Status of Biogas Technology in Swaziland: Challenges and Opportunities

Shiri T, Makota T

Abstract: This paper serves to investigate the status of biogas energy including challenges and opportunities in the Kingdom of Swaziland. Increasing regional energy demand coupled with increased climatic challenges against depleting fossil fuels has seen a number of countries turning to renewable sources of energy to augment the current supply. These include solar, wind power, biomass, geo-thermal and hydro electric power. Swaziland has adopted some of these renewable energy interventions to meet its own energy needs and curb climatic issues. During the study period, it was discovered that there are less than twenty biodigesters across sectors at national level. Despite a strong biomass base, positive regional experiences and favourable climatic factors, the growth of biogas technology industry remains partially stagnant primarily due to shortage of local skilled, experienced project developers and weak policy emphasis. This paper recommends the relevant stakeholders in the renewable energy sector to establish a national biogas programme by exhausting regional experiences. This will help to immediately reduce over reliance on wood fuel, paraffin and LPG, improve energy security, reduces electricity costs to the consumer and lower the energy import bill.

Keywords: Biogas, challenges, opportunities, status

I. INTRODUCTION

Biogas is produced using biomass under anaerobic conditions driven by different microbial consortia. The process takes place in a biodigester. The degradation process that leads to the formation of the gas can also occur in natural environments such as waterlogged areas, wetlands and uncontrolled landfills. A nutrient rich slurry is also produced which can be used as a fertilizer and in waste water treatment to remove lead [1].Biogas can be used for cooking, lighting, heating, vehicle fuel and electricity generation. Wood, certain crops, animal waste and charcoal make up biomass fuels. Biomass fuels have accounted for the largest proportion of Swaziland energy supply at 66% followed by oil contributing 23% and only 8% from coal [2]. There is continued reliance on wood fuel mainly in the rural areas where 70% of the population is made up of middle and low income groups [3], thus according to the 1997 Census Report. Increasing forests depletion for wood fuel, construction and agricultural purposes has led to land degradation in some areas where deep gullies can be observed which poses environmental hazards. The growing gap between demand and supply for wood fuel and inefficient wood stoves exposes communities to consequences of desertification, health and climate change. Despite rural electricity access improving from 26% to 50% between 2007 and 2013, wood fuel has remained the most preferred energy source for cooking [3].

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Mr. Tariro Shiri, Harare Institute of Technology, Harare, Zimbabwe.
Mr. Tigere Makota, Faculty of Social Studies. University of Zimbabwe, Harare, Zimbabwe.

There are no complimentary reforestation programmers to augment the high wood fuel demand. Similarly, urban electricity access was 77% in 2013 [3]. This meant other energy sources were utilised as well which are neither environmental friendly nor renewable [3]. According to the Department of Veterinary and Livestock Services, Swaziland had a national herd (cattle) above half a million as of 2015 and significant numbers for other animals such as pigs and goats [4]. This translates to significant amount of biomass that can be tapped to generate biogas for cooking, heating and lighting.

Local power generation is insufficient to meet national demand leading to overreliance on imports for the bulk of power supplies [2].This is insecure. South Africa which constitutes a significant proportion of electricity supply to Swaziland has proposed cost-reflective tariffs which will affect affordability irrespective of accessibility [2]. Such a scenario will increase the burden on the customers who are already paying more on electricity tariffs as compared to other regional SADC counterparts [5]. It is difficult to control costs of imports. Additionally, jobs are lost when imports are not controlled.

The country produced an average 24, 4% of total energy needs from 2010 to 2015 with the balance sourced from regional partners such as ESKOM, ADM and DAM [6]. Power demand grew by 11.8% during the same period. Low water levels in dams supplying the generation plants have attributed to reduced power generation in some instances. The bulk of electricity energy produced by Swaziland Electricity Company (SEC) is obtained from hydro source accounting for 86% with the remainder obtained from diesel [2]. There is currently one local independent power producer; Ubombo Sugar Limited, with a biomass-based electricity generation system supplying the national power utility. Royal Swaziland Sugar Corporation has a standalone power generation plant that relies heavily on coal and biomass thereby reducing the burden on the national grid. However, they continue to rely on the power utility [2].

Swaziland's favorable climatic conditions, low projects development costs and abundant biomass will serve as key drivers for the growth of biogas technology. Biogas energy will play a crucial role in light of energy, environmental and social landscapes thereby complementing the current power generation mix. Despite the potential impact the technology holds, little has been done in Swaziland mainly due to a limited biomass policy and lack of skilled, experienced local project developers. The international development partners who can give impetus to the dissemination of the technology have not been fully involved.

II. A BRIEF INTERNATIONAL AND REGIONAL OVERVIEW ON BIOGAS PRODUCTION AND DISSEMINATION

The evolution of biogas production was necessitated by the

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need to find a sustainable way of generating energy. Due to the increasing prices of fossil fuels and taxes on energy sources, finding alternative, clean and economical sources of energy has become a major concern for households' and nations' economies [1]. Various countries have explored different methods of generating energy, the use of biogas has proven to yield positive and long lasting benefits to both economies and individuals.

Various initiatives were developed. The IEA Bio-energy Task 37 Biogas Country Overview is a consortium of European, Asian and Latin American nations implementing various ways of harnessing biogas. Biogas production in the IEA Bio-energy Task 37 member countries is clearly dominated by Germany with more than 9000 biogas plants. No other member country today has more than 1000 biogas plants and only UK has more than 500 plants except for Germany, according to the available data. Around 0.5-2 TWh of biogas is produced annually in most countries except for UK and Germany where the production is several times larger. In UK 10 TWh of energy (mainly electricity) was produced from the biogas during 2012 and in Germany the amount of energy generated was 40 TWh, mainly electricity [7].

Opportunities such as favourable policy environment and financial support from governments have seen biogas technology being adopted in most first world nations. Jiang and Christensen [8], observed that there were more than 30 million household digesters in China, followed by India with 3.8 million, 0.2 million in Nepal, and 60,000 in Bangladesh in 2011. Investment in biogas infrastructure in China increased rapidly and according to National Development and Reform Commission 2007 report, it was projected that by 2020, 80 million households in China are expected to have biogas digesters serving 300 million people [9].

The largest renewable energy programs with varying scales of technologies are being implemented in India. One of the strategies used was to promote biogas plants [10], [11]. India began the project half a century ago, and was further supported by the National Project on Biogas Development in 1982 [1]. According to Rajedran and others [1], biogas technology has been pioneered in Asia at varying scales, as a result of intervention from Non-Governmental Organizations such as SNV which installed 23,300 plants in Vietnam

In America, 162 farm scale plants were in operation by 2010, providing energy for 41,000 homes; in addition, 17 plants were operating in Canada [1]. These researchers also observed that the number of farm scale digesters in Europe has increased drastically. At the end of 2011, the number of these digesters was more than 4000 in Germany, 350 in Austria, 72 in Switzerland, 65 in the United Kingdom followed by Denmark with 20 community type and 35 farm scale plants, and Sweden had 12 plants [1].

In some African countries the technology uptake is increasing despite the numerous challenges it faces. This was made possible through establishment of national biogas programmes and several biogas initiatives which saw Non Governmental Organizations (NGO) coming on board [12]. NGO's are involved in providing technical backstopping. Some of these organizations are; SNV, WINROCK International, German Technical Cooperation (GIZ), Netherland Directorate General for International Cooperation (DGIS), Hivos, Biogas Institute of Ministry of Agriculture, China (BIOMA). Six African countries also benefitted through an initiative between African Biogas Partnership Program (ABPP) and DGIS as well as SNV providing the technical advisor [13]. As of 2012, there have been significant small biogas plants installations. Kenya had 1884 household plants, Ethiopia 1140[1]. It was also reported that nearly 2000 and above 2000 biogas plants were installed in Rwanda and Tanzania respectively [13]. South Africa installed both several small and large scale biogas plants [14].

In Zimbabwe, the biogas projects programme were split into two namely the institutional and the domestic biogas programme. These projects were financed by the government in collaboration with UNDP and some developmental organizations such as SNV and Hivos. The government financed the institutional biodigesters programme with UNDP financing some pilot projects. The Rural Electrification Agency was the implementing body. Hivos and SNV were also instrumental in resource mobilization and technical support for the domestic biogas programme. Most of the biodigesters are still functional having been installed three years ago.

III. BIOGAS: THE LEGAL AND POLICY TRAJECTORIES IN SWAZILAND

Much has been done in trying to harness and support the renewable energy sector in Swaziland. A plethora of policies and legal frameworks were enacted, and a generic focus on renewable energy has put the production and use of biogas on the sidelines of the government attention. In 2003, Swaziland adopted a National Energy Policy (NEP), which highlighted the need to develop the renewable energy sector. In the year 2007, the government of Swaziland conducted some reforms in the electricity supply industry. Some of those reforms culminated in the formation of a new Electricity and Regulatory Authority legislation, covering both on-grid and off-grid power systems [2]. However, readiness to adopt the renewable energy, and biogas in particular has been lacking, for example, the IRENA 2014 report revealed that the government needed to resolve several important issues for the country to be ready for renewable energy. The government does not have a regulatory framework specifically aimed at biogas production as a renewable energy.

The Swaziland policy environment is governed by the NEP, the National Forestry Policy, the National Energy Policy Implementation Strategy (NEPIS) and the National Bio-fuels Development Strategy [2].

A. The National Energy Strategy

The NEP, of 2003, used a broad based stakeholder approach and was designed in a participatory mode. NEP was designed to prevail over the challenges of the energy sector transformation and development. According to MNRE, 2003, this was to be achieved through stimulating economic growth and progress by ensuring energy security and energy access, while encouraging job creation and preserving long-term sustainability and health. According to the NEP policy document, all locally available renewable energy resource could play a greater role in achieving NEP aims if a conducive framework was in place [2].

B. The National Bio-fuels Strategy

In an endeavor to promote renewable energy, the Ministry of Natural Resources and Energy (MNRE) in 2008 developed the National Bio-Fuels Development

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Strategy and Action Plan. The major thrust of the strategy was to promote and find ways of replacing fossil fuels with bio-fuels [15]. The plan raised awareness amongst the stakeholders, and advocated much on the establishment of National Bio-Fuels Institutional and Regulatory structures and the enactment of policies to produce, process and market the bio-fuels. The Bio-fuels Strategy and Action Plan was completed in 2011 when it was approved by the cabinet [2].

C. The Public Private Partnership Policy.

This was established by the Ministry of Finance in 2013 in trying to engage the private sector to improve and develop infrastructure and service provision. However, this was developed as a blanket policy, applying to all ministries, government departments and other state owned enterprises and local authorities. It was devised to drive cooperation with private sector. In particular, the policy aim to speed up efficient and cost effective implementation and management of services offered to customers and give precedence to the private sector to focus on its core function [2].

D. The Legal and Regulatory Framework

Two major legal and regulatory frameworks are available in Swaziland. These are;

The Energy Regulatory Act and Electricity Act of 2007

The Energy Regulatory Act and Electricity Act of 2007 led to the creation of the Swaziland Energy Regulatory Authority (SERA) which is mandated to oversee the functions of the electricity sector. The same Act also gave leeway to electricity generation, transmission and distribution to third parties. SERA is also responsible for issuance of electricity production licenses and regulating the tariffs [2].

The Environment Management Act of 2002

This transformed the Swaziland Environment Authority, established by the 1992 Environment Act, into a corporate body .The mandate of the Swaziland Environment Body is to establish a framework for environmental protection and integrate natural resource management, including the promotion of renewable energy.

However, biogas production is rarely mentioned in most of the policy papers yet it has the potential for integration into the country energy generation mix for industries and home consumption, thereby reducing the cost of importing energy. For instance, in the Swaziland Renewable Readiness Report of 2014, the potential contribution of biogas technology towards the growth of the energy sector was not captured compared to other renewable energy options such as hydropower, wind and solar. This is regardless of the fact that biogas is also a centralized form of energy. In another report that sought to survey the household energy access in Swaziland, by the MNRE in 2014, it went silent on the usage and harnessing of biogas. However, another source of renewable energy such as solar was discussed [3].

IV. BIOGAS PRODUCTION IN SWAZILAND

A study was conducted over five months to ascertain the status of biogas plants in Swaziland through engaging the stakeholders in the renewable energy sector. Questionnaires were used for the survey as well as site visits. Total combined national number of biogas plants found was less than twenty. Biogas has been exploited for the past twelve years in Swaziland. Municipalities incorporated anaerobic digestion earlier. The biogas is only used for cooking, heating and flaring. Domestic, farm and institutional biodigesters were installed recently and are less than five years old. All biodigester units installed at households and farms are no longer functional. Table 1 below give a brief description of different biodigesters categories as used in the context.

Biodigester type	Definition
Industrial	Biodigester units installed in industries such as brewery, sugar, paper and pulp and other industries that require advanced and large units.
Domestic	Biodigester units installed at household level
Farm	Biodigester units installed on farms
Institutional	Biodigesters units installed on institutions such as schools, hospitals, prisons, hotels and other public or private institutions
Municipal	Biodigester units installed at municipal waste treatment plants

Swaziland is divided into four regions namely Hohho, Manzini, Shisweleni and Lubombo. Lubombo and Manzini have the largest number of biodigesters with Hohho only having two known plants. Shisweleni has no known record of biodigesters as shown in Table 2. It was also noted that the same region is the most affected in terms of wood fuel availability as well as electricity access [3]. In the same region each cattle owner has on average of 10 beef cattle [4]

Table2. Biodigesters distribution by region

REGION	BIODIGESTER TYPE				
	Institutional	Farm	domestic	industrial	Municipal
HOHHO	1	-	-	-	1
MANZINI	-	2	-	1	1
SHISWELENI	-	-	-	-	-
LUBOMBO	-	-	7	-	-

Domestic biogas plants constitute the largest number of biodigester type installed in the country at 54% followed by municipal plants and farm biodigesters with 15% each. Institutional and industrial biodigesters are the least distributed plants at 8% each as indicated in Fig 2.Industrial biodigesters are set to increase as one plant is under consideration for installation at a distillation company in Lubombo.

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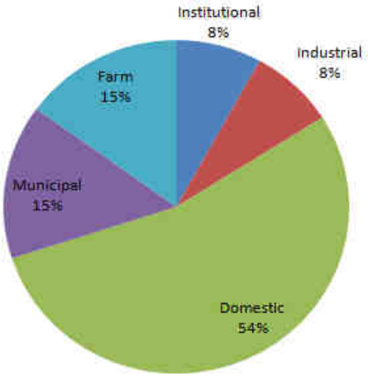

Fig 2.Biodigester installations categorized into Domestic, Industrial, Farms, Institutional, Municipal and Landfill

Swaziland Agricultural Development Enterprise (SWADE) installed the domestic biogas plants as shown in Fig 3. They are tubular type of biodigesters. Fixed dome types are installed at a farm in Manzini See Fig 4.

Fig 3 showing a tubular biodigester in Lubombo

Fig 4 (a)showing a fixed dome biodigesters installed in 2012 at a piggery farm in Manzini

Statistics related to functionality, beneficiary and use of biogas are given in Table 3.There are different types of small biodigesters that have been implemented across the globe namely, fixed dome, floating drum, balloon type, horizontal plants, earth-pit plants and ferrochrome plants [16]. However, the fixed dome biodigester, floating drum and the balloon type are popular in developing countries. Different factors are considered on choosing the appropriate model. Cost of replacement parts, available budget, availability of technical expertise, climate, amount of feed material available and water availability [17]. On a large scale, UASB reactors, EGSB reactors, and CSTR reactors have been in use particularly in large farms, municipal sewer treatment plants, large commercial bioenergy producers, brewery, sugar processing and others. Reasons for the popularity in using these types of large reactors were centered on treatment efficiency and simplified designs [18].

At large scale, Swaziland has a UASB reactor installed at Swazi beverages by Talbot & Talbot from South Africa. The biogas generated can be channeled to other essential uses such as boiler and water heating. Large scale biodigesters were installed by international companies which are in contrast to some of the small scale biodigesters. A large number of small scale biodigesters are no longer functional as a result of problems ranging from construction to droughts issues.

Table 3: Biodigesters statistics in Swaziland

Biodigester type	Functionality	Owner/ authority	Use
Institutional	Functional	Water Kamhlaba UWCSA	Water heating
Industrial	Functional	Swazi Beverage	Flaring
	Under development	USA Distillers	-
Domestic	Non-functional	Rural Households	Cooking
Municipal	Functional	SWSC	Flaring
Farms	Non-functional	Farmer	Heating

(b) showing the second biodigesters installed at the same piggery farm in Manzini during the same year(2012)

V.CHALLENGES OF BIOGAS TECHNOLOGY IN SWAZILAND

In order to fully realize the success of incorporating biogas energy in Swaziland, the following issues need to be considered; limited technology knowledge, droughts, funding and energy sector priorities. Awareness campaigns are still low which are critical to capture the attention of key stakeholders who include farmers, institutional authorities, policy makers and development partners. Poverty levels may also serve as an impediment for the distribution of biogas projects particularly in rural areas considering the fact that there is high initial capital cost with respect to the suitable technology: fixed dome biodigesters. Swaziland being a tropical to near temperate climate, it is preferred to have digesters underground due to the geothermal energy [19], [20]. Failure to introduce financial incentives on renewable energy projects by the government may also reduce the rate of

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uptake of the technology. Financial institutions still perceive the renewable energy sector as high risk [2]. This will prohibit prospective biogas project developers who may want to finance their operations.

Currently there are no committed financial schemes for renewable energy projects although banks are ready to fund any project presumed viable. Limited research work, public database on biogas projects and coordination by academics in the renewable energy industry currently derails the growth of this sector. There is limited literature on biogas activities in the country. The problem is not confined to Swaziland alone; research shows that many African countries lack renewable energy databases [13] .Earlier work done on the status of biogas technology in Swaziland did not specify the actual statistics for the smaller biogas plants despite indicating their existence [14].

VI. OPPORTUNITIES FOR BIOGAS TECHNOLOGY IN SWAZILAND

The Swaziland Household Energy Access 2014 [3] survey noted that most households still depend on wood fuel for cooking at 47.4% nationally. Over 70% and 10.1% also relied on wood fuel in rural and urban respectively during the same period. Promotion of biogas energy can come as a relief to many households particularly those in rural areas with enough biomass. For instance a family with an animal herd of six cattle can obtain about one cubic meters of biogas which is sufficient to cook three meals for 5-6 people [21], [22]. That will translate to significant financial savings and environment protection during the plant' lifespan. Fixed dome biodigesters have an average lifespan of about 20 years [16].

Although droughts can impede the development of biogas technology, solid state biodigester are an alternative viable option in areas that receive low rainfall. These biodigesters require less water for their operation. Rural dwellers can benefit immensely especially considering the availability of biomass and low operation costs. Institutional and industrial biodigesters will less likely face a challenge of drought as they have reliable water supplies. Swaziland had an average of 5.2 people per household in a rural areas as of 1997 [23] . Such a family size can rely on $1m^3$(one cubic meters)of biogas to cook three meals per day [22].Although the 2015 livestock census [4] did not specify the statistics with respect to urban or rural, more animals (particularly cattle) were found in the rural areas as per the 2007 Swaziland Population and Housing Census. This will reduce the burden of electricity costs and low energy access in these areas.

Municipalities, schools, hotels, prisons can also tap this technology as part of their solid waste management strategy to cut down on landfill deposits, greenhouse gas emissions, electricity costs and revenue generation as well as employment creation. The rural electrification programme will also be complimented. Demand for wood fuel is set to fall thereby preserving the environment and improving the quality of air. Swaziland can exploit the good relations that it has with current developmental partners who are involved in several capital projects to consider funding biogas projects particularly at domestic and institutional level. Availability of most project materials at affordable prices required to develop the fixed dome biodigesters is particularly encouraging. In some instances the total implementation costs may be high due to the mountainous terrains. The government, development partners, academics and researchers must work together to formulate a clear road map on a national biogas program.

VII. BENEFITS OF BIOGAS TECHNOLOGY

Developing countries are faced with inadequate budgets and are often criticized for lack of prioritizing key sectors such as health and education. According to Professor Dudley Seers [24], development can only be measured when we look at what has been happening to poverty, inequality and unemployment. If the levels of the three variables were seen to be decreasing, then the intervention may be seen as a critical driver of development. It is not uncommon to associate the impact of a technology with its products in terms of the development it has brought to an ordinary man. However, adopting some essential technologies such as biogas technology in developing countries has seen some challenges being addressed from a social, environmental and economical standpoint.

A.Social benefits

i. The provision of localized and home based bio digesters may lessen the time taken by families and children in fetching firewood. This might give the children, enough time to concentrate on their school work. Additionally, a biogas light can be used for studying purposes at night. Indeed, the lighting quality of biogas lamps is generally better than traditional lighting methods [1].
ii. Anaerobic Digestion in Developing countries can improve the indoor air quality [17]. It was found that smoke from firewood may lead to respiratory and affluence linked diseases [25]-[27].
iii. In the case of Swaziland, the use of biogas might be seen from the gender perspective lens in that it has the potential to empower women. Just like in many developing nations, women and girls do most of the cooking, and therefore, have a disproportionate exposure to indoor rural air pollution in comparison with their male counter parts. This makes them susceptible to some chronic health problems [26], [28]. According to reference [26], 40- 45% of Chronic Obstructive Pulmonary Disease experienced by women in less developing countries is caused by indoor air pollution from the use of biomass cooking fuel. A well adopted technology of this nature may set the path for Swaziland to achieve one of the Sustainable Development Goals of gender equality and women empowerment.
iv. The digestate from the digester was found to be rich in nitrogen, phosphorous and potassium [29], [30]. These nutrients are easily taken up by plants due to the anaerobic digestion process [31]. Hence increase yields. This lead to improved food security.

B.Economic benefits

i. Energy expenses are reduced. Some of the biodigesters have a long life span which shorten the return on investment. Rakotojaona 2013 [21] reported that crop yields increased by 10% to 50% when digestate is used as fertilizer or even more when compared to traditional fertilizers such as compost. Increased yields to the farmer may mean

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surplus which can be sold and boost their income. In Swaziland where the majority of the population is agriculture dependant, the impact of the technology may not be underestimated [32].

ii. The technology leads to job creation. More importantly with popular technologies such as the fixed dome biodigesters which is labour intense. Such a scenario may help cut down the high unemployment rate amongst the youth particularly in the context of Swaziland [32]

iii. Beneficiation of biogas may cut down on fuel imports thereby saving foreign currency. When biogas is upgraded the final product which is pure biome thane can now be used as a vehicle fuel as well as in electricity generation.

C.Environmental benefits

i. High deforestation rates can be reduced when the use of biogas is included in the energy mix. Swaziland Households Energy Access of 2014 report [3] noted that firewood is still the most popular fuel used for cooking purpose This has led to massive deforestation rates. In Nepal, it was observed that the introduction of households' biodigesters decreased the use of wood fuel by 53% with each household saving 3 tons of firewood per year [33].

ii. Biogas technology is essential in reducing the greenhouse gas emissions. Methane which is the rich fuel component of biogas is converted to carbon dioxide when combusted. Carbon dioxide is absorbed by the carbon sinks which are plants and converted to oxygen which is not a green house gas. Methane gas has a global warming potential that is twenty- one times greater than carbon dioxide [17]. Global warming has far reaching consequences such as increased temperature and rising sea levels.

iii. Anaerobic digestion technology leads to a reduction in amount of biodegradable solids to be disposed. This will save on space required for the installation of landfills.

iv. Biogas technology is also essential in treating both animal and human waste which may contaminate water bodies. Nutrients contained in these wastes promote the rapid growth of phytoplankton. This lead to oxygen depletion and death of aquatic life. Some pathogens present in untreated animal waste is the cause of infections worldwide when they contaminate water bodies [17] .

In spite of many advantages of biogas technology, there are some few disadvantages to consider. Individual economic status can also have an impact on the uptake of the system, particularly the need to have finances to cover up for the initial cost. Cost for a small household biodigester, $4m^3$ is shown below in Table 4[13]. The high cost of installation can be overcome if different stakeholders are involved. Subsidy schemes and provision of reliable credit facilities were identified as mechanism that may ease adoption of the technology [13].In the case of Swaziland, the installation cost may be ballooned due to mountains and rocky areas as specialized earth moving equipment is needed to dig the pit in case of fixed dome biodigesters. A similar $4m^3$ fixed dome biodigester may cost USD514.71 in Swaziland.

Secondly recurrent droughts may serve as an impediment in areas that receive low rainfall since process water is required each time feed is introduced in the biodigester. Also the unavailability of organic waste may hamper the development of this technology in some instances.

Table 4: showing cost for installing a $4m^3$ biodigester

Country	*Cost for $4m^3$ digester in USD*
Rwanda	979.08
Kenya	665.37
Uganda	554.97

VIII. RECOMMENDATIONS

In order to increase the dissemination rate of biogas technology in Swaziland, the following factors can be considered;

a) Awareness campaigns by the stakeholders in the renewable energy sector. Examples of some key stakeholders are the Ministry of Energy and Natural Resources, Ministry of Agriculture, Swaziland Environment Authority, Renewable Energy Association of Swaziland and Swaziland Agricultural Development Enterprise.

b) Government to set up a fund to support the pilot phase biodigesters construction. This can also be done through working together with development partners such German Technical Cooperation (GIZ), UNDP, regional counterparts with success stories amongst others.

c) Establish a national biogas programme which will enable the development of skills, manage the biogas fund and help spearhead marketing of the technology.

d) Universities and other research centres to step up research efforts in anaerobic digestion(AD) technology

e) Influence the demand side of the technology by educating the service users about the importance of using renewable energy and conserving the natural resources. Most people might not appreciate how biogas works or how it is produced. This might involve formation of Biogas Technology Dissemination Stirring Committees.

f) Increase coordination among various stakeholders already disseminating the technology as a way of sharing learned experiences and best practices, thereby overcoming perceived and real challenges faced.

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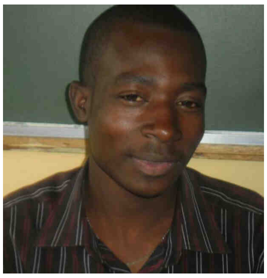
Tariro Shiri holds a Bachelor of Technology Honours Degree in Biotechnology from the Harare Institute of Technology. His research interests include energy technologies particularly biomass based. He drives his inspiration from the provision of pro poor cutting edge clean and affordable technologies which are central to poverty alleviation. He provides consultant services on domestic and institutional biogas projects. He possesses wide knowledge in developing and managing projects and has worked with a wide range of NGOs providing biogas technology in the developing world. He is currently based in Swaziland



Tigere Makota is a holder of Bsc Honours Degree in Social Work from University of Zimbabwe. He is passionate about development models and technologies that are child sensitive particularly ideas and technologies focusing on child protection and that improve their situations and their families. He is a member of the Council of Social Workers, and is currently working as a Case Management Officer in Zimbabwe. He is one of the few researchers to pioneer the implementation of the Case Management Model in Zimbabwe and has extensive knowledge and passion about evolving Child Protection Models and Technologies. He has all-embracing knowledge about working with children and families from diversified cultures.

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