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A Review of Uganda's Energy Mix

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Abstract: This paper makes a review of Uganda's energy mix, it is richly endowed with vast energy resource potential of over 41800MW. It is dominated by the use of renewable energy of about 90%, however, most of it is the traditional biomass of firewood and charcoal; this requires a quick transition to clean modern energy to meet the Sustainable Development Goal (SDG7). Hydro power provides 80% of total electricity generated, Solar is underdeveloped and remains a missed opportunity due to the abundant solar insolation of about 8 hours every day for all the days of the year and Electromagnetic radiation averaged at 5.1 kWh/M^2. Wind and geothermal are also grossly untapped but potential for them exists. Modern energy development technologies should be improvised either through Public Private Partnerships (PPP), Multilateral or bilateral financing arrangements. Several bottlenecks still exist in the energy sector despite increased electricity generation that hinder full utilization of all renewable energy resources. The Clean Development mechanism (CDM) and Sustainable Energy for all have presented varying opportunities to increase energy consumption.

Key words: energy mix, renewable energy, Uganda

1. Introduction

Uganda's energy mix is dominated by biomass 87% (Firewood constitutes 78%, Charcoal 5% and crop residues 4%), Electricity (2%) and Fossil fuel (11%) (NDP 2020). Uganda's overall energy potential is about 41800MW, it is richly endowed with renewable energy resources. Its energy matrix mainly includes hydro, biomass and solar energy [1]. Although Uganda's renewable energy constitutes 90% of the energy mix, most of it is traditional primary energy sources. There is a need for a quick transition to clean, reliable and affordable energy sources for all as proposed in the Sustainable development Goal (SDG 7).

Uganda's electricity consumption per capita is 215 KWh making it one of the lowest in the world. Comparatively Kenya electricity consumption per capita is 355 KWh, South Africa 5040 KWh, Sub Sahara is 552 KWh while the world is at an average of 2975 KWh (MEMD, 2019). Uganda's long term target is to increase per capita energy consumption from 215kWh in 2020 to 3668 kWh by 2040.

The Uganda Vision 2040 is a broad policy goal is to transform the country from a peasantry to a modern economy. This requires energy planning to increase electricity production from the 822 MW (in 2012) to 41 800 MW (by 2040) and electricity consumption per capita to 3668 KWh (GoU-V2040). The proposed distribution of installed capacity of power generation in Uganda in 2040 is shown in graph 1, renewable energy resources (hydropower, geothermal, solar energy and biomass) are expected to contribute 12 700 MW to national grid in 2040. Furthermore, it can be deduced from the same table that, solar energy resource is expected to provide about 12% of the Uganda's installed power capacity by 2040 and 39.4% of renewable-based power capacity. However, the current power supply capacity of 1285.2 (3%) of 418000MW target by 2040. To meet the government's target, therefore, there is great opportunity to investment and diversification of energy mix by individual as well as private and public organizations in this country. This

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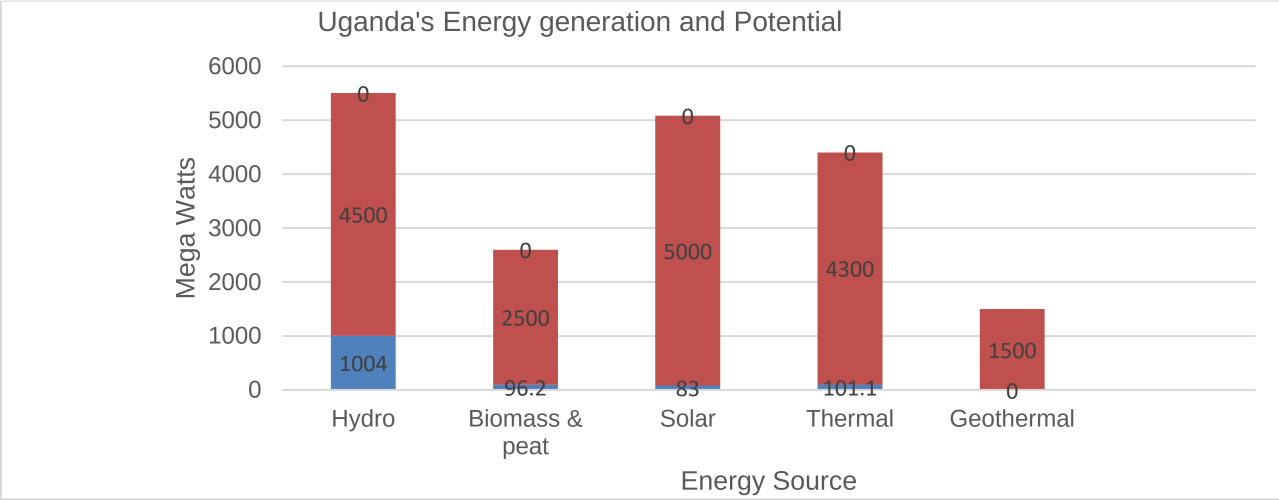

Fig. 1 Present and future cumulative power generation potential in Uganda. Source MEMD (2020)

has the potential of driving this economy into a middle class economy.

This paper seeks to highlight Uganda's energy mix. It also examines the bottlenecks of the sector and steps to overcome them. It suggests policies to guide decision making towards cleaner and affordable modern energy consumption.

The rest of the paper is structured as follows: the second section explores an overview of the energy resource mix in Uganda; the third section is on bottlenecks, section four explains the steps and policy measures to overcome the bottlenecks, while the last section is conclusions of the study.

2. An Overview of the Energy Resource Mix in Uganda

Uganda's abundant energy resources are unevenly distributed. Most hydroelectricity potential is along the R. Nile, Geothermal energy and most nuclear power is in Western Uganda while Fossil fuels are also predominantly in Western Uganda. Wind energy potential is in the mountainous, isolated, hilly and remote areas of Karamoja. Biomass and Solar are more evenly distributed all over the country. The energy resource mix is as explained below.

2.1 Hydro Electricity

Uganda's total energy potential is 41800 MW, it constitutes of Hydro power estimated at 4500 MW, currently the installed capacity is 1285.2 MW (938 MW in 2017, 870 MW in 2015 and 683 MW in 2014) with peak demand of 700 MW (550 MW in 2015, 493 MW in 2013), Uganda's load profile reflects strong industrial demand of 62%, domestic consumers constitute 22%, commercial consumers 12% and 4% is exported. Uganda now has surplus electricity, so periods of load shedding have greatly reduced and new connections have accelerated [2]. Access to electricity is 26.1% (14.88 % on centralized grid and 11.22% decentralized) and with urban electrification rate of 40% and rural electrification rate at 5% is still low due to socio-cultural barriers, power theft and high costs (SE4A Report 2015). The costs of energy are generally high, a unit cost of power averaged (US cents 21 in 2018, US cents 19 in 2012) for domestic users. Uganda's import bill on petroleum products was some US$ 956million (2019) to provide 11% of her energy needs mainly for transport related electricity consumption.

Hydropower is the major source of electrical power having developed about 27.8% of her hydropower potential, makes it the most popular power source in the country. Uganda has a comparative advantage in hydropower resources in the region. The Unit cost of developing 1 MW of Hydro energy is U.S$ 2.6million. Most of its hydropower potential is concentrated along the Nile, with a total estimated potential of 4,500MW, about 25% of this potential has been developed Almost all of Uganda's current hydropower is generated at Bujagali (250 MW which contributes 19.97%), Kiira (200 MW which contributes 15.97%), Isimba (183 MW which contributes 14.62%) and Nalubaale (180 MW which contributes 14.38% of total electricity generation) located along the Nile valley system. The Large Hydro power Projects contribute 855 MW (68%) while small-scale hydropower schemes contribute over 149 MW (12%). A total of 59 medium sized hydro power plants have been identified with a potential of 210 MW while 50 potential small size sites identified have an estimated 164 MW capacity of electricity. Currently, domestic peak power demand of 750 MW is less than available supply Capacity of 1252 MW by as much as 502 MW (about 40% reserve capacity), and is growing at the rate of 8 percent per year. Load shedding is becoming less common, any shortfall may be due to system failure, upgrading, repairs and maintenances or vandalism [2]. The dominant source of Electricity 1004.2 MW (80%) is hydro-electricity. Other sources of electricity include 100 MW (8%) is generated from thermal power, 96.2 MW (8%) from biomass (Bagasse cogeneration) and 50.8 MW (4%) from solar power.

2.2 Biomass

Bio-energy potential is 1700 MW and 800 MW of peat if exploited however, only less than 96.2 MW (3.8%) is produced by three bagasse co-generation plants of Kakira sugar, Kinyara sugar and SCOUL mainly for own consumption while the rest is sold to the grid. Biomass dominates the basic energy needs of cooking water heating in rural and urban areas. Uganda has a biomass standing stock of 284.1 million tons with a sustainable yield of 45 million tons per year and 250 million TOE of peat. A significant sustainable wood resource exists of which is about 26 million tons is feasibly available this is 59% of total demand of 44 million tons per year. A significant peat

Table 1 Current and projected hydropower schemes (in MW) in Uganda.

Bujagali	250
Kiira	200
Isimba	183.2
Nalubaale (Owen falls)	180
Kyambura	76
Aswa	42
Mini Hydro	
Mpanga	18
Siti II	16.5
Bugoye tronder/ Mobuku II	13
Mobuku III/Kasese Cobalt	10.5
Nkusi	9.6
Nyamwamba	9.2
Buseruka	9
Ziba	7.6
Ishasha/ECO	6.6
Ndugutu	5.9
Sindira / Butama	5.3
Rwimi	5.2
Lubira	5
Kilembe	5
Mobuku I	5
Nyagak	3.5
Siti I	5
Waki	4.7
Mahoma	2.7
Kisizi	0.3
Proposed projects	
Murchison	700
Karuma	600
Ayago	600
Kalagala	450
Oriang	400
Kiba	300
Bugumira	109
Muzizi	52
Waki	5
Kikagati	18
Siti II	16.5

Source: ERA annual Report (2019).

resource for power generation equivalent to 800 MW of potential capacity for 50 years. Biomass cogeneration from agricultural waste holds a potential of 150 MW and a promise as a technology for Uganda [3]. The production of agricultural residues is about 1.2 million tons per year.

Smaller cost effective biogas technologies have been installed in five districts including Iganga, Kabarole, Mbale, Mpigi and Tororo at a rate of 10 biogas per district bringing the total to 50, more effort, however is required by the government to cover the remaining 128 districts.

Table 2 Energy production potential from agro-residues.

Biomass Type	Estimated annual production (000 Tons/Year)	MWe Average
Bagasse	590	
Bagasse surplus(Immediately Available)	50	67
Rice husks	3×25-35	16
Rice straw	45-55	30
Sun flower hulls	17	20
Cotton seed hulls	*+50(being developed)*	1
Tobacco dust	2-4	2
Maize cobs	234	139
Coffee husks	160	95
Ground nuts shells	63	37
Total		407

Source: Ministry of Energy and Mineral Development, Uganda 2015.

2.3 Solar Energy

The total global renewable energy generation capacity (including hydropower power) reached 2 588 GW at the end of 2019, with solar PV accounted for 627 GW (that is, 24.2%) and CSP accounted for 6.2 GW (REN21).

Solar power potential for Uganda is estimated at 5000 MW, of this only 83 MW has been developed representing 1.7% of her estimated potential. Uganda lies astride the equator and is estimated to have Electromagnetic radiation from the sun averaged at 5.1 kWh/m^2, with solar insolation of 8 hours every day throughout the year. Uganda could generate over 400,000 TWh of solar power annually. Three solar plants in Soroti, Tororo and Mayuge have been installed with an installed capacity of 10MW each, and 20MW at Kabulasoke this is sold to the grid. Solar Energy for Africa is exploring 50 MW solar plant at Namugoga (Wakiso). Another plant of similar capacity was developed at Nkonge solar power plant (Mubende district). Most solar energy used is off grid Photo Voltaic (PV) for lighting rural communities. Solar for cooking, water heating and for public buildings in the urban areas [1]. The number of small scale installations for home and institutions can be estimated at 31.2 MW above the utility scale installation of 50.8. This makes the total installed solar energy 82.2 MW [4]. The Unit cost of developing 1 MW of Solar energy has declined from U.S$ 1.9 Million as of 2016 to U.S$ 1.1 Million as of 2019 [4].

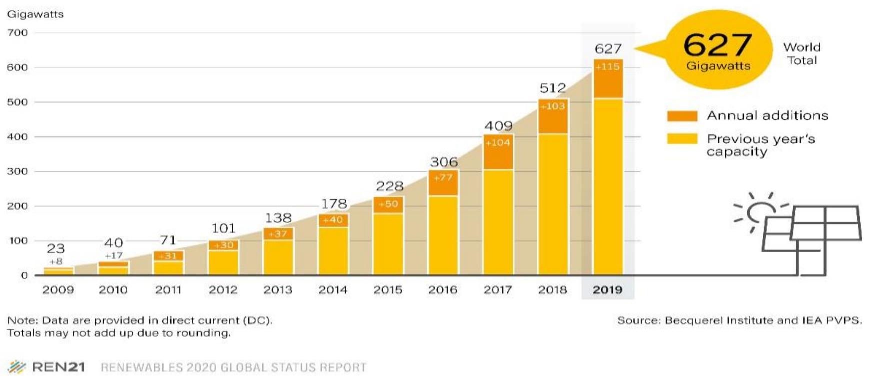

Fig. 1 Global trend of solar PV cumulative installed capacity and annual additions (REN21).

Table 3 List of solar power plants operational and those under construction in Uganda.

Solar power station	Location	Fuel type	Inst.Capacity (MW)	Year completed	Owner
Bukuzindu Hybrid Solar and Thermal Power Station	Bukuzindu Kalangala District	Solar power & Diesel fuel	1.6	2014	KIS & Uganda Development Corporation
Soroti Solar Power Station	Soroti District	Solar	10	2016	Access Power MEA (Access), Total Eren
Tororo Solar Power Station	Tororo District	Solar	10	2017	Simba Telecoms Limited, Building Energy SpA
Kabulasoke Solar Power Station	Kabulasoke, Gomba District	Solar	20	2019	Xsabo Power Limited
Mayuge Solar Power Station	Bufulubi, Mayuge District	Solar	10	2019	Tryba Energy
Namugoga Solar Power Station (proposed)	Wakiso District	Solar	50	*Not ascertained*	Solar Energy for Africa, Naanovo Energy Inc.
Nkonge Solar Power Station	Mubende District	Solar	50	*In development*	The Xsabo Group

Source: Extant literature

What is clear is that the solar installed on the grid is 50.8 MW while 32.2 MW is the estimated solar systems off grid.

2.4 Geothermal Energy

Geothermal potential of 1500 MW exists in the Uganda Rift valley system with four areas namely Katwe-Kikorongo (Katwe), Buranga, Kibiro and Panyimur in West Nile. Geological surveys were first done by a British geologist Wayland in 1921 and geysers in Western Uganda were studied. The temperature levels range between 150°C to 200°C, a model by Government and federal Institute of Geosciences and natural resources Germany has been developed for possible geothermal power development with 150 MW for the start. Preliminary viability and feasibility studies involving drilling of deep exploration wells that will help provide information on the reservoir temperature, fluid chemistry and other petro physical parameters are being done. This would allocate electricity to 3,000,000 people in rural areas of western Uganda.

2.5 Wind Energy

Wind energy potential in Uganda is not clearly known, most areas have moderate winds ranging between 2-4 m/s. In areas with rugged relief wind speeds may reach an average of 6m/s in mountainous, hilly areas and Karamoja. Wind speeds in most parts of Uganda can run small wind plants of 50 kWp. Bulchoz has indicated that wind speeds recorded at Meteorology department, Ministry of Water, Lands and environment have been recorded at low meteorological height, not carried out for the intention of measuring wind energy development, and this gives us for results when assessing alternative energy assessment and utilization of wind energy. Recently, low speed turbines have been developed and have proved to be effective for wind power generation [3].

2.6 Fossil Fuels

Uganda's crude oil potential is estimated at 6 billion barrels of which 1.4 billion barrels is recoverable. Only 40% of the Albertine region has been evaluated. The natural flow rate of 350000 barrels per day would create an extraction path of 26 years. The annual petroleum consumption is 1.5 billion liters per year with an annual growth of 7%. This constitutes imports of about US$ 956 million, 2019. The composition of diesel 53%, petroleum 41%

and kerosene 6%. Thermal energy potential is estimated at 4300 MW so far 100 MW (2.3%) is currently generated by thermal generators at Electro max Tororo and Jacobsen Namanve in Mukono district each is 50 MW.

2.7 Nuclear Energy

Nuclear power potential is 24000 MW, but preliminary findings indicate 50000 square kilometers of estimated uranium prospects around Buyende, Nakasongola, Mubende, Kiruhura, Buhweju plateau and Lamwo. The unit cost of developing 1 MW of Nuclear energy is U.S $6 Million. Government efforts are to build a 1000 MW power plant this will cost an estimated U.S $6 billion.

Uganda's National development plan targets to invest in energy infrastructure and raise generation capacity to 3500 MW, it also seeks to increase per capita consumption from current 215 kWh to 674 kWh in the medium term. It intends to construct large hydro power of 1800 MW, mini-hydro of 150 MW, thermal plants of 700 MW, solar thermal of 150 MW, geothermal of 150 MW (SE4A Report 2015).

Uganda's energy consumption is dominated by residential consumption, this means a lot of energy consumed is not directed toward productive sectors. It is mainly primary energy like charcoal for cooking amongst households. However, Electricity consumption is dominated by the industrial sector as shown by Table 4.

The comparison shows Uganda still having a competitive advantage in electricity supply capacity

Table 4 Uganda's overall energy consumption vs electricity consumption pattern (%).

	Energy	Elec.
Residential	70.3	22
Commercial	13.6	12
Industrial	10.7	62
Transport	5	4
Others	0.4	-

Source: NDP Report 2015

Table 5 Comparison of Peak demand and tariffs in the region.

Country	Installed Capacity (MW)	Peak demand (MW)	Tariffs (US $)
Uganda	1253	750	0.20
Kenya	2250	1640	0.47
Tanzania	1680	1090	0.43

Source: Energypedia indicators, (2019)

and tariff rates charged in the region as shown in Table 5. Uganda was able to export electricity, it sold 19.2 MW to Kenya and earned foreign exchange of U.S $33.7 Million while 8 MW to Tanzania earning U.S $14.2 Million.

3. Bottlenecks Facing Uganda's Energy Sector

The underlying bottleneck is the lack of proper mix of energy sources in the generation of electricity, the low levels of access to modern energy sources, insufficient infrastructure for generation transmission and distribution and low energy efficiency. The distribution and transmission losses account for 22.8%. Other bottlenecks include:

3.1 Weak Governance, Institutional and Regulatory Framework

The legislative framework is weak leading to a poor legal and regulatory regime for instance the electricity act of 1999, Energy policy of 2002 and renewable energy policy of 2007 and currently energy policy draft under review show very little scope in both renewable energy like geothermal and nonrenewable energy like nuclear and peat yet these resources abundantly exist in the country. The institutional set up of Uganda's energy segment was under government control with the concern for energy generation and supply assigned amongst numerous government units it was at this moment that critical energy agreement were sealed [7]. Nonetheless, there is limited harmonization by the different energy units and their regulator. This inadequate synchronization causes a lot of delays with regard to developing energy projects. Moreover, public officials charged with the licensing of energy projects sometimes follow bureaucratic red tape thus causing delays in the development of energy resource. As a result, this creates a lot of distortions in the investment landscape which escalates risks and reduces the level of investment. More so, the wide spread poverty has resulted in limited investment in research and development. As such, the country has continued to lag behind in the areas of innovation. Unfortunately, the country does not have a regional or national research centres which would help in creating new innovations in area of energy systems development [5].

3.2 Grid Unreliability

Another critical bottleneck in Uganda's energy sector is the absence of the grid infrastructure in form of transmission and distribution lines, the existing grid is too old and in a sorry state of disrepair [6]. It has been argued that, building extension high-voltage transmission lines to these remote areas is inefficient and not cost effective [6]. Grid unreliability prevails as a limiting factor especially for large transmissions and this leaves most remote areas in Uganda without access to electricity or at worst using inefficient and very small solar systems. It is noted that some areas in Uganda are not yet connected onto the national grid, for example, Kalangala Island and some mountainous areas. Consequently, to overcome this challenge, part of the population in these places may have to embark on the stand alone energy systems which may be inadequate and inefficient.

3.3 Lack of Human Capacity & Training

Availability of trained professional to build and maintain energy project is crucial for successful development of these energy projects in Uganda. Furthermore, the development of energy conversion technologies calls for special skills in the areas engineering, physics and energy economics and governance, renewable energy technology as well as business management and project planning and development. Nevertheless, capacity building in form of training on the use and development of various energy technologies is crucial for the enhancement of the varied skills of the different groups of people. As such, both users and non-users of energy technologies should be trained on how this resource could be tapped into and used. There is a lot of ignorance by the populace about the various uses of energy conversion technology for the end user. Notably, simple solar energy technologies could be used for cooking food, warming water for bathing and so on. This knowledge seems basic but it is lacking in the majority of the Ugandans. It is not magical to use a box made out of glasses and placed under the sun to cook food, but to a Ugandan, this may sound too abstract. Additionally, the diffusion of solar PV in the villages requires a relatively large workforce with basic technical know-how than having few experts with a lot of technical skills. Ugandans require a platform where they can get technical and engineering training especially the artisans but also create an avenue for them to access spare parts which can be used in their training.

3.4 Inadequate Attention to Research and Development

Presently, there is limited research effort by the government of Uganda in the subject area. The government has done little in encouraging innovations in the area of developing energy technologies, and to be precise there is no any visible effort by the government to fund universities and other institutions of higher learning to conduct research on how to develop energy technologies [7]. Notably, there is no well noticeable energy research and development program that is reinforced with government funding. Additionally, there are clear working systems that could foster quality international research and some collaborations that can speed up skills and technological transfer. More so, the development of energy technologies has been limited by the laxity on the government of

Uganda to provide an enabling supportive environment. As a consequence, the local technical knowledge regarding these products is insufficient and, hence, associated technologies are imported expensively. Nonetheless, with a local skilled and semi- skilled workforce, Uganda could draw closer to the attainment of a sustainable Renewable Energy industry in the near future. This suggests that scholars from multidisciplinary backgrounds and research institutions are needed to champion the research and development activities in the country in the area of renewable energy.

3.5 Huge Initial Investment Cost

On average, over 10 million (or about 28% of the population) of Ugandans are living on less than US$1.90 per day [8]. On small-scale or rural households level, investing in the various electricity components such as; inverters, solar panel mounts, batteries, off-grid solar panels, charge controllers, power optimizers and many energy technology equipment require huge initial capital outlays, which an average Ugandan may not afford. This implies that there is generally low disposable income among the population yet investing in solar technologies require substantial amounts. In Uganda, most SHS are sold on a pre-paid business model. Therefore the Cost of investment in renewable energy technologies are still high and prohibitive.

3.6 High Operation and Maintenance Cost

There are higher operational and maintenance costs for energy projects and there are regulations that require urban dwellers to invest in these technologies. Alternative renewable energy is considered as a substitute to hydro-electricity which constitutes 80% of Uganda's energy mix as it can be used in the urban, rural and remote regions in Uganda. Nevertheless, the associated cost of maintenance and operation of energy projects is remarkably high in Uganda [9]. This is increased cost is attributed to lack of technically skilled human resources and inadequate institutional capability in both the private and public sector that can perform and accomplish energy infrastructures. A case in point, is that, of the 85% of the Ugandan population living in rural areas, only an insignificant number of both public and private sector enterprises are involved in the energy business in these communities [9].

3.7 Competition with Land Uses

Land issues are very complicated especially in Uganda where the land law and property rights are not properly assigned, worse still the intending project to be sited on such land, is non-governmental. There may be a major challenge in siting and securing of permits for RE projects in new locations. Most land in rural communities are for traditional subsistence agriculture being the major occupation of the inhabitants; ownership of such piece of land may also belong to families or communally owned. Most communities are preventing foreigners from owning land for fear of total destruction of their heritage. Since geothermal energy projects on a large scale will involve private participation, prohibiting foreigners from owning land will constitute barriers to their involvement in project development hence a major barrier to large scale application.

3.8 Lack of Information and Public Awareness

The slow development of energy conversion technologies in most parts of the world has been attributed to the lack of information and limited public awareness [10, 11]. Additionally, Peidong Z. et al. (2009) highlighted that, some Ugandans have limited knowledge about energy conversion technologies as well as the associated environmental and socio-economic benefits. For instance the importance of solar radiation in drying clothes and foodstuffs is widely acknowledged in Uganda, though most Ugandans are not aware of the use of biogas and solar technologies to generate electricity, heat water and cook food. This is attributed to little or lack of education or social cultural values especially for biogas. Moreover, many Ugandans know the actual costs of solar kits and related components and/or aware that there are credit facilities to acquire these facilities and maintenance services for acquired systems. This limited awareness and the fear to undertake the perceived risk by investing in these technologies has limited potential energy prospects [9].

3.9 Lack of Information and Public Awareness

The application and development of energy technologies in most parts of the world has been attributed to the lack of information and limited public awareness [10, 11]. The main challenge associated with this limited awareness, is inadequate knowledge regarding the usage, significance, socio-economic and environmental benefits that are accrue from energy technologies [11], coupled with the fears associated with the economic viability of energy installation projects. Relatedly, renewable energy technologies like solar are somewhat new in Uganda, a considerable number of the public sector do not know anything about these technologies or know very little about them. Moreover, the public sector lacks adequate and sufficient training necessary for them to make informed choices (i.e., there is a shortage of practical information). Meanwhile the deficiency of vital information and appropriate awareness has created disproportionality in the energy technology market hence giving rise to a greater risk perception for would-be energy prospects [9]. Nevertheless, the availability of such important data could intensify investors' attention to energy application and development. Additionally, Consumer education has been stressed as one of the top challenges facing the diffusion of PV systems in rural areas in Uganda. There is a great need to raise the awareness levels of the target market of the energy generation options available and their benefits, as well as the hazards involved with using the more dangerous dirty fuels to light their homes. The shortage of entrepreneurial skills and entrepreneurial capacity in the energy sector has limited the marketing of energy products. Lastly, the aspect of awareness that is most challenging to overcome is caused by Market spoilage. In a related development, market spoilage occurs due to the presence of inferior products in the market. In a study carried out by the Lumina Project on LED torches in East Africa, it was found that 90% of the users experienced quality-related problems during the six-month study period. Poor-quality products, although cheap, increase the difficulty of market penetration because the end users no longer trust the technology. In 2009, Lighting Africa began testing the quality of energy products available in the African market. The study revealed that 13 out of the 14 Pico PV products in circulation did not pass their quality tests. A second round of tests was carried out in 2012 when the number of products in the market had risen to 120. The results were similar in that only 46 of the products passed the quality tests. Consumer education is an expensive hurdle that has to be overcome for any energy product to develop a client base, especially in rural parts of Uganda.

3.10 Poor Planning, Coordination and Implementation of Energy Sector Plans

Renewable Energy policy and signing of contracts that are hazardous to local electricity consumers.

4. Steps and Policy Measures to Overcome Them

4.1 Mitigate Governance and regulatory investment Risk

The development of necessary minimum reform processes in political, economic and societal structures that will be needed to manage corruption in a country where corruption is entrenched, establish standards of accountability and transparency in public administration and enforcing established laws are essential in reducing the fundamental barriers of the political and regulatory risk of the country. There is need for political will and determination to address security related issues. Investment risk arising from political factors can be mitigated. However, the regulatory risk must equally be controlled for by refining regulatory structures, RE subsector need to be defined and developed with reputable laws and regulatory framework that RE infrastructure investors a can trust.

4.2 Energy Subsidy Reforms and Cost Reduction Measures

The government of Uganda may undertake an energy subsidy reforms from fossil fuels to renewable energy technologies. More so undertaking this measure will go a long way in bridging the competitive gap that exists between renewable energy technologies such as solar, biogas technologies and fossil fuels (COMSATS; 2005). Moreover, instead of subsidizing kerosene, the government of Uganda should consider channelling its subsidies to renewable energy technology because they provide a cleaner and more efficient source of energy.

4.3 Capacity Building

The knowledge offered by the academic institutions is considered to be a catalyst in capacity building for any country. These institutions occupy an important and envisaged central role, in contributing to capacity building for sustainable energy development. It is anticipated that capacity building can easily be achieved through education and research. It is argued that, the development and success of sustainable energy systems depends on enhancing capacities of the local population through education and as such, in Uganda, Makerere University introduced graduate programs associated with energy studies including Ph.D. and master of Energy Economics and Governance, M.Sc. Renewable Energy with the aim of building capacity in the area of energy systems and resources. It is envisaged that when the students on these programmes, will be having adequate knowledge that could be utilized to promote the utilization of energy and its development in Uganda. By investing in education and training to ensure the availability of skilled employment in the sector, Uganda will be able to accelerate market growth, scale up the number of jobs created- especially in the rural areas and expand energy access. The faster the market grows, the more jobs will be created, and helping Uganda achieve universal energy access targets.

4.4 Competition with Land Uses

Large-scale energy projects are often associated decisions of how large pieces of land ought to be apportioned to competing uses. Most big chunks of land are favourable for agriculture and a serious trade off must be considered for a geothermal project to acquire that land. Land use issues arising from commercial scale energy crops are another area of increasing attention. Government should establish compensations scheme policy which can be offered to affected populations for possessing their source of income (land) for geothermal development and equip them with relevant skills in geothermal technologies to provide alternative job opportunities.

4.5 Reliable Information and Technology Awareness Creation

The execution of large-scale energy applications can only be taken on successfully if there is public acceptability and support. Henceforth, an amplified consciousness of the prospects and benefits attendant with the advancement of energy technologies, and the central advantage for climate change mitigation is quite imperative to expeditiously and noticeably improve the desire and attention among the Ugandan masses. Largely, a consolidated data-based information centre that is all-inclusive and reachable to the public demands to be put up. More so, this centre will be used to maintain records of the numerous experiences attained in the areas of installation, operation and repairs of energy technology schemes and avail the information connected to energy incentives, energy technologies and most importantly the policy framework for renewable Energy's as well as the application of these renewable energy equipment for modest investors. Additionally, the collection of such information could create an important window for learning more about the different energy technologies thereby permitting energy workers to develop and become accustomed to energy technologies for specific environmental settings. Relatedly, the focal point will not only work as a means of appraising resources, but also as a monitoring tool. Consequently, with appropriate administration of the centre, there will be upsurge in overall awareness, acceptance and attention in energy technologies. In this regard, it could be observed that an amplified access energy technology-related info and know-how is central to the effective development of energy schemes in Uganda.

4.6 Smart Grid and Off Grid Solutions by Installing Solar PVs

4.7 Providing Incentives for Replanting Trees to Increase the standing Stock of Biomass

- Expanding the development of bioenergy
- Careful review of Power Purchase Agreements (PPA) and feed in tariffs
- Develop Geothermal energy resource through bilateral arrangements
- Re-assess wind energy feasibility with more recent technologies for more accurate estimates.
- Establish a clear fiscal and financing framework for energy projects.
- Incorporate Clean Development mechanisms
- Promote Renewable Energy and Energy Efficient Programs (REEEP) through distribution of energy saving stove and Fluorescent (LED) energy saving bulbs for households.

5. Conclusions

Uganda has a lot of energy resources abundantly distributed in the country, though there is increased investment into renewable energy in the last decade, and however, more effort is still needed to meet the SDG 7. Capacity building should be increased in the modern energy technologies and increase the financing stream for the energy sector both in the fiscal policy and donor partnerships.

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