). Mean monthly wind speed at Setchet was above the annual average from about mid July to mid November. From August to October the wind speed was above 10 m/s and also fairly steady. From June to December, the wind speed was above 7 m/s. This windy season coincides with the period when most parts of Tanzania are usually dry (Kainkwa 1999, Kasasi 1998), and use of wind energy, in electricity generation, would help to alleviate the shortage of hydroelectricity that normally prevails during the dry season.

January to May was a calm period because wind speed was below the annual average. This calm season coincided with the wet season in most parts of the country when there usually is sufficient water in the rivers to run the hydroelectric plants.

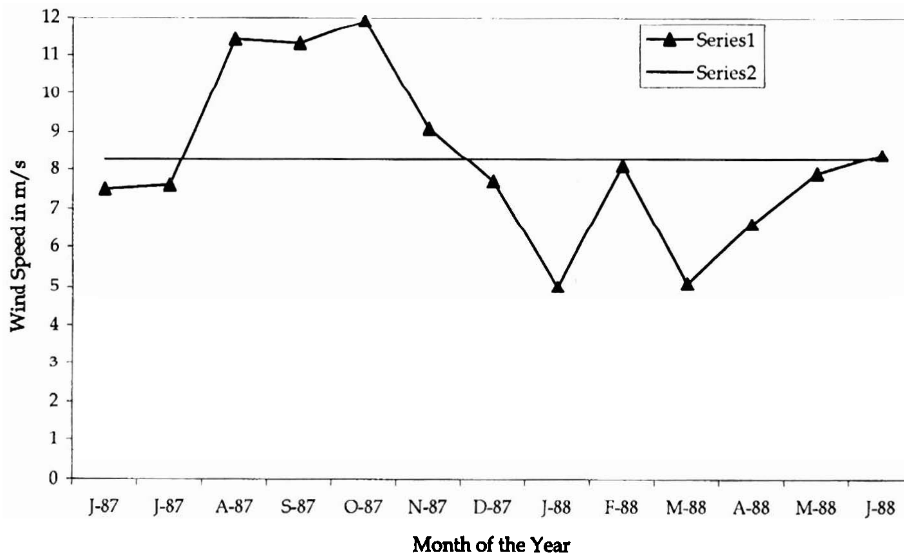

Fig. 1: Wind speed (m/s) at height of 20 m (a.g.l) plotted against month (From June 1987 to June 1988) for Setchet. Hanang district, Tanzania

Except for January and March 1988, wind speed was greater than 6.0 m/s. The minimum value of monthly wind speed was slightly above 5 m/s as recorded in January and March 1988. If this minimum value is extrapolated to a height of 40 m, it would definitely be greater. Therefore if a wind turbine whose hub height is 40 m is installed at this site, it would produce electricity even during this calm period. A wind turbine with a cut-in wind speed of at most 5 m/s would thus generate electricity throughout the year.

Electric power and energy

The annual average wind power as calculated from Eq. 2 and using the monthly wind speed of 8.3 m/s is 293.61 W/m^2. Annual electric energy that could be produced from this wind power is 25723.05 kWh. The wind power available during the windy season, which was from August to October, would, on the average, be 513.50 W/m^2, while the corresponding energy during this period is 1108.08 kWh. The periods from June to December and

April to December had average power of 176.13 and 110.92 W/m^2, while the corresponding energies were respectively, 887.70 and 559.02 kWh. The calmest months, which are January and March, had monthly average power of 64.19 W/m^2 during which the energy available would be 92.43 kWh.

The amount of electricity that can be harvested from the wind energy is reasonably high. Therefore, if proper wind turbines that can harvest wind energy at an optimum level are installed at this site, the electricity produced can be connected to the national grid line to supplement the shortfall that arises during the dry season.

CONCLUSIONS AND RECOMMENDATIONS

Setchet has been found to be a promising site for wind harvesting because wind speed is fairly strong. January to May was a calm period, but the winds were still strong enough to generate electricity when the cut-in wind speed of a wind turbine is at most 5 m/s and the hub height is assumed to be at least 40 m.

Most intense winds occurred from August to October, with the latter month being the windiest. It is suggested that, possibilities of using renewable energy sources like wind should be investigated because such energy production systems are environmentally friendly.

By generating electricity from wind, the already scarce hydrological resources in Tanzania could be used for irrigation schemes. During extended droughts and dry seasons, it has been forbidden to irrigate farms that are situated upstream the hydroelectric dams, so that the little water available in the rivers is used for hydroelectric generation. The question is whether crop production is less important than production of electricity.

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