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EVALUATION OF RENEWABLE ENERGY AS AN ALTERNATIVE SOURCE FOR RURAL ELECTRIFICATION IN TANZANIA

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ABSTRACT
This paper presents an evaluation of renewable energy as an alternative source for rural electrification in Tanzania. Biomass is the basic form of energy for the majority of the population. It is being used by over 90 percent of the rural population. Cogeneration based on wood waste and bagasse could generate electricity sufficient to electrify the rural areas around the industries. Wind and Geothermal are future potentials for future use in electrification. Solar energy is promising as an alternative. Initial cost and technical know-how is the obstacle in its implementation. International technical facilitation is needed to be a player in future rural electrification.

KEY WORDS

Tanzania, biomass energy, renewable energy, alternative energy, sustainable energy

1. Introduction

1.1 Motivation

About 80 percent of Tanzanian population lives in rural areas. Accessibility of the population to electricity is about 1% and majority of the population use wood fuel for cooking and kerosene for lighting. Biomass is therefore, the main source of energy. Its evaluation and potential can give way for use as an alternative source for rural electrification in the country. The paper strives to explore its potentiality of biomass and other renewable energy for rural electrification in Tanzania.

1.2 Country Profiles

Tanzania is located in Easter n Africa between Longitude 290 and 410 East, Latitude 10 and 120 South. The country's population is estimated at 37.445 million [1] spread over an area of 945,083 [2] square kilometres. Tanzania is the biggest (land area) among the East African countries, with a variety of land scape features, mountains and lakes.

The population is concentrated in the periphery, leaving the central part of the country relatively sparse populated. Majority of the population about 80% lives in the rural area [3] and depends on agriculture activities. The country is agricultural dependant. Agriculture provides about 50 percent of the GDP and above 80 percent of its export earnings [4].

Provision of electricity as a source of energy for cooking and lighting in the rural area is low. Only 1% of the rural population is accessible to electricity. About 12 % of the entire population is accessible to electricity, majority from urban areas. It is evident that, 94% of total energy consumption in rural Tanzania is heavily depends on wood fuel for cooking and kerosene for lighting.

1.3 Energy Profile

The country has a considerable and diverse energy sources including hydropower estimated at 4,700MW [5]. Wood fuel estimated at 50-55 million cubic meters per annum [6]. Coal more than 1,200 million tones of which 304 million tones are proven [7]. Natural gas about 45 billion cubic meters is proven. Value for natural gas estimation is expected to increase as more explorations are being conducted and its results are promising.

Use of coal as an energy source is low and limited compared to existing reserves. Few industries are using it. But it has promising use in cement industry and in small industries and factories.

Solar, wind, and geothermal have a good potential as well. These sources have not been tapped. Their future use is bright. They could be used for rural electrification.

1.4 Objective of the paper

The objective of the paper is to make evaluations of renewable energy resources, its potentials and explore its impact on rural electrification in the country.

1.5 Contribution

Since there is abundant biomass, wind, solar and geothermal energy which are not fully tapped, the evaluation will give a true picture of exploitation of this abundance of renewable energy for future use.

1.6 Organization of the paper

The paper is organized as follows. In section II energy consumption pattern is discussed and provided. Section III gives evaluation and potential of renewable energy in the country. In section IV, discussion on the obtained result is made. Finally, section V draws conclusion of the paper.

2. Energy Consumption Pattern

Energy is an essential factor in human development and movement. It stimulates and support growth and development. Thus, human civilization and development owes much to the use of energy.

Tanzania has an estimated annual per capital consumption of 0.7 tonnes of oil equivalent. About 90 % of which comes from biomass, mainly for cooking in the household sector, 8% from petroleum and gas; 1.5% from electricity; coal and other renewable energy (non-hydro and nonwood) less than 0.5%

Energy type use for rural areas is depicted in table 1.

Table 1
Main energy types by households (rural)

Energy Type	Total amount Consumed (TJ)	Share to the Total Consumption (%)
Biomass	363,840	97.70
Petroleum	7,446	2.00
Electricity	1,135	0.30
Coal	0	0.00
NRSE	0	0.00
TOTAL	**372,421**	**100.00**

Source MNRT 2001

There is a big gap in the country's demand, and requirement of energy for domestic, urban, and industrial application. Consumptive energy use and energy used for social activities in the country is dominated by wood fuels. The trend will continue as it is in the near future.

The only option of reversing the trend is improvement use of the renewable energy. Renewable energy can meet some of demands, especially in the rural areas. It could accelerate electrification if effectively applied.

Renewable energy should be encouraged in use, promoted, invested, and implemented. But, before this, its potential for use and convention has to be assessed and established.

3. Evaluation and potential of renewable energy in Tanzania

Renewable energy is that energy obtained from sources that are essentially inexhaustible. These include: wood, wood waste, agricultural waste, solar, wind, and geothermal.

In the country, renewable falls also under non-wood biomass fuels. These are common and are used or could be used for energy production. Non-wood include: farm residue like maize cobs, coconut shells, and agroprocessing wastes like, coffee, cashewnut, rice husks and bagasse from sugar factories.

3.1 Evaluation of Biomass

Biomass is a blanket term that refers to organic matter and includes plants,trees,residue from crops, organic waste from municipalities and towns, and waste from forestry operations, including sawdust, timber slash and mill waste.

Estimated average annual production levels of non-wood biomass fuels from agro-processing industries are:

Coffee husks: Present production of coffee is 45,000 tones. It is expected to increase to 65,000 tones in 2010. About 20% of the gross weight is coffee husks which are not utilized so far.

Rice husks: Rice husks are estimated to be 355.41 tones at present. Annual production in the country is estimated at 800,000 tones. Husk production from each tone is estimated at 0.33 tones. With emphasize on agriculture revolution production of rice is expected to triple in near future. More husks will be produced and can be used for energy generation purposes.

Cashew nut husks: They are available. It is estimated that the production in 2005 [8] stand at 90,385 tones. But their production levels of husks are not yet assessed.

Coconut shells: They are available in coast areas. Their production levels are not yet compiled. They are good source of energy if utilized fully.

Sisal residue and waste: Are estimated at 27,794 tones (2005) of sisal but will increase due to high demand and raising market prices. One tone of sisal generates 25 tones of residue, which are currently not used for energy generation.

Bagasse from sugar industries: Present production capacity is 263,317-300,000 tons of sugar (2005). Assuming that it will go up to 500,000 tones within a decade, and fully covered by domestic production, the bagasse residue would be in the range of 2.0-2.5 million tones.

Maize cobs: Maize production in 2005 [8] stands at 3,131 tones. Production levels of cobs are not yet assessed. Cobs can be used in energy generation in rural areas. Wood fuel: About 50% of the total land area of Tanzania is forested and wood fuel is obtained from forest and woodland.

The consumption of wood fuel and other wood product is estimated to be in the range of 1.0-1.3 cubic meters per capita and year. The current need stands at 50-55 million cubic meters.

The requirement in 2020, with 3 percent annual population growth and unchanged consumption pattern would be 78-85 million cubic meters. The volume of residues slabs and saw dust will increase. Saw dust could be source of energy.

Sawdust: Volumes of slabs and sawdust are produced every year (5-10%) of the Sawmill's total input. The volume could reach 600,000-700,000 cubic meters per annum. These large volumes have been accumulated at the different sites in the country. The accumulated volumes could be source of energy production.

Tannin residue: Currently, the factory uses 40,000-50,000 tones of wattle to generate electricity. (1 KWh=2.4Kg of wood). With a demand of export of tannin at 5,000 tons, this is equivalent of harvesting 70,000 tons of wattle wood. The factory will generate more electricity in future.

3.2 Evaluation of other sources

Biomass is not the only alternative source of energy for electrifying the rural areas. Other sources in the form of:

Min/Micro hydropower: Are small scale hydropower. Their potential is estimated at 180GWh per annum or 27.9 MW.

Geothermal energy: It is a renewable energy, onpolluting, reliable and sustainable. Its potential is estimated to be in the range of 500-1,000MW

Wind energy resources: Accuracy and degree of detail of most of the existing data is not sufficient to identify potential of wind energy resources. However, its potential is estimated to be 10-20MW. The estimate could reach 200MW if more studies are conducted.

Solar energy: Considerable good for rural electrification. Solar energy potential in the country is for those areas with minimum monthly average insolation of 4.5-5.3 KWh/d.

Other globally known renewable energy resources like tidal, wave and ocean are yet to be studied locally. More studies are required to establish their potentials.

4. Discussion

Coffee, Rice, Cashewnut husks, Maize cobs, and Coconut shells are source of energy that is not used. They are left unutilized. With proper technology for convention, they could produce sufficient energy for the rural.

Introducing highly efficient boilers and turbines in the sugar industries, and using supplementary fuel during off season of production, the supply of electricity from bagasse could be up to 300-500GWh/a. This amount of energy could be used for rural electrification of the areas near to the industry.

Sawdust from wood processing could be other source of energy. Its potential is estimated at 75-100MW on yearly basis. In addition, Briquettes could be made out of sawdust. The product could be used in place of firewood.

Wattle tree residue is a potential source for electricity generation. Its potential is estimated at 15MW. It will play a role in rural electrification for areas around the factory.

Biogas produced from sisal residue and waste is a source of electricity generation. Biomass gasifies in the range of 100-500KW could become rural energy source for electrification where sisal estates exist. In long term projection, it has been established that, electricity generation from sisal residue and waste could reach 46MW in ten years time.

Tanzania, with its large population of cattle, estimated at over 20 million, the country has considerable potential for biogas as a renewable source of energy. Biogas technology has to be used and could play a significant role in decentralized energy supply in areas where cattle keeping is common.

Geothermal and wind energies require more exploration and studies to establish their exact potentials. However, they are promising source of alternative energy for rural electrification.

Dissemination of PV system in the country is still quite low. Its initial cost is high. Malfunctioning and early breakdown of the system discourages customers. Lack of after sales services also contribute to discouragements. In addition, rural households are not in position to service or maintain the PV systems. Proper training of technicians is a solution to solve the relating problems emanating from using PV systems.

Summary of potentials of renewable resources is provided in table 2.

Table 2
Available potential for different renewable energy resources in Tanzania

S/No	Renewable energy resources	Potential in [MW]	Observation
1	Min/Micro Hydropower	27.90	
2	Geothermal	1,000	
3	Wind	200	
4	Solar		More study needed
5	Saw dust from wood processing	100	
6	Biogas from sisal residue	46	Expected to increase in near future
7	Biogas from cattle dung		More study needed
8	Wattle residue	15	
9	Bagasse	57	Expected to increase in near future
10	Crop residue (Various)	212	Expected to increase in near future
11	Forest residue	523	
	TOTAL	2,181	

The above potential meet Tanzania raising future needs particularly for rural electrification. In addition, the cost of production of energy from these renewable is low,

when compared to fossil fuels. It is estimated at U$ 0.948/GJ.

Renewable energy is cheap in utilization as compared to fossil fuels. Prices for fossil fuels continue to fluctuate, and highly depends on world oil markets. This makes it expensive and not affordable to the majority poor in the rural areas. Ultimately, renewable energy is environmentally friendly as compared to fossil fuels. It is clean and safe.

5. Conclusion

Energy like other infrastructure is essential to human and societal development. It is clear that no modern society has developed without modern, clean and affordable energy services. Affordable and efficient energy enables the communities to light their homes and schools, refrigerate their supplies including medicines, power their telephones and support productive businesses.

The level of Tanzanians' access to modern energy services is very low and this is a challenge that planning and resource allocation process should address so as to ensure availability of reliable, affordable and environmentally and socially acceptable energy services. Biomass is the basic form of energy to majority of Tanzanian. Over 90 percent of total energy consumption is in form of firewood and concentrated in rural areas.

Developing and promoting environmentally sound energy resources and technologies including renewable energy and related technologies could accelerate rural electrification and increase accessibility of rural population to modern energy.

Biomass could be used for co-generation based on wood waste and bagasse for generation of electricity. Fuel energy production such as heat, steam and biogas could be produced based on biomass from forestry and agricultural waste. Solar, wind, and Geothermal are also available as sources of alternative energy. These alternative sources of energy can be harnessed and used for rural electrification However, International technical assistance is necessary for improving technical know-how and managerial skills in running them particularly the PV systems.

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Appendix

Calorific value conversion factors for wood fuel (firewood) at final user level

1 Kg of firewood	=13.8 MJ
1 Kg of Charcoal	= 30.8 MJ
1M3 of solid wood	= 0.725 Tonnes
1M3 of wood	= 10,000GJ
1 Kwh	= 3.6 MJ

1 Tonne of fibre of sisal produces 25 tonnes of residue
1 Tonne of sugar produces 5 tonnes of bagasse
Energy content of wood fuel (air dry, 20% moisture) =15GJ/t
Energy content of agricultural residue (range due to moisture content) = 10-17GJ/t
Energy cost: 1 GJ costs U$ 0.948