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**Review Article**

# Renewable Energy Policies and Practice in Tanzania: Their Contribution to Tanzania Economy and Poverty Alleviation

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**Abstract:** Tanzania is facing challenges in energy provision with a lot of people leaving in rural areas experiencing energy poverty exhibited by lack of access to electricity, therefore relying on traditional fuels for cooking and lighting. In Tanzania, the electricity access has risen from 18.4% in 2013 to 24% in 2015. Power generation remained generally stable in 2013 which contributed 7.3% to the growth of the National economy. In 2014 the estimates shows that the National economy grew by 7.2%, and is projected to reach 7.4% in 2015. It is reported that, the electricity demand in Tanzania is about 7% per year over the past 10 years. A large proportion of majority of rural population is located far away from the National grid and it is un economical to connect to the grid. The main objective of this paper is to examine renewable energy policies and practices in Tanzania and their contribution to Tanzania economy and poverty alleviation. The study focused on content analysis of projects reports and policy in 10 years. Tanzania has drafted renewable energy policies so as to shift dependence from hydropower which is many times affected by draught and weather patterns and petroleum that have been affected by price fluctuation to solar, wind, biogas and other biomass which are renewable. However, the adoption rate of these renewable energy technologies is low because of financial constraints, lack of awareness, lack of coordination between the Government, non Governmental organizations and private sectors. Existing renewable energy policies should be harmonized and the current practice should be evaluated so as to upgrade the adoption rate of renewable technologies.

**Keywords:** Tanzania, Energy Poverty, Renewable Energy, Policies, Practices

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## 1. Introduction

Energy is one of the main components in the development of any country. Satisfying the energy demand through the use of renewable energy resources is one of the main issues now days because of the fossil fuel depletion and environmental impacts. Njiru et al [1], point out that, the world energy demand is expected to grow at the average annual rate of 1.8% between 2005 and 2030, where wealth generation and drivers for social economic development are the main reason for the increased global energy demand.

Africa has many energy resources such as hydropower, solar, wind and geothermal but only a small fraction is harnessed for domestic use. In the developing world, Africa has the lowest electrification rate, and the number of rural

population without electricity in Sub Sahara Africa (SSA) is expected to increase [1]. Power utilities in Africa have failed to provide adequate levels of electricity services especially to poor societies living in rural areas [6].

In Sub Sahara Africa, 70 – 90% of primary energy supply and even up to 95% of total energy consumption is from tradition biomass energy [7], and only 8% of the rural population has access to modern energy services [2]. More than 650 million people in Sub Sahara Africa, rely on traditional biomass for cooking, heating and lighting, despite the effort done to promote electrification rate [5]. These areas of SSA have much renewable energy resources for decentralized renewable energy technologies which march the dispersed nature of settlements and which are also environmentally friend [1].

## 2. Energy Profile of Tanzania

### 2.1. Energy Consumption

The main source of energy in Tanzania is dominated by traditional biomass to satisfy the energy needs for rural households, where by other modern sectors such as transport, industries and commercial depend on imported petroleum. The country has abundant renewable energy resources in terms of hydro, sunlight, wind and biomass but only hydro is currently being exploited in a renewable manner. Other renewable energy sources such as solar, wind power, and biogas offer a small fraction source of energy [4]. About 24% of the total population has access to electricity services of which 7% is in rural area.

Demand for electricity is growing between 10% and 15% per annum and the country is aiming to increase connection levels by 30% by 2015. Power generation remained generally stable in 2013, contributing to the good performance of the manufacturing sector. The estimate shows that the economy grew by 7.2% in 2014, driven by good performance in manufacturing, services, mining and quarrying, and agriculture. This growth is projected to reach 7.4% in 2015 [10, 39].

It is estimated that, 90% of the population in Tanzania relies on traditional biomass such as wood fuel for cooking, because the majority of these people are rural, poor and cannot afford the cost of modern energy sources such as electricity [2]. 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 [3]. Consequently, the country faces a lot of challenges caused by unpredicted level of use of firewood and charcoal as well as high and frequently unstable price of oil import [3, 32]. Janbert [8] highlight that, for those rural households willing to use modern energy services were discouraged by the high costs of connection in the past few years.

### 2.2. Electricity Access and Generation Capacity

In recent years, the demand for new electricity connections has increased due to the improved energy policy done by the government, by increasing electrification rate through Rural Energy Agency (REA). Before 2013, the connection charges were uniform for both rural and urban areas. The charges were Tsh 455,104.76 without pole, Tsh 1,351,883.52 with one pole and Tsh 2,001,421.60 with two poles. In 2013, the Government issued new electricity connection charges by lowering the connection charges in rural and urban areas as shown in Table 1.

The electrification rate has increased from 14% in 2010 to about 24% in 2015 [10]. The increase is due to identified additional power demands from existing new customers and a special electrification program which tallies with government policy statement of connecting 30% of population by 2015 [31]. The government's policy to advance electrification and the significant reduction of the connection fee in early 2013

are the main reasons behind the sharp increase [37]

*Table 1. New Connection Charges [38].*

	No pole- one way	One pole- one way	Two pole- one way
Urban	Tsh 320,000.00	Tsh 515,618.00	Tsh 696,670.00
Rural	Tsh 177,000.00	Tsh 337,740.00	Tsh 454,654.00

The update and improvement of energy policy has resulted to the increase of new customers from 1.2 million in the end of 2013 to about 1.5 million people in 2015, effectively raising electricity access from 17.7% in 2013 to about 24% of the total population in 2015 [9, 37, 38]. However, Tanzania energy sector and rural electrification level still lags behind that of middle income countries and is in line with low income countries and that of SSA averages [11]. The application of renewable energy technologies have the potential to alleviate poverty that face rural population of Tanzania, and will be a viable option because they can easily be decentralized thus providing energy in areas far from the national grid.

The power generating capacity in Tanzania up to the end of 2014 was 1583 MW. In October 2015, another Gas fueled power plant, Kinyerezi I with 150MW capacity was commissioned, thereby increasing the total generating capacity to 1733MW. Out of these, 561MW is hydro, 677MW thermal and 495MW liquid fuel power plants. The main sources of electricity are hydropower and thermal generation, and the power system (interconnected grid) comprises of generation units owned by TANESCO and IPP's (permanent and rental) [10].

The new energy policy implemented by the government and Tanzania Development Vision- 2025 (TDV) is aiming at raising the generating capacity to 10,000MW by 2025. This will be done by the government itself through it power utility company (TANESCO), and Independent Power Producers-IPP. It is expected that, after the implementation, the electricity generating cost as well as electricity cost for commercial, domestic and industrial will be reduced [32]. The reduction cost of energy will stimulate the economic activities especially for people in rural areas when they access modern energy services.

Tanzania, along with the Sub-Saharan African countries has experienced a prolonged drought happened in 2003, 2006, 2009 and 2011. These dry spells have often depleted the entire hydropower reservoir system. The worst situation was in 2006 and in 2011 in such a way that the country was threatened by complete closure of Kidatu and Mtera hydropower plants, which accounted for an average of about 25 % to the entire power system installed capacity. This led to severe energy shortages which resulted in power rationing, an experience that made the government to start focusing on exploitation of other renewable energy sources, mainly solar, wind, biogas and other biomass which are not mainly weather dependent. This paper therefore, aims to evaluate how renewable energy policies have informed the energy practices in this country in order to overcome the challenges facing Tanzania.

### 2.3. Energy Sector in Tanzania

According to the structure of energy sector of Tanzania shown in Figure 1, the Government through the Ministry of Energy and Minerals (MEM) is responsible for policy formulation. The Energy and Water Utilities Regulatory Authority (EWURA) is an autonomous multi-sectoral regulatory authority under the MEM, established by the Energy and Water Utilities Regulatory Authority Act, Cap 414 of the laws of Tanzania. It is responsible for technical and economic regulation of the electricity, petroleum, natural gas and water sectors in Tanzania pursuant to Cap 414 and sector legislation.

Other functions of EWURA include among others, licensing, tariff review, monitoring performance and standards with regards to quality, safety, health and environment. EWURA is also responsible for promoting effective competition and economic efficiency, protecting the interests of consumers and promoting the availability of regulated services to all consumers including low income, rural and disadvantaged consumers in the regulated sectors.

Rural Energy Agency-REA is an autonomous body also 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. REA in Tanzania perform the following main functions:-

1. Promote, stimulate, facilitate and improve modern energy access for productive uses in rural areas in order to stimulate rural economic and social development.
2. Promote rational and efficient production and use of energy, and facilitate identification and development of improved energy projects and activities in rural areas.
3. Finance eligible rural energy projects through Rural Electrification Funds (REF).
4. Prepare and review application procedures, guidelines, selection criteria, standards and terms and conditions for grants allocation.
5. Build capacity and provide technical assistance to project developers and rural communities.
6. Facilitate preparation of bid documents for rural energy projects.

REA has already supported various off-grid projects in small hydro power projects, biomass cogeneration projects, and biomass gasification projects in various parts of the country such as Mafia and Mkonge energy project in Tanga Region. The supported projects are currently at various stages of implementation and the total expected capacity is 46 MW, with the expectation of about 7400 new connections. REA support fiscal incentives for rural energy projects and programs and count amongst the National aid initiatives attracting fiscal initiatives. On top of Government subsidy to REA, the agency is also allowed to take up to 5% surcharge on each unit of energy generated by commercial electricity

producer. REA subsidies also support solar PV Systems. However, the subsidy is limited to 100Wp for domestic use and up to 300Wp for Institutions.

At industry level, there is Tanzania Electric Supply Company Ltd (TANESCO), which dominates the sector in the Generation, Transmission and Distribution of Electric power. There are also Independent power producers- IPPs whose provide additional power capacity to the generating industry.

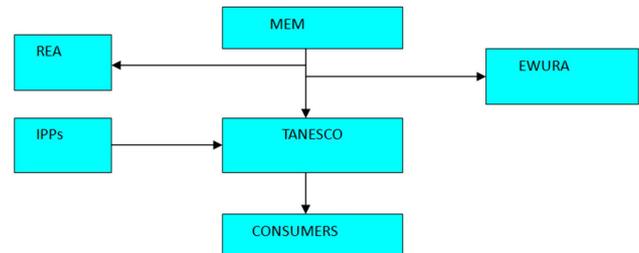


Figure 1. The Structure of Energy Sector [15].

All Independent Power Producers- IPPs generate and sell power to TANESCO, which connect it to the national grid. Electricity generation in Tanzania is from hydro, natural gas, coal, diesel oil, biomass and to a minor extent, solar photovoltaic [16].

### 2.4. Energy Policy

The first National Energy Policy (NEP) for the Country was formulated in 1992. Since then the energy sector has undergone a number of changes, necessitating adjustments to the initial policy. With various changes, the energy policy of 1992 was replaced in 2003. The objective of the 2003 NEP is to ensure availability of reliable and affordable energy supply and use in a rational and sustainable manner in order to support national development goals.

The National Energy Policy of 2003 aims to establish energy production, procurement, transmission, distribution and end-user systems in an efficient, environmentally sound, sustainable and gender-sensitized manner. Key objectives of the 2003 NEP regarding to Renewable Technologies (RT) and services include:

1. Encourage efficient use of alternative energy sources.
2. Facilitate Research and Development (R&D) and application of Renewable Energy for electricity generation.
3. Facilitate increased availability of energy service including off-grid electrification of rural areas.
4. Introduce and support appropriate fiscal, legal and financial incentives for Renewable Energy Technologies.
5. Ensure the inclusion of environmental consideration in energy planning and implementation.
6. Support Research and Development (R&D) in Renewable Energy Technologies
7. Establish norms, codes, of practice, standards and guidelines for cost-effective rural energy supplies and for facilitating the creation of an enabling environment

for the sustainable development of renewable energy sources.

8. Facilitate the creation of an enabling environment for sustainable development of Renewable Energy Sources.
9. Promote entrepreneurship and private initiatives for the production and marketing of products and services for rural and renewable energy.
10. Ensure priority on power generation capacity based on indigenous resources. The policy encourages public and private partnerships to invest in the provision of energy services. It also seeks to promote private initiatives at all levels and stresses the need to make local and foreign investors aware of the potential of the Tanzanian energy sector.

### 3. Renewable Energy Policies and Practices

The Government intends to develop these renewable energy sources so as to minimize production costs which will make electricity affordable to the majority of Tanzanians. Many times, Tanzania has improved its energy policy in order to encourage Independent Power Producers- IPP especially in remote locations because of the excessive cost of transporting electricity from large scale power plants to rural areas. The government also aims to contribute to at least 260MW of new renewable power generation being connected to the national grid by 2016 [31].

#### 3.1. Biomass

Tanzania Government has issued ban for more than ten years ago on production and transportation of charcoal in order to stop illegal deforestation. This enforcement has not well succeeded because of delay and corruption in issuance of licenses for sustainable charcoal production and therefore allows illegal charcoal to dominate the market. Napendael [3] point out that, the average daily consumption of charcoal in Dar es Salaam is estimated to be 24,000 bags per day, and it has been revealed that only 10-20% of this amount passes through legal checkpoints and thus earning the government revenue. Biomass comes in a variety of forms, which can be utilized as an energy resource. It is possible to classify the material into two main groups; wood biomass and agro-forestry waste (that is, crop wastes, animal manure and forestry processing wastes).

These materials can be burnt directly or first converted into solid (charcoal), liquid (ethanol) and gaseous fuels (biogas, producer gas). The main source of fuel in both urban and rural areas of Tanzania is biomass in the forms of charcoal and fuel-wood. Charcoal is the energy source that is made from wood, while fuel-wood is collected and used directly from the field [4]. Biomass resources are mostly derived from forests, wood logging and agricultural residue, animal dung, solid industrial waste and landfill biogas.

The total forest area of Tanzania is about 39% which supply about 37% of the total biomass energy resources such as

firewood. The other biomasses, agricultural residue, animal dung, solid industrial waste and landfill biogas cover the remaining part [35]. The main biomass energy use in most rural area of Tanzania includes charcoal making, direct firewood and dung. The utilization of this conventional biomass is still high due to poor conditions facing rural areas.

#### 3.2. Biogas Practices

Biogas is a commonly used biofuel around the world and is generated through the process of anaerobic digestion or the fermentation of biodegradable materials such as biomass, manure, sewage, municipal waste, rubbish dumps, septic tanks, green waste and energy crops. This type of biogas comprises primarily methane and carbon dioxide, which is combustible and when burnt will produce heat. Domestic biogas in Tanzania was introduced by Small Industries Development Organization (SIDO) in 1975.

A number of other Non Governmental Organizations (NGOs), joined in the promotion of this technology all around the country whereby the involvement of CAMARTEC, later in cooperation with GTZ accelerated awareness and dissemination, particularly in the northern regions of the country. CAMARTEC and GTZ carried this work forward in the 1980s-1990s by developing, promoting and providing training in the biogas sector, where during those years, interested parties built around 6,000 biogas digesters [17].

It is estimated that, about than 7,133 domestic biogas plants have been built countrywide for domestic and commercial applications since 2009 as shown in Figure 2. However, as these new technologies get rolled out to more remote areas, biogas invariably encounters some isolated local cultures in few areas of the country. For example in predominantly Muslim households it is difficult to convince the community to use pig dung to generate energy. Studies have revealed that pig dung is more efficient fuel than cow dung [30].

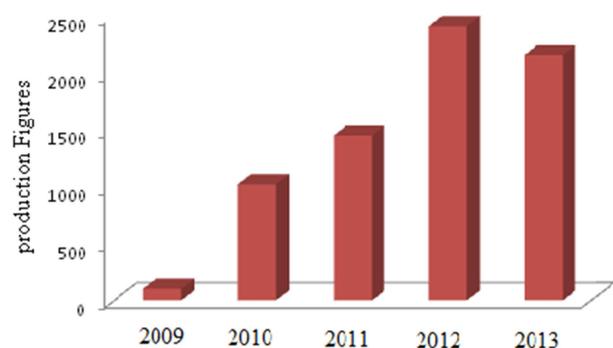


Figure 2. Annual production of biogas Plants in Tanzania since 2009 [17].

Based on the 2007 - 2008 feasibility study and the 2012 program implementation document, Tanzania Domestic Biogas Program (TDBP), estimates that the technical potential for domestic biogas in Tanzania is around 165,000 households [17]. The potential is the number of household with basic requirements of enough availability of dung and water, the ambient temperature, the availability of construction materials, enough land (space) for plant installation, freedom from

natural disasters like floods and earth quakes and availability of human resources for plant construction.

To date, different and affordable digester plants have been introduced and promoted in many parts of Tanzania. Recently, Dar es Salaam Institute of Technology (DIT) has developed a portable biogas plant shown in Figure 3, made from plastic containers which can be used by rural households. Biogas is used mostly for cooking and lighting by people who do not have access to grid connection in rural areas.



Figure 3. A biogas plant using plastic containers made by DIT [30].

Biogas technology has been disseminated and promoted by various NGOs, and by the support of Government through MEM purposely to increase the awareness to the general community in dissemination and promotion of this technology in order to reduce the dependence in fuel wood and charcoal as the only source of energy in rural areas of the country.

Table 2. Power generation and installed capacity from sugar industries [13, 14, 22].

Factory Name	Cane crushing capacity (tons/day)	Bagasse available (tons/day)	Installed capacity (MW)	Electrical energy generation (Gwh/yr)	Internal usage (Gwh/yr)	Export (Gwh/yr)
Kagera	60	3000	5	15.84	15.84	NIL
Mtibwa	350	2511	4	23.10	23.10	NIL
Kilombero	180	13,729	10.6	39.4	39.4	NIL
TPC	130	2674	20	21.09	21.09	NIL
TOTAL	720	21914	39.6	99.43	99.43	NIL



Figure 4. Sisal Energy (Biomass) Plant – Hale, Tanga [22].

Table 3. Existing Bio-mass fueled Power Plants in Tanzania [13, 22].

Station	Installed capacity(MW)	Energy source
Mtibwa Sugar Estate Ltd	4	Co-generation-bagasse
Tanganyika Planting Company Ltd-TPC	20	Co-generation-bagasse
Kilombero Sugar Company Ltd	10.6	Co-generation (bagasse)
Kagera Sugar Estate Ltd	5	Co-generation-bagasse

However, among the factors which seem to block the widespread initiation of biogas systems include the lack of enough education and information regarding their potential benefit, lack of construction skills, high cost of digester construction, poor construction design and maintenance and lack of financial support in the community [17].

### 3.3. Co-generation

In Tanzania, sugar industries use bagasse waste from sugarcane processing to produce steam for running a turbine for electricity generation. Bagasse is a fibrous waste product produced after sugarcane has been crushed. Annual production is about 776,000 tones which is about 33% of the weight of the crushed sugarcane from all sugar Industries in the Country [13]. Table 2 shows the present installed capacity of sugar industries for generation from bagasse in Tanzania which is 40MW with estimated energy generation potential of 99.42GWh per year [14, 23].

Co-generation potential from bagasse, wood waste and from a sisal waste plant such as the one shown in Figure 4 in Tanzania is estimated at 395 MW. At present the installed capacity is 61.3 MW from sugar and wood-based industries shown in Table 3. Currently the generation capacity in most of the sugar and wood based biomass factories is designed to cover the requirements of the factory only, there is no export to the national grid and therefore, their contribution to the energy mix in the nation is low.

Station	Installed capacity(MW)	Energy source
Tanzania Sisal Board-Hale	0.3	Biomass-Sisal waste
Tanganyika Wattle Company Ltd	2.5	Biomass-Wood waste
Sao Hill Industries- Mufindi	15	Biomass-Wood waste
TANWAT-Njombe	2.5	Biomass- Wood-waste
Ngombeni Power Ltd-Mafia	1.4	Biomass- Wood-waste
Total	61.3	

Studies have revealed that, Tanzania has the potential of generating more than 395MW of electricity per annum from biomass sources. However, the contribution of biomass in the energy mix of the country is still small [30].

### 3.4. Liquid Bio-fuels

Liquid bio-fuels are liquid energy sources derived from plant materials specifically used to replace or supplement conventional petroleum-based fuels. Liquid biofuel can be used in existing vehicles with little or without any modification of engines and fueling systems. There is high

potential for production of biodiesel and bio-ethanol in Tanzania [24]. Food and Agriculture Organization (FAO) and Government of Tanzania have identified a number of bio-fuel production scenarios using different feedstock crops and different types of downstream processing plants. In the analysis they focused on a subset options in order to capture the core difference in these crops.

The research shows that jatropha is a potential viable feedstock for biodiesel [24]. *Jatropha curcas* (JC) is a

perennial small tree or large shrub, which can reach a height of up to 5 m, and is an ever green drought-resistant species that sheds its leaves during very dry periods. It is adapted to arid and semi-arid conditions, currently in Arusha and Moshi as shown in figure 5. The current distribution of *Jatropha* shows that introduction has been most successful in drier regions of the tropics with an average annual rainfall between 300 and 1000mm [39].



Figure 5. *Jatropha* plantation at Kikuletwa Moshi. (a) 1.2 m height, 8 months after planting, (b) 3.5 m height, 5 years old trees [39].

Only recently Tanzania has started production and marketing of straight vegetable jatropha oil for use in adapted car engines, but the output is still negligible. Nationally produced biodiesel is so far not available at competitive prices. Tanzania is highly dependence on oil imports, which places great strain on the country’s balance of trade, especially in the time of soaring oil prices. The interest which has been shown by the Government for the production of oil liquid biofuels has great potential in terms of economic development for Tanzania by reducing the oil bill and support rural development [18, 23, 25].

### 3.5. Small Hydropower Practices

The estimation of small, mini and micro hydro potential in Tanzania is 4800MW at National level [20]. The detailed studies carried out on site surveys have identified more than 85 mini hydropower sites with a total potential of 187MW [26]. Many of these sites are in rural areas and are suitable for standalone systems for supplying power to small communities away from the grid. The existing small hydropower plants in Tanzania are given in Table 4 [26].

Table 4. Existing small, mini and micro hydro Plants [20, 21, 38].

Location	Year Installed	Turbine Type/manufacture	Installed Capacity(kW)	Owner
Sakare (Soni)	1948	Geisel Brecht	0.0063	Benedictine Fathers
Mbarali (Mbeya)	1972	Chinese	0.7	NAFCO/Govt
Ndolange(Bukoba)	1961	B. Maler	0.055	RC Mission
Ikonda (Njombe)	1975	CMTIP	0.04	RC Mission
Makumira (Arusha)	2011	Gross Flow/Ossberger	0.01	J Mungure
Ngarenanyuki (Arusha)	2011	Gross Flow/Ossberger	0.01	Ngarenanyuki Sec School
Tosamaganga (Iringa)	1951	Gilkes& Gordon/Francis	1.22	TANESCO
Kikuletwa ( Moshi)	1937	Boving & Voith Reaction	1.160	TANESCO
Mbalizi (Mbeya)	1958	Gilkes& Gordon/Francis	0.34	TANESCO
Kitai (Songea)	1976	Gross Flow/Ossberger	0.045	Prison Dept/Govt
Nyagao (Lindi)	1974	N/A	0.0158	RC Mission
Isoko (Tukuyu)	1973	N/A	0.0155	Morovian Mission
Uwemba (Njombe)	1971	N/A	0.8	Benedictine Fathers
Bulongwa (Makete)	-	N/A	0.18	-
Kaegesa (S’wanga)	1967	N/A	0.044	RC Sumbawanga
Rungwe (Tukuyu)	1964	N/A	0.0212	Morovian Mission
Nyagao (Lindi)	1974	N/A	0.0388	RC Mission
Isoko (Tukuyu)	1973	N/A	0.0073	RC Mission
Ndanda (Lindi)		N/A	0.0144	RC Mission
Ngaresero (Arusha)	1982	Gilbsk	0.155	MH Leach
Mamba (Katavi)	1932	Gross Flow/Ossberger	0.01	Mamba Mission

Location	Year Installed	Turbine Type/manufacture	Installed Capacity(kW)	Owner
Mwenga Mini Hydro Ltd	2012	N/A	4.00	Community
Mapembasi hydro Power Ltd (Njombe)	-	N/A	12.00	Community
ACRA Tanzania	2013	N/A	0.3	Community
Andoya Hydroelectric Power Ltd	2013	N/A	1.0	Community
Kitonga Hydro (Ikololo)	-	N/A	10	Community
Ndola Hydro (Ruhuhu)	-	N/A	10	Community

Implementation of some of these projects started before independence but uptake has been slow because of the lack of encouragement and sufficient fund to support individuals and Non-Governmental Organizations in the uptake of this technology.

### 3.6. Solar Energy

Solar resources are good in the central portions of the country. This makes it naturally a suitable country for the application of solar energy as a viable alternative to conventional energy sources if efficiently harnessed and utilized. Both solar PV and solar thermal technologies are in development in the country. As grid electricity reaches about only 7 % of the rural population in Tanzania, the use of solar electricity seems to be an attractive option. The country average annual solar radiation levels are said to range between 4.2-5 kWh/m<sup>2</sup> per day. This solar energy is equivalent to 210 million tons of oil equivalent (Toe) [19].

The lowest annual average radiation value in the country is found to be 15MJm<sup>-2</sup>day<sup>-1</sup> while the maximum value is 24MJm<sup>-2</sup>day<sup>-1</sup>. The lowest radiation value in many parts of the country is obtained in July (winter) which is sufficient to satisfy the needs of rural family demand. The important use of solar energy in Tanzania include solar thermal for heating, drying and photovoltaic (PV) for lighting, water pumps, refrigeration purposes and telecommunication. The solar energy market of Tanzania has grown and increased over the last few years.

The rapid increase of solar equipment market is due to partly, the need of providing electricity to houses and institutions located in remote areas, where there is no grid connection and also to supply power to equipments like water heaters which are used in domestic and commercial applications. The demand for SHS has been driven by the spread of broadcasting signals and the availability of TV sets and radios in rural areas, where they have become the biggest segment in Tanzania's solar market.

Currently, there are about 65,000 houses in Tanzania with solar PV panels ranging from 10-100kW per house. In 2008 the installed capacity was approximately 1MW<sub>p</sub> and doubled to 2MW<sub>p</sub> in 2009. This capacity was an estimate of 40,000 SHS in 2008 with annual sales of 4,000-8,000 SHS [28]. Individuals purchase solar equipments and accessories from whole sale dealers and retail shop owners who import them from abroad. Tanzania has free market, therefore solar equipments import is done by several companies, vendors and several installers.

Recent estimates on the installed capacity of PV systems in the country is about 1.7 MW, however market potential for solar PV countrywide is estimated to be 20.2MW. Tanzania is now experiencing significant growth in its PV market 350kW

in 2008 to about 500kW in 2012 [27]. The Government is carrying out awareness and demonstration campaigns on the use of solar systems for domestic and industrial use, as well as supporting direct installation in institutions. VAT and import tax for main solar components (panels, batteries, inverters and regulators) have been removed to allow the end users to get PV systems at more affordable price.

Implementation of a solar PV for electrification of schools and other institutions which are far from the grid is currently done by the support Government and some NGOs as part of utilization of renewable source of energy to the overall energy supply [32]. It is anticipated that by 2025, about 800MW, will be fed to the national grid from solar power generation which will be located in the central part of the country. Although Tanzania has high levels of solar energy, ranging between 2800-3500 hours of sunshine per year, it seems the percentage contribution to the total energy mix is still small [32].

### 3.7. Wind Energy

Amjad et al [41] insist that, the beginning of twenty one century has been of an exciting time for wind energy. This is due to the various changes in technologies, policies, environmental concerns and challenges facing electricity industry infrastructure. Therefore, the coming years offer many opportunities for wind energy to emerge as a viable electricity source. Tanzania has large areas with average wind speeds of 5-7m/s. It is coupled with existing long coast line of about 800km with prevailing surface winds, moving from south east to north east.

There has been a trial by individual people in Tanzania to attempt to generate electricity from wind but there is no success. The wind energy development approach which has been used in Tanzania is perhaps wrong and that may have been the reasons for the failure to generate electricity from wind. Wind turbines and windmills have been installed without proper investigation on wind speed characteristics at the prospective sites [30, 34, 36].

Wind Energy has been used primarily in Tanzania for wind mills to pump water. However, their uses have declined due to lack of maintenance as well as the alternatively use of internal combustion engines, which are sometimes flexible and cheap compared to wind mills. It is estimated that about 101 wind mills have been installed in Tanzania for water pumping purposes [30]. Currently, interest of the community in wind power electricity generation is expanding due to factors such as the rising cost of oil, increased demand of power, and effect of long draught on hydropower.

Recent researches in Tanzania have shown that, wind farms for commercial plants appear promising at Makambako and Kititimo in Singida. Areas along rift valleys, the southern high

lands and along Lake Victoria are reported to have some possibilities of potential wind sites [30]. At present, there are no grid connected wind turbines in Tanzania but the Government has shown much effort to ensure the utilization of this resource. There are about 7 potential wind sites located for electricity generation at Singida, Makambako and Mkumba. The constructions of the wind farms (300MW) in Singida have already started and are expected to generate in phases until its completion in 2018 [29, 33].

## 4. Conclusion

Tanzania has great potential of renewable energy which could supply about 50% of the electricity. Much focus has been on large hydropower and thermal power projects leaving sources such as biomass, solar, biogas and wind under exploited. There is a need to harmonize policies addressing issues on renewable energy exploitation in order to ensure timely implementation of the planned energy projects. The regular review of the existing policies to ensure encouragement of private investment in the energy sector and competitiveness should also be ensured, as renewable energy practices are in line with existing policies. However, adoption of renewable energy technologies has been slow mainly because, most of these require high initial costs. The current energy policy and the subsidy from the government though REA have encouraged private partnership in implementing solar and wind energy projects.

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