

**Review Article**

The Role of Renewable Energy in the Supply of Energy for Rural Development in Tanzania

Halidini Sarakikya^{1,*}, Peter Mashingo¹, Iddi Ibrahim¹, Jeremiah Kiplagat²¹Departments of Electrical and Mechanical Engineering, Arusha Technical College, Arusha, Tanzania²Department of Energy Engineering, Kenyatta University, Nairobi, Kenya**Email address:**

sarakikyablon@yahoo.com (H. Sarakikya), mashingopp@hotmail.com (P. Mashingo), ibrahiddi@gmail.com (I. Ibrahim), jeremykiplagat@gmail.com (J. Kiplagat)

To cite this article:Halidini Sarakikya, Peter Mashingo, Iddi Ibrahim, Jeremiah Kiplagat. The Role of Renewable Energy in the Supply of Energy for Rural Development in Tanzania. *International Journal of Sustainable and Green Energy*. Vol. 5, No. 2, 2016, pp. 13-18.doi: 10.11648/j.ijse.20160502.11

Abstract: Renewable energy supply has been very important and necessary in Tanzania due to recent high demand of energy supply, the high cost of supply of fossil fuels, and the increase of environmental impacts caused by frequently use of fossil fuel. At present Tanzania depends on hydro and thermal power supplies as the main sources of energy. On the other hand, many hydropower plants (sources) are mainly erected or placed in the existing natural flow of water in a given specific area, and therefore ensure the economical and viability of using the hydropower in that particular area. Practically, the high cost of transmission from hydro power sources prevent and hinder the grid connected electricity to the widespread populated area in Tanzania. The biomass use account for 89% of the energy consumption and it is estimated that, 90% of the population in the country relies on traditional biomass such as wood fuel and charcoal for cooking, because their majority are rural, poor and cannot afford the cost of modern energy sources such as electricity. The data shows that by 2015, about 24% of the total population in the country was connected to electricity, of which 11% is from rural areas. Only 12% of the hydro potential which is about 561MW has been delivered. The hydroelectric potential in the country is reported to be in excess of 4700MW of the installed capacity. Mini hydros have shown the potential of 187MW but only 4.7MW has been exploited. Tanzania has solar radiation of about 200Wp/m², and the estimated potential of solar PV is around 20.2 MW. There are several sites with wind speed ranging from 5-7m/s mostly in central parts of the country. Co – generation and geothermal resources are estimated at 395MW and 5000MW respectively. However, still the utilization of these potential renewable energy resources remains very small especially in rural areas of the Country. Renewable energy resources, excluding large hydro has very little contribution in the generating capacity. This paper focuses on how renewable energy application based on local or decentralized grid on commercial bases will overcome energy deficiencies in rural areas of the country. The Government campaign on exploitation and use of renewable energy in rural areas will reduce rural poverty.

Keywords: Tanzania, Renewable Energy, Poverty, Rural

1. Introduction

Tanzania is endowed with diverse forms of renewable energy resources, including biomass, hydropower, geothermal, solar and wind. Much of these potential has not been fully exploited. Without doubt, if properly utilized, such renewable resources would contribute significantly to Tanzania energy supply, thus moving the country closer to achieving middle income status, as envisioned in the Tanzania National Development Vision 2015 [1].

After recognizing the potential contribution of renewable

energy to the energy mix of the country, Tanzania is now striving to promote the development of low carbon energy initiatives all the way through harnessing its renewable energy resource base. Renewable energy which is environmentally caring will improve access to sustainable modern and cleaner energy services with the potential for contributing to job creation, generation of income and improved live hoods of marginalized social groups, particularly women and children in rural areas [1, 2].

NEEDS & George [3, 4] depict sustainable development of any Nation schematically using three circles for targets

dimensions of environment, economy and society. They conclude that, the equal treatment of these three dimensions have controversy, which brings the perception and claims that human society has to develop within the environment and that economy has to satisfy societal needs. This concept has led the

Government, Non Governmental Organization (NGOs) and energy stakeholders to have the campaigns which fall into three policy tools to promote the uptake of renewable energy resources as summarized in Figure 1.

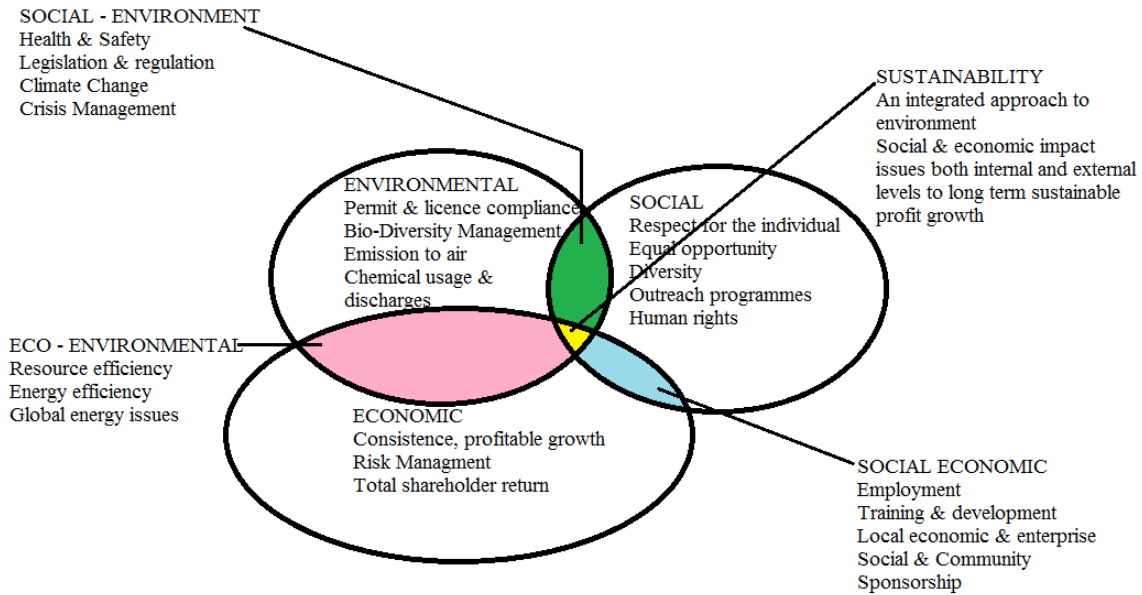


Figure 1. Three Energy Policy Tools [3, 4, 25].

Jayant et al [14] insists that, pursuing a renewable energy deployment strategy in the context of sustainable development implies that, all environmental, social and economic effects are taken explicitly into consideration. Integrated planning, policy and implementation processes can support this by anticipating and overcoming potential barriers to and exploiting opportunities of renewable energy deployment. For this reason, energy can be linked directly to the sustainable development of human being. Figure 2, depicts concerns of the linkage between energy on one hand and poverty, women, population, urbanization and lifestyle on the other. This means, energy access is the engine towards development of any society [15].

protecting the environment from various pollutions [5]. It also aims to establish energy production, procurement, transmission, distribution and end-user systems in an efficient, environmentally sound, sustainable and gender-sensitized manner.

The first National Energy Policy (NEP) for the Country was formulated in 1992. This energy policy of 1992 was replaced in 2003 due to some changes and challenges faced by energy sector in Tanzania. On the other hand, the main agenda of the Tanzania Energy Policy was to reduce and eliminate the energy demand gap facing the rural population of Tanzania, and to increase the energy supply in rural areas of the country. It aimed so because the vastness of the Country, coupled with low population densities in most regions, makes grid extension an enormously challenging and expensive way to electrify rural areas.

Today it is estimated that, 90% of the population in Tanzania relies on traditional biomass such as charcoal and wood fuel for cooking, because majority of these people are rural, poor and cannot afford the cost of modern energy sources such as electricity. Even for those rural minorities who could afford, it is not possible because electricity is not readily available, as connection to distant grids is too expensive to be cost effective for many rural areas and there is no priority to electrify those poor people living in rural areas [6]. Access to modern energy services and rural development are inextricably linked, that is why UNCTAD [12] define access to modern energy as a household ability to obtain an energy service, should it decide to do so. For energy to be considered to be available to a house hold, the household must be within

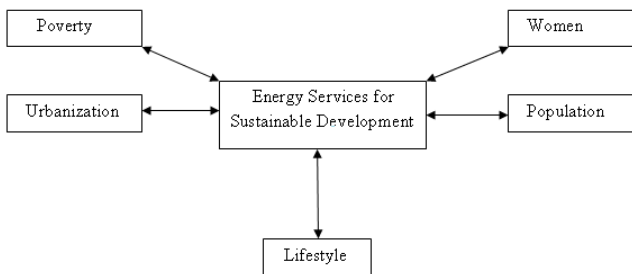


Figure 2. Energy and Social Issues [15].

One of the key objectives of the 2003 National Energy Policy (NEP) of Tanzania is to ensure the inclusion of environmental consideration in energy planning and implementation, facilitation of provision of clean, sustainable, reliable, provision of supplying energy at low costs while

the economic connection and supply range of energy network or supplier. Affordability means the ability of the household to pay the upfront connection cost (first cost) and energy usage costs. A high- upfront cost may discourage poor household from making a switch to a modern energy form.

The biomass use accounts for over 89% of energy consumption in Tanzania. Petroleum and electricity accounts for about 9.2% and 1.8% respectively, 0.1% contribution from coal and 0.3% other energies. From Figure 3, it is evidently that the biomass supply as the main source of energy in Tanzania is the most dependent in residential areas.

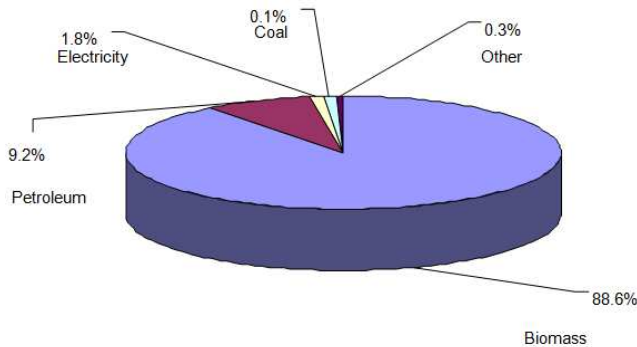


Figure 3. Energy Supply sources in Tanzania [1, 2].

A recent household budget survey done in Tanzania shows that 28.2% of Tanzanians are poor, whereby poverty still exists in rural than in urban areas [7]. According to World Bank, the total population of Tanzania in 2014 was 49,639,138 whereby out of this amount, 69.1% which is about 35,808,913 people are living in rural areas [24]. Only 24% of this total population and only 11% out of 35,808,913 people living in rural areas have access to electricity. The average demand is increasing at the rate of 10-15% per annum [8, 16].

2. Generation Input Mix

Tanzania is blessed with diverse forms of energy resources such as natural gas, hydro, coal, biomass, geothermal, solar wind and uranium which have not been optimally utilized. Up to the end of 2015, the total installed capacity in Tanzania was 1733 MW composed of hydro 565.8MW (32.6%), Natural gas plants 651MW (37.5%) and Oil plants of 495MW (28.5%), small renewable energy and imports contributes about 1.3% as shown in Figure 4 [1, 2].

There are huge potential and renewable energy sources such as hydro, solar, wind, biomass and Geothermal in the country which has ability to ensure energy reliability, generation of income for rural people, security, and which can ensure prevention of pollutions to environment.

The Tanzania hydropower potential is located in about five geographical areas with major drainage basins which are Lake Victoria basin, Rufiji basin, Pangani basin, Lake Tanganyika basin and Ruvuma basin. The country has extensive undeveloped hydro electric resources mainly located in the Southern regions. Only 12% of the hydro potential which is 561MW has been delivered. The hydroelectric potential in the

country is reported to be in excess of 4700MW of the installed capacity. This amount is about 3,200MW of firm capacity [18]. Studies have identified about 85 mini- hydro power sites with a total potential of 187MW. Many of these sites are situated in rural areas and are suitable for standalone systems for supplying power to small communities away from the grid but only 4.7MW of this mini- hydro potential has been exploited [19].

The country has solar radiation of about 200Wp/m², and the market potential of solar PV countrywide is estimated to be 20.2MW. Solar resources are good in the central portions of the country and this makes it naturally a suitable country for the application of solar energy but still the percentage contribution of solar to the total energy mix is still small [22]. There are several sites with wind speed ranging from 5-7m/s. Preliminary wind resource assessment has shown that wind systems in certain parts of the country has commercial electricity generation. Wind farms for commercial plants have been identified at Makambako, Kititimo at Singida, areas along Rift Valleys, the Southern highlands and along Lake Victoria [16, 21].

According to Tanzania Domestic Biogas Programme (TDBP), the technical potential for domestic biogas in Tanzania is around 165,000 households [20]. Co-generation potential from bagasse, wood waste and sisal waste is estimated at 395MW [21].

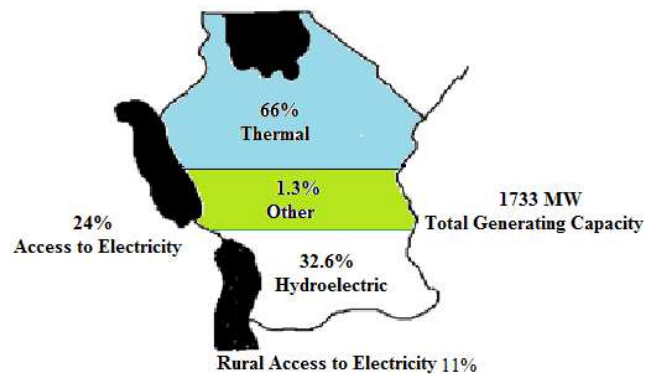


Figure 4. Current generation input mix of Tanzania [1, 2].

Geothermal is another potential source of power in the country. Currently, there are about 50 geothermal potential sites in Tanzania, with an estimated geothermal potential of more than 5000MW. Two Zones in the country have been identified for enough geothermal potential. These are Northeastern Zone (Kilimanjaro, Arusha, and Mara regions) and the South-western Zone (Rukwa and Mbeya regions) [16, 23]. Today, renewable energy (excluding large hydro) has very little contribution in the generating capacity because the utilization of these potential renewable energy resources remains very small especially in rural areas of the Country [17].

George et al [3] point out that, the wealth of many household in rural areas are often characterized by unmet or inability of using basic human needs. Factors such as lighting with kerosene and cooking with firewood are mostly used to characterize poor households. The cost of grid electrification in rural areas cannot be justified since the demand is very low

and connection to distant grids is too expensive [9].

Most of people in Villages use electricity during night especially in activities such as eating, studying, television watching and listening to radio. Moreover, many houses are locally built and scattered and therefore, these services can be met by the application or by using renewable energy resources, and that is why the renewable energy sector reform has been accelerated by the Government through Rural electrification Projects [2].

However, many more renewable energy reforms are needed so that many people in rural areas of country will have energy access in the form of commercial. The revision of the National Energy Policy (NEP) in 2003 among other thing, aimed at promoting affordable energy supplies to support national development goals. The supply of energy to the rural poor should be made in such a way that, there will be a financial acceptable form so that many rural poor will afford. The application of renewable energy technologies have the potential to alleviate poverty that face rural population of Tanzania and will stimulate the economic activities within these areas [2, 5].

3. Rural Energy Programmes

The need of energy is important for rural society in order to overcome and fulfill the basic human needs and for sustainable rural development. Energy is required in various sectors such as agricultural activities, food beverage and processing, telecommunications, constructions and in education [10]. Karekezi [10], continues to emphasis more on the impacts caused by the lack of energy or energy poverty in the society that are hunger, health problems, delivery of poor education to children, and many other factors. Many energy partners and stakeholders have concluded three very important issues to be addressed and practiced:

1. Rural Energy development should be given a higher priority by policy makers in the country. This is because energy poverty is among the factors which characterize the rural resident. George et al [3] define energy poverty as the absence of sufficient choice in accessing adequate, affordable, reliable, high quality, safe and environmentally caring, and all energy services to support economic and human development. Many rural residents often rely on purchasing energy carrier equipments, especially those which use kerosene and charcoal and sometimes rely on purchasing candles for their lighting. Minorities of these rural residents have batteries for their torches and radios and sometimes they tolerate to have rechargeable batteries for entertainment such as television systems, cinemas and video watching.
2. Rural development must be compacted to make rural society to have own ability of planning and implementation. When compacted or consolidated into groups, rural residents who live in more remote areas are characterized by small, scattered settlements access energy carriers. This always reduces cost of distribution systems and superimposes capital of the grid itself.

3. Other development activities aiming for rural development such as agriculture, education, infrastructure, social, health, environmental and sometimes political issues should be integrated with rural energy development. This will tie together provision of rural energy develop ent with many other essential services.

Rural Energy Agency-REA is an autonomous body under the Ministry of Energy and Minerals of the United Republic of Tanzania. Its main role is to promote and facilitate improved access to modern energy services in rural areas of mainland Tanzania. REA facilitates rural energy development by working in partnership and collaboration with private sector, Non Governmental Organizations, Community Based Organizations, and Government agencies [11].

However, REA has been able to execute its functions with high capacity, but some challenges still exist. Firstly, rural poor should be consulted and involved in defining and establishing REA's objectives and priorities so as to really outline their actual energy needs instead of other people from outside. Secondly, planning should use top down approach to allow from energy experts and those relevant authorities. Thirdly, values and attitudes embodied in REA's resultant interventions should not be imposed on the rural poor. This will allow for the improvement of the REA development programmes to meet the needs of the rural poor and at the same time to recognize specific national development goals [3, 11].

4. The Significance of Renewable Energy Sources

1. *Multipurpose or Flexible resources*: These are resources where renewable energy technologies can be applied to obtain various forms of a fuel from a resource. Example is when a thermal chemical conversion is used to convert a biomass into char, methane, hydrogen carbon monoxide, carbon dioxide, methanol, electricity or heat.
2. *Wealth resources*: The consumption of non renewable fossil resources such as crude oil, natural gas and coal leads to a steady depletion of these energy carriers. Wealth resources are those resources which will not run out because are from natural environment, and are not finite like fossil fuel resources. Conversely, there must be a suitable selection of a renewable energy technology which goes with a particular local environment energy resource available at a particular place.
3. *Carbon neutral resources*: Renewable energy is clean source of energy which does not have or have very small environmental pollution compared to those of conversional source of energy. UNCTAD [12] concludes that, if both the cost of obtaining the fuels and the cost of protection against the environmental pollutions are considered, then the renewable energy is cheap for the society. Cleaner use of traditional fuels can significantly improve health by reducing acute respiratory infection and conjunctivitis, commonly caused by indoor

pollution. Cooking with more efficient technologies can make dietary choice, and boiling of water will be more affordable.

The use of electricity from renewable energy resources can significantly reduce the time required to devote to household activities. It can make possible refrigeration of vaccines and operational of medical equipment in rural health clinics. It also provides higher quality illumination than kerosene latent and provides better security, comfort and safety.

4. *Job opportunities and net income:* Jayant et al [14], insists that renewable energy already account for about 2.3 million jobs worldwide and in many countries job creation is seen as one of the main benefit of investing in renewable energy resources. The manufacture of renewable energy systems and their maintenance requires manpower and therefore create employments which enhance local economy in the form of the income.
5. *Stability:* Energy security of any country will depend on how much the foreign oil supply is reduced when the use of Renewable energy is increased. Nevertheless, renewable energy has few disadvantages in its applications. A really example is for a solar power system which has less efficiency during cloudy whether condition as well as wind power during calm days. A better practical solution in this situation is to integrate these systems of solar and wind to complement each other during either the calm or cloudy days.

5. Opportunities and Commercializing of Renewable Energy

The supply of renewable energy in countries along Sub Sahara Africa (SSA) has been very important due to high demand for energy in the diversification of energy supplies, and by the increase of danger of environmental pollution caused by fossil fuels as well as the depletion of their reserves. REA is supposed to have a very attracting policy and strategies to facilitate and make optimal commercial exploitation and utilization of renewable energy, in the case of limited resources and potential of renewable energy in order to meet the energy needs of the rural population in the country.

In order to ensure fast and efficient development of Renewable energy in rural areas of Tanzania, the country must have strategies which will be hand to hand from both the Government and constituent levels. Renewable energy will and has already created jobs and business opportunity to individuals. People have invested in design, manufacture and even assembly of facilities such as solar panels, solar water heating systems, wind turbines, small and micro hydro systems, briquettes pressing and many other investments.

On the other hand, besides the large capital cost required by individuals for implementation of renewable energy systems and technologies, the Government of Tanzania through the ministry of Energy and Minerals (MEM), provides supportive measures. REA continues to play an instrumental role in

promoting renewable energy projects, in order to ensure access to modern energy services to rural poor. Rural electrification through renewable energy activities and projects continues to be funded by Rural Energy Fund-REF [2, 13].

6. The Way Forward

Tanzania's long term growth potential is high, as the country begins to efficiently make use of its renewable energy resources. The availability of sufficient energy is a key factor to accelerating the pace of growth of modern sector of economy. The following suggestions indicate the way forward in the use of renewable energy:

1. Fast development and commercialization on emerging renewable energy is required through intensive research and development among all stakeholders.
2. Since some areas of the country generate electricity through renewable energy resources successfully, this should build confidence in transferring these renewable energy technologies to other areas especially in the rural areas.
3. There should be establishment and upgrading the existing institutions in order to promote public and private funding in the infrastructure and those sectors dealing with renewable energy technologies.
4. Political inclination or reasons should not interfere projects development and implementations. However, long term planning based on resource data and reliable technology should be given priority and is fundamental.

7. Conclusion

Despite the potential of renewable energy resources and renewable energy technologies to catalyze rural developments, access to renewable energy technologies has not always translated into widespread adoption and effective performance. Current studies show that only 12% of the hydro potential is exploited. There are extensive undeveloped hydro resources in Southern regions of the country. On the other hand, geothermal resources potential is estimated at more than 5000MW which is undeveloped. The data shows that, renewable energy resources in the country (excluding large hydro) have little contribution in the total electricity generating capacity. The country has great potential of renewable energy which could supply about 50% of the total generating capacity.

To be suitable, efforts to strengthen access to renewable energies technologies need to be accompanied by right incentives, policy, political and institutional support and the development of local technological capabilities, the "know-how" and the "know-why". In order to commercialize Renewable Energy projects, different government organs, private sectors, investors, higher learning institutions and various NGOs should establish a special partnership.

There must be outlined programs and process to long term thinking in terms of energy investment in the country.

Commercializing Renewable energy will effectively work if long term sustainable energy projects for energy supply and security is put into priorities. The government should put much effort in reducing rural poverty by ensuring that the campaign for provision of affordable, clean and sustainable energy to the rural poor of Tanzania is successful. Those renewable energy resources which are cheaper in the long run and which require a little maintenance cost should be expanded by the Government. If Renewable Energy is available at affordable and reasonable price rural poverty will greatly be reduced.

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