Biogas Technology Uptake in Tanzania: Improving Energy Pliability, Challenges and Prospects

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Abstract

Energy crisis is a serious problem in Tanzania and its shortage is serious especially in oil and wood fuel, particularly in the rural areas. Several NGOs in the country have therefore introduced biogas technology as an alternative source for renewable energy. Despite its potential, the adoption of biogas technology is however low. This paper tries to address the issues through which biogas technology can be harnessed to improve the current shortage of energy in Tanzania. It discusses such a possibility especially by examining three important areas; the current energy status of the country, challenges on uptake of biogas technology as an alternative energy source, and the future prospects of making biogas technology an effective source of energy in the country. Categorically, authors argue that the provision of energy services has to be implemented through an interdisciplinary process that addresses the interface between climate change, energy provision services, and the role and needs of targeted groups within Tanzania. An ideal prospect of biogas technology in Tanzania depends mainly on local anchorage as an important factor for supporting income-generating activities and government financial support towards fulfilling requirements in respect to alternative energy sources. Ultimately, the prospects of biogas technology in Tanzania can be viewed from its usefulness in the fields of rural energy, agriculture, health, residential housekeeping, and environmental conservation, thus contributing to achieving poverty reduction goals in the development policies. The lesson is that lack of government involvement in promoting and supporting biogas activities will negatively affect the speed of its uptake.

Key word: Biogas Technology, Energy, Pliability, Challenges, Prospects

Introduction

This paper intends to explore the socio-economic and legal challenges involved in making biogas technology highly adopted and used efficiently as an alternative source for domestic energy use in Tanzania. Basically, this paper is a literature study of scientific articles that deal with biogas technology, energy utilisation and various government policy documents. The paper has four sections, section one addresses the country profile, its energy status, biogas history worldwide, background of biogas technology in Tanzania and legal frameworks related to biogas technology. Section two presents the challenges facing uptake of biogas technology in Tanzania while section three deals with the prospects of biogas technology on improving energy pliability in Tanzania. Finally, section four presents the conclusion and recommendations.

Background and Legal Framework of Biogas Technology in Tanzania

The Profile of Tanzania

Geographically, Tanzania lies on the eastern coast of Africa, along the Indian Ocean, between latitudes 1° and 12° south of the Equator and longitudes 29° and 41° east. It borders Mozambique, Malawi and Zambia to the south and south-west; the Democratic Republic of the

Congo to the west; Rwanda and Burundi to the north-west; and Uganda and Kenya to the north. Most of the land mass consists of the inland plateau rising gently from the coastal belt and stretching 1,000 kilometres inland, with highland areas to the north and north-east as well as the south and the south-west. The coastline extends for some 1,424 kilometres, with three major islands along the Indian Ocean. These islands are Unguja, Pemba and Mafia.

The Energy Status of Tanzania

Tanzania is amongst the Third World countries facing energy crisis. The crisis is not only limited to shortage of oil but also to scarcity of wood fuel. Tanzania's energy consumption is met by biomass, primarily wood fuel (90%) where 80 percent of this energy is used in rural areas (REA 2008). Nearly 80 percent of the national energy consumption is applied for domestic use mainly for cooking and lighting, and poor households spend a considerable share, up to 35 percent of their income on domestic energy (TDPB, 2013). According to Rural Energy Agency (REA) 2008 report, the excessive dependence on wood fuel for energy has led to the continual depletion of forests which in turn has been resulting into shortage of wood fuel. Due to scarcity of wood-fuel particularly in rural households, people have to use maize stalks, maize husks and sometimes dry cow dung for cooking; all of which provide inadequate and unreliable energy. Furthermore, cooking is carried out mainly on traditional three stone hearths leading to severe health consequences mainly due to indoor air pollution. Women in particular, due to their roles and close interaction with the environment, are the major victims of the domestic energy crisis. Kerosene is mostly used for lighting for more than 80 percent of the rural population. However, kerosene use as is the case with other oil based energy sources is faced with a challenge of continuous rise in price hence becoming unaffordable to majority of the rural population. For many years, there have been predictions that energy supplies particularly oil would run out and cause recessions from which the world would never recover (Day, 2010). The recent reports as quoted by Day show that there would be a gap of 5 percent in energy supply by 2010 rising to 23 percent in 2015 and 32 percent in 2020. He further comments that as the world oil fields are declining, the prices will rise as evidenced from the year 2008 where prices rose from $ 100 to over $ 139 a barrel against a long term trend of under $ 50. The above data is an indication that there is an increasing energy supply gap caused by the diminishing supply of non renewable energy sources.

According to United Republic of Tanzania (hereafter, URT) (2003), one of the challenges facing the Tanzanian government is the failure to reach rural households with modern energy services. According to the Household Budget Survey done by REA in 2008, the proportion of households in Tanzania that were connected to the national electricity grid increased slightly to 12 percent with more concentration in urban areas, and only 2.5 percent in rural areas. It should be noted here that in Tanzania, more than 80 percent of the total population live in rural areas. Even for the population with access to electricity, about 80 percent has very low purchasing power; hence they continue to depend on wood-fuel as a cheaper and easily accessible energy source. Furthermore, in areas with electrification, the energy supply is not reliable. This was revealed by the Minister of Energy and Minerals who in an interview with Corporate Tanzania in 2010, made it obvious that the current energy supply in Tanzania is unreliable due to frequent interruption of power supply and over dependence on mono-source of hydro-power base which is affected by unreliable rainfall as a result of adverse climatic changes (Corporate Tanzania, 2010).

However, there are other energy sources in Tanzania apart from wood fuel and hydro- electric power. These include renewable sources like solar, coal, natural gas, geothermal, and biogas. These are potential energy sources which could be harnessed to meet the growing energy requirements hence reducing over-dependence on wood fuel. Economically, renewable energy sources stand a better chance of supplying sparsely populated areas of Tanzania but have so far not been fully tapped and the fact that they are unaffordable to the majority poor households. Biogas in particular has a big potential for domestic energy supply in Tanzania (URT, 2003). This is supported by the study by Schmitz (2007) which places Tanzania as relatively mature in biogas technology compared to other African countries.

History of Biogas Globally

The history of biogas utilisation shows independent developments in various developing and industrialised countries. Anecdotal evidence indicates that biogas was used for heating bath water in Assyria during the 10^{th} century BC and in Persia during the 16^{th} century. In India, the first digestion plant was built at a leper colony in Bombay in 1859, while in England, anaerobic digestion reached there in 1895 (Biogas works, 1999). The countries with the greatest experience in using biogas are Germany, China and India. Among these, Germany remains the world's leading biogas energy producer which accounts for roughly one fourth of the global biogas installed capacity. The German government has been instrumental in developing the biogas electricity market in the country through development and generation of agricultural methanization plants. The German Technical Cooperation GTZ launched in 1980, chose biogas technology as a focal point of its activities. This resulted in a cross-sectoral scheme that has accompanied and supported the development and dissemination of biogas technology in Latin America, Asia and Africa. A number of biogas dissemination programmes involving GTZ were launched in Bolivia, Colombia, Nicaragua, the Caribbean, Tanzania, Kenya, Burundi, Morocco and Thailand (Ngwandu et al., 2009).

India has a long and varied experience in the field of developing simple and easy-to-operate biogas technologies to suit different climatic conditions and socioeconomic groups of users. According to Bui Xuan An (2002), a top-down centralised government initiative in India, was recommended to promote the design and use of rural energy interventions because there were few options for rural India to alter deteriorating biomass resources. Bui Xuan An (2002) further comments that in India, biogas production has been stimulated by popular publicity campaigns and subsidised construction cost of biogas plants by central and local governments.

In China, the development of biogas received strong government support and at times, subsidies from local government were up to 75 percent. Chinese Government stressed the importance of training local people. They also consider the influence of team and brigade leaders as extremely important for the popular acceptance of biogas technology (Gunnerson and Stuckey, 1998). According to Gunnerson and Stuckey, the biggest constraint in the biogas programmes has been the high price of the digesters.

In Africa, Biogas plants operate successfully in some countries. In Rwanda, bio-digesters have been built in 5 Rwandan prisons and provide more than half of the prisons' kitchen energy, thus saving about 50 percent of wood for cooking. In Nigeria, the Ibadan city has the biggest biogas

installation in Africa providing gas to 5,400 families a month (Brown 2006). The Ibadan city, according to Brown, takes advantage of the city's abattoir where nearly two thirds of animals in Oyo state are slaughtered. In Kenya, biogas dissemination experience, according to Ngwandu et al. (2009) started with educational institutions. Later, the biogas programmes focused on local artisans and commercial outlets working in the private sector. The Kenyan Government also set up the Special Energy Programme (SEP) to coordinate biogas activities. Generally, biogas technology in Africa has not been widely adopted (NOVA Institute, 2013). According to the NOVA institute, the main reason for this is that there is no truly large scale coherent and continuous biogas dissemination as have been seen in countries like China and India. Relatively limited projects have also been conducted by Non Governmental Organizations (NGOs) without support from governments on permanent basis.

Biogas Technology in Tanzania

Tanzania has been among the forefront African countries promoting the use of biogas at the household level as an alternative renewable energy source intended to reduce excessive dependence on wood fuel. According to Schmitz (2007), the history of biogas dissemination in Tanzania dates back to 1975 when the Small Industries Development Organisation (SIDO) built 120 floating-drum biogas plants between 1975 and 1984. In 1982, a parastatal organisation; Centre for Agricultural Mechanization and Rural Technology (CAMARTEC) was founded and charged with the task of dissemination of biogas technology in the Arusha region. About a year after this initiative; a contract on technical cooperation was signed between Tanzania and the Federal Republic of Germany. This led to the introduction of the Biogas Extension Service (BES). In its initial years, the BES disseminated biogas technology mainly in the so-called 'Coffee and Banana Belt', which was the region around Arusha town where particularly positive conditions promised a high dissemination density for biogas plants. CAMARTEC and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) were in charge of implementing this project.

In 1990, the dissemination strategy and project structure underwent decisive changes which resulted into the withdrawal of GTZ from the BES. The project was later seconded to an interdisciplinary team of scientists, mechanical engineers and agriculturists under CARMATEC (Schmitz, 2007). Schmitz further informs that CARMATEC under Special Energy Programme (SEP) provided coordination, support and training of local craftsmen, monitoring and evaluation of biogas technology in the country. There was however no arrangement for credit schemes to help the farmers to acquire biogas plant. High initial costs of biogas installation have limited uptake of biogas technology with exception of only very few rich farmers and some capable institutions.

Apart from CAMARTEC, which has done pioneering work in the design of appropriate digesters as well as promoting the use of biogas technology, several non-governmental organizations have implemented biogas projects. These projects include; Sustainable Rural Development (SURUDE), which was established in 1993 as cooperation between farmers and Sokoine University of Agriculture in Morogoro region. Other biogas projects are MIGESADO, (a Swahili acronomy for 'Miradi ya Gesi ya Samadi Dodoma', meaning *gas projects from cow dung in Dodoma region*). Other projects include: Biogas and Solar Company project established in Arusha region dealing with fabrication and installation of solar panels and biogas plants; The

Evangelical Lutheran Church in Tanzania (ELCT) located in Arusha, Friends in Development Trust Fund (FIDE) based in Babati, Manyara region; and, The Eastern and Southern African Management Institute (ESAMI) based in Arusha. All of these projects focused on developing training courses aimed at capacity building for biogas market promotion. Tanzania Traditional Energy Development Organization (TaTEDO) is another non-governmental organisation that crusades against over-dependence on wood fuel by promoting efficient biomass technologies (improved cook stoves and baking ovens). TaTEDO also conducts capacity building training of artisans on construction and promotion of improved stoves and biogas plants. From the above examples, it is established that by the year 2007, there were about 4,000 biogas plants countrywide most of them using subsidies (Schmitz, 2007).

In 2007, the Biogas for Better Life, an African Initiative was launched. Following this launch, Tanzania biogas stakeholders aimed at the establishment of a National Biogas Programme, Tanzania Domestic Biogas Programme (TDBP). The main objective of TDBP is to support the development of biogas sector and coordination of all relevant stakeholders. Ngwandu et al. (2009) explain the aim of TDBP as supporting the realisation of government policies in the field of energy, poverty reduction, livestock development and rural development. The programme was funded by Netherlands Development Organization (SNV) up to June 2009 after which the programme had to seek funding from other donors. This funding environment of the National Biogas Programme is not promising as it is still dependent on donors. This may result into previous experiences where the withdrawal of GTZ from SEP initiatives led to financial impairment on dissemination of biogas technology.

The biogas history in Tanzania reveals the interest of various stakeholders in biogas sector development. There is potential for networking amongst these stakeholders. What has been missing is coordination which the recent established National Domestic Biogas Programme has a potential of doing. Furthermore, the existence of biogas projects for all this time promises the potential of technological skills. It is established that there is a creditable effort done for strengthening awareness and knowledge of biogas technology. The majority of rural population are in a position to tap the benefits of biogas technology if only effective dissemination is done by innovators. This can be accomplished through awareness creation campaigns, training, seminars and demonstrations to the potential biogas adopters.

Biogas technology involves biochemical degradation of complex organic materials into simple organics and dissolved nutrients, with a methane-rich gas and nutrient-rich liquid as by-products. Biogas technology which converts biological wastes into energy is considered by many experts to be an excellent tool for improving life, livelihoods and health in the developing world. Furthermore, properly designed and used biogas digesters may mitigate a wide spectrum of environmental undesirables. Its use decreases demand for wood and charcoal for cooking and thus helps to preserve forested areas and natural vegetation. It also provides a high-quality organic fertiliser for crop production improvement. Biogas technology is capable of improving sanitation and reducing greenhouse gas emissions which contribute to climate change (Brown, 2006).

Climate change, which is a change of the earth's average temperature over time, has become a popular, controversial topic among major scientific and political issues worldwide. The third

assessment report of the Inter-governmental Panel for Climate Change (IPCC) confirmed that the Earth's climate is changing as a result of human activities, particularly from energy use. It confirms that further change is inevitable. Human activities produce and release greenhouse gases such as Carbon dioxide, Methane, Nitrous oxides to the atmosphere. The concentration of these gases to the atmosphere leads to global warming. Other human activities which cause climate change include deforestation or widespread cutting of trees hence there aren't enough plants to consume CO_2. Methane is another greenhouse gas which is produced through mining, large scale livestock farming, rice paddies and landfills. The use of inorganic fertilisers also contributes to giving off of nitrous oxides, all of which contribute to the increase of greenhouse gases concentration in the atmosphere.

Essentially, the link between biogas technology and climate change can be viewed from the fact that massive emissions of carbon dioxide (CO_2) from the burning of fossil fuels bring substantial effects to the climate. Future stabilisation of the atmospheric CO_2 content requires a drastic decrease of CO_2 emissions worldwide. Energy savings and carbon sequestration, including CO_2 capture/storage and enhancement of natural carbon sinks, can be highly beneficial. Renewable energy technologies provide an excellent opportunity for mitigation of greenhouse gases emission and reducing global warming through substituting conventional energy sources. Rajeswaran (1983) establishes that renewable technologies are considered as clean sources of energy. The optimal use of these technologies minimises environmental impacts by producing minimum secondary wastes which are sustainable and are based on current and future socio- economic needs. Biogas technology in particular is one of the few technologies that utilise wastes as valuable resources.

In describing the rationale behind the promotion of biogas technology, particularly in the rural areas of Tanzania, Rajeswaran (1983) observed that Tanzania with an agrarian tradition is ideally suited to use agricultural residues for the production of feeds, fertiliser, and fuel as a result of biogas technology implementation. According to Tanzania Agriculture and Livestock Policy of 1997, livestock production is one of the major agricultural activities in Tanzania comprising three livestock production systems; commercial ranching practised by National Ranching Company (NARCO); pastoralism, a nomadic livestock keeping which is disintegrating due to increased livestock number, human population growth and expansion of farmland; agro- pastoralism, which is characterised by production of crops and livestock keeping (URT, 1997). This is a major production system commonly practised by agricultural households in Tanzania and is the one which favours the availability of feed-stocks for biogas digesters.

The adoption of biogas technology would not only contribute to sustainable development of rural energy supply, but also livelihoods (in terms of agriculture, health, sanitation, gender and environment). Despite the advantages of biogas and the existence of biogas projects in the region for a reasonable period of time, the response of people towards biogas technology is still low thus necessitating the need to examine the challenges facing biogas technology uptake in Tanzania. Currently, Tanzania energy status show a high consumption of wood fuel which contributes to deforestation and land degradation. Furthermore, modern energy sources are unreliable, unaffordable, and the national electricity grid is inaccessible to majority of people. In this case, there is strong demand for alternative energy sources in Tanzania.

The Legal Frame Work of Biogas Technology in Tanzania

In Tanzania, the legal framework of biogas technology is highly connected to the laws dealing with energy as well as climate change. In this aspect, different laws (including international obligations towards climate change)[1] and a number of initiatives have been undertaken with policies, strategies, and programmes being put in place to address environmental concerns and energy generally. These include the National Environmental Policy; the Environment Management Act, 2004; Rural Development Policy; the Agricultural Sector Development Strategy (ASDS); the Tanzania Assistance Strategy (TAS); the National Strategy for Growth and Reduction of Poverty (NSGRP); and the Tanzania Development Vision 2025. Despite having all the laws dealing with energy and climate change already mentioned as existing in Tanzania, this paper will only discuss briefly the energy policy as well as the Rural Energy Act, 2005.

The Rural Energy Act, 2005: The Act[2] has been enacted to establish the Rural Energy Agency (REA) that is responsible for promotion of improved access to modern energy services in the rural areas of Mainland Tanzania. REA is operated through Rural Energy Fund (REF) within the Agency to provide for grants and subsidies to developers of rural energy projects and for related and consequential matters. Several authorities like Energy and Water Utilities Regulatory Authority (EWURA), Tanzania Electric Supply Company (TANESCO) and Commission for Science and Technology (COSTECH) dealing with energy in Tanzania also derive their powers from this Act. A broad interpretation of the phrase, *'...rural energy projects...'* as well as *'...modern energy services in the rural areas...'* can be interpreted to mean biogas technology has been encompassed within the legislative framework of the country.

Tanzania Energy Policy and its role to Biogas Technology: Tanzania Energy Policy was first formulated in April 1992. Since then, the energy sub-sector as well as the overall economy has gone through structural changes. Where the role of the Government has changed, markets have been liberalised and private sector initiatives encouraged. The current energy focus is to use market mechanisms to reach energy objectives and achieve sectoral efficiency while balancing national and commercial interests. The 1992 policy document has therefore been revised taking into account structural changes in the economy and political transformations at national and international levels. In 2003, Tanzania adopted a new National Energy Policy,[3] which categorically takes into consideration the need to:

a. have affordable and reliable energy supplies in the whole country;
b. reform the market for energy services and establish an adequate institutional framework, which facilitates investment, expansion of services, efficient pricing mechanisms and other financial incentives;

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[1] Among others, Tanzania ratified the UN Framework on Climate Change (hereinafter to be referred to as UNFCC) and subsequently acceded to the Kyoto Protocol to this Convention in April, 1996 and February, 2003, respectively. Consequently, Tanzania officially submitted her Initial National Communication (INC) to the UNFCC in February, 2003. During the development and following the completion of the INC, Tanzania has made some efforts in creating public awareness on climate change issues within relevant sectors and agencies, thereby trying to mainstream and integrate climate change issues across all sectors of government. Other international treaties connected to biogas technology and environment include Convention on Biological Diversity (CBD) and its Bio- safety protocol, the Stockholm Convention on Persistent Organic Pollutants, Ozone Depletion, and the UN Convention Combating Desertification (UNCCD).

[2] Act No. 8 of 2005

[3] The United Republic of Tanzania, Ministry Of Energy and Minerals, The National Energy Policy Para 1.1.1

c. enhance the development and utilisation of indigenous and renewable energy sources and technologies;
d. adequately take into account environmental considerations for all energy activities;
e. increase energy efficiency and conservation in all sectors; and
f. increase energy education and build gender-balanced capacity in energy planning, implementation and monitoring

From the above mentioned policy statements, it can be correctly argued that this policy supports biogas technology in two-fold aspects. One is on supporting research and development as well as application of alternative energy, and secondly is promoting entrepreneurship and private sector initiatives towards affordable and reliable energy.

The practical application of the energy policy in Tanzania resulted into the establishment of REA and REF. However, there is no policy implementation strategy, although there are emerging strategies to promote affordable and reliable energy in the country. Environmentally sound energy technologies like biogas are key candidates for promotion under REA and REF. Biogas technology is one amongst these technologies whose supply and use is both rational and sustainable supporting national development goals, and should meet the Millennium Development Goals.

Challenges for Biogas Technology Uptake in Tanzania

There are several challenges that inhibit uptake of biogas technology in Tanzania. As a result, the potential for wider use is still unexploited. The adoption of biogas technology, like any other technology, entails the whole sequence of events occurring to an individual from the time he/she becomes aware of the technology until the adoption stage. The whole process is referred to as the innovation-decision process, which may involve knowledge, persuasion, decision, implementation and confirmation stages (Roger, 1995). People are rational in decision-making; they do balance between a need to innovate and the expected benefits from the new innovation as compared to the existing or traditional practices.

There are a number of factors associated with the decision for adoption or non-adoption of an innovation. Several studies (Baidu, 1999; Nhembo, 2003; Simon, 2006) have pointed out that adoption and dissemination of new technologies depend to a larger extent on demographic characteristics, environmental characteristics, institutional support services, nature of the technology and its benefits as perceived by the clientele. Such characteristics make adoption responses unique as they are related to the individual, while some are related to the situation in which the individual is exposed to, and yet others to the nature of the practice. In addition, some innovations are also subject to the control and manipulation of change agents while others are not and are specific to the study area and are often incomparable. For the purpose of this paper, these challenges which are discussed hereafter are categorised into Socio-economic, Institutional, Legal and Technological challenges.

Socio-economic Challenges

Socio-economic factors such as education, age, income, gender and cultures are the determinants of an individual's ability to receive information, knowledge and perception towards uptake of the

technology. Furthermore, these factors determine the capability of the household to afford installation costs and operations of biogas plants.

The nature of bio-digester adopted in Tanzania (Chinese Fixed dome) and its raw materials requirements (cow-dung) requires cattle ownership. Biogas technology is therefore greatly linked to livestock keeping. However, the major challenge facing livestock keepers in Tanzania is the diminishing of grazing land and shortage of water, caused by high deforestation rates and drought particularly in central semi-arid zones (Tanzania Bureau of statistics, 2009). Shortages of pastures directly affect quantity and quality of raw materials for biogas plants as well as negatively affecting sustainability of the technology uptake.

Financial requirement is one amongst the factors affecting biogas uptake. The major challenge facing wide spreading of biogas technology in Tanzania, as revealed by several studies is the high costs of installation (Kambele, 2003; Ng'wandu et al., 2009). Generally, biogas technology involves installation, operational and maintenance costs. These costs vary depending on the sizes of bio-digesters and availability of requirements. Installation costs for a normal household biogas plant according to a report by MIGESADO (2009), ranges from Tanzania Shillings 1.2 to 3.5 millions, without subsidy. These costs are too high for an ordinary rural Tanzanian. The implication is that majority of rural Tanzania cannot afford the construction costs of biogas plants.

The economic development of Tanzania, which is similar to that of most developing countries, is confronted with a perpetuation of increasing poverty. The country's economy depends on agriculture where 80 percent of the population depends on smallholder primary agricultural production, which is characterised by the use of hand tools and reliance of traditional rain-fed cropping methods and animal husbandry. According to URT (2010), poverty rates remain highest in rural areas; where 37.6 percent of rural households live below the basic needs poverty line as compared to 24.1 percent in urban areas. The implication is that the majority of rural Tanzanians cannot afford biogas installation costs, hence subsidy is inevitable. Although it encourages low income rural population to adopt the technology, the subsidy approach that is based on donations as revealed by MIGESADO project reports, is neither reliable nor a sustainable source of funds for biogas projects. Many biogas projects depend on donor funds to be able to give the subsidy to their customers. Unexpectedly, the National Biogas Programme that was recently established in Tanzania also falls in the same trap of depending on donor funds, which from previous experiences have already proved unreliable and unsustainable (Ngw'andu et al., 2009). Poverty, on the other hand has increasingly become an environmental destructor where the poor have no option but to overexploit the natural resources in order to survive (Schmitz, 2007). Additionally, the poor cannot afford modern energy technologies which would reduce overdependence on fuel wood.

Gender is another socio-economic factor that can positively or negatively influence the uptake of a technology, depending on family responsibilities and ownership of resources within the family. Women, particularly in rural areas are among the majority poor who depend entirely on natural environment and are the most hit by environmental degradation (Wawa, 1999). Analysis done by Budlender (2008) in Tanzania shows that women are more involved in firewood collection than men where participation rate for women is 38.9 percent while for men it is only 17.1

percent. Women would prefer biogas technology as an alternative energy but its adoption is determined by men who unlike women, are not directly affected by domestic energy problems. Traditionally, men dominate household decision making and resources ownership. The implication is that if a man who is a decision maker and controller of household resources is neither convinced nor willing to adopt biogas technology, he would decide not to adopt it. Additionally, the burden of unpaid workload like firewood collection, water fetching, food preparation, home maintenance, and family care especially for children, old people and sick people is mostly done by women; these consume most of their time. Women therefore have diverse, pressing needs to attend to, and may have little time to involve themselves with new technologies.

Women's educational constraints are another challenge leading to their lack of access to information, skills and technical expertise. Khasiani (2000) in her study on enhancing women's participation in governance revealed that one third of women in Kakamega and Makueni districts in Kenya, are illiterate. She observed that women are not of the favoured gender and are therefore not targeted for skills development. Marcelle (2000) with the same concern recommends that women should have access to well-designed training programmes that develop hands-on skills and that they are provided with motivational training materials, user friendly manuals and local user support. Karlsson (2003) describes a case study in India where rural women in Huluvangala village had rejected the stove technology disseminated under the government programme. Two NGOs in the area consequently realized the need for new dissemination strategy. The NGOs thereafter engaged themselves in a dialogue with rural women on various aspects of the stoves design, performance, durability and efficiency so as to select a stove that would cater for women's needs and their expectations. A training programme was therefore tailored to meet the site specific conditions and the women were trained in stove construction. The result was that the women in the village not only used the stoves, but they were also able to sell their services to other women and encouraged more women to use the stoves.

The existing studies further show that cultural challenges are related to certain beliefs and peoples' perceptions. In Tanzania, biogas is known to result from the combination of cow dung and human manure as feed stocks for biogas plants. Schmitz (2007) observed the reluctance of biogas users to connect their biogas plants to pit latrines. The reluctance was due to biogas users regarding handling bio-slurry from toilet connected to bio-digesters as hazardous or unclean. However, connection of biogas plants to the latrine could be an alternative means of supply of feed-stocks in addition to cow-dung which seems to be unreliable in some household. This reluctance could be attributed to limited information about the technology and not to a general resistance of people towards biogas technology uptake in Tanzania.

Institutional Challenges

Institutional support is another factor affecting adoption of a technology. Rejection or acceptance of a new idea largely depends on how the information is relayed from the source (Kalineza, 2000). Information sources include government agents and non-governmental organizations dealing with energy issues. The government in particular is assumed to influence the adoption of biogas technology through its policies, extension services, awareness creation campaigns and through financial support. Extension services, for instance, are known to catalyze awareness, organization, and information exchange and technology promotion among individuals.

Information dissemination problems may limit people's ability to correctly anticipate the long-term profitability of a given technology hence negatively affecting its adoption.

Promotion of any innovation has a direct link with the country's policy environment. Unfortunately in Tanzania's energy policy, there is no statement clearly directing on implementation of alternative sources of energy. Lack of a policy statement by the responsible Ministry has had negative implications on implementation efforts towards biogas sector development. Furthermore, the Tanzania energy policy encourages commercialization as well as private sector participation in the development of energy sector, but the efforts for promoting renewable technologies have been left with the private sector without clear coordination. As a result, there is minimal effect and many projects are unsustainable (Sawe, 2009). REA for instance, intends to enhance investment in energy supply through private sector. However, the investment and overall interest of commercial actors over the years have been insignificant (URT 2003). These projects by nature attract substantial capital investment. According to URT, there is lack of adequate capacity of these private sectors in design, manufacture and market distribution and maintenance of renewable energy technologies due to financial constraints. Other challenges facing biogas dissemination in many developing countries are frequent changes in the government policies, rising interest rates and decreasing subsidies (MIGESADO, 2009). These changes have disappointed investors in long-term biogas development and in turn the progressive farmers who would like to have biogas, and have become doubtful about their long-term biogas investments. Government involvement in biogas promotion is required in the following areas; promotion, coordination of implementers of the policies as well as creation of an enabling environment for both biogas projects and beneficiaries.

Legal Challenges on Biogas Technology Uptake in Tanzania

The legal framework related to biogas technology uptake in Tanzania is viewed from three main aspects; namely, biogas production, promotion and use. The first and most important challenge in making maximum pliability of biogas is seen from the fact that there is currently no umbrella legislation specifically governing the production, promotion as well as use of biogas technology. There are however various laws and regulations that contain provisions which may be applicable to biogas technology but they are very general. These laws dealing with biogas technology are viewed from different angles, like land ownership and land use planning, food security, environmental protection, social guarantees as well as trade and investment.

It is a matter of fact that legislation is one of the main instruments by which the Government steers and controls the development of the energy sector. Generally, some legislation is missing and the existing laws are outdated and consequently do not reflect recent developments. There is a need to update the legislation and existing laws like the National Energy policy of 2003 (URT 2003). Generally, it can be argued that the current laws dealing with biogas technology do not adequately address the issues of liability and responsibility. There is therefore a need to make more elaborate provisions in the existing laws on the issues of rights, duties and responsibilities in respect to the biogas technology in Tanzania. The legislations in respect to biogas technology ought to be well framed and developed putting main consideration on the country's socio- economic issues. There must be legal interventions for biogas production, promotion and use in the country.

Technological Challenges

Technological characteristics of an innovation are very important determinants of its uptake. The availability of maintenance services is deemed necessary for good performance of biogas plants, hence the realisation of benefits of biogas technology. This in turn facilitates dissemination of information to potential adopters and influences the adoption of biogas technology. Good performance and reliability of biogas plants are good advertisements for biogas technology; the vice versa is also true that poorly functioning bio-digesters cause not only capital waste but also do a lot of harm to the reputation of the technology itself and to the desired future of biogas programme (Ghimire, 2008). Schmitz (2007) on his feasibility study for biogas technology in Tanzania reported that unavailability of maintenance and repairs services, spare parts and appliances such as gas lamps is a common problem in Tanzania and that biogas units were non-operational because in the past, one appliance failed. This situation according to Schmitz disappointed biogas users and resulted into the technology being abandoned.

Competing Technologies

The main competing product for biogas technology with regard to cooking are improved firewood stoves. These stoves are available at lower costs; in the year 2011 they cost Tanzanian Shillings ranging from 15,000 to 50,000 (equivalent to US dollars 9 – 31). This is definitely cheaper than the high costs of biogas plants installations. The improved stoves use firewood with a reduced consumption at least by half, which leads to saving of firewood and reduced indoor air pollution. However, for biogas technology, the initial costs are high but after they have been paid, the operational and maintenance costs are usually low as the raw materials for bio-digesters are locally available and easily operated by household members.

Other competing products to biogas technology could be stoves fired by Liquefied Petroleum Gas (LPG), but the realisation of this competition depends on the availability and affordability of LPG to rural populations. For lighting, the solar panels could be considered as the competing product to biogas technology. However, its costs are relatively high for rural residents. In 2011 for instance, costs for a normal household-use solar panels for a readily installed system were about Tanzanian shillings 330,000, which is equivalent to US dollars 206 (Schmitz, 2007). However, in comparison to biogas technology, Schmitz observed that a biogas lamp will always shine brighter with longer daily operating times than a solar powered lamp. Furthermore, biogas technology has got multi-advantages when compared to the mentioned competing technologies. It therefore stands as a better and appropriate sustainable energy for the rural population in Tanzania.

Prospects of Biogas Technology on Improving Energy Pliability in Tanzania

Prospects of biogas technology on improving energy pliability in Tanzania are discussed from the point of economic prospects, coordination of biogas actors, and policy and law toward improving pliability.

Economic Prospects

High installation costs of bio-digesters have been mentioned by many studies as being an obstacle for the large dissemination of biogas technology, especially to the poor rural population hence efforts have to be made to reduce construction costs. The government through its Rural Energy Agency should introduce credit schemes; soft loans as well as subsidies if rural people

are to adopt alternative energy sources like biogas. This is due to the low income status of rural populations where people cannot pay in lump-sums for biogas plant construction. Subsidies on construction materials as well as to institutions dealing with biogas dissemination could reduce the costs of biogas plants hence enable many people afford the costs of construction. People need to be educated on the on-going high rates of environmental destruction which have higher potential future costs than what could be incurred now by constructing a biogas plant. Furthermore, the commercial approach proposed by some scholars to be adopted by Tanzania Domestic Biogas Programme needs to be monitored legally and by the responsible ministry to ensure economic benefits to both biogas projects and biogas customers. The current environmental degradation, particularly desertification threats, proposes that people will have no option but to turn to renewable energy technologies. This means that governments have to prepare an economic enabling environment to promote such technologies.

Coordination of Biogas Actors

Biogas issues cut across different government sectors such as energy, environment, agriculture, economics, education and health. There should be a unit to play a coordination role for biogas activities nation-wide. It is hoped that the newly established National Biogas Programme (TDBP) if well planned and fully supported by the responsible ministry, will ensure sustainability and the implementation of set strategies for the development of biogas sector in the country. Biogas technology in Tanzania is not new and has been in existence for a reasonable period of time; hence TDBP should critically examine the short comings so far addressed by different studies, researches and experiences of long existed biogas projects like CARMATEC and MIGESADO. This will help to improve the biogas technology and add some value to make it more attractive and at the same time remain affordable to the rural population as compared to other energy alternatives. The coordination of research and development of the technology has to be designed efficiently, sustainably and possibly centralised to ensure the use of research findings for the improvement of biogas sector. On the other hand, the flow of information, feedback and experiences from biogas projects and biogas users has to be secured as well.

Policy and Law towards Improving Energy Pliability

The examination of policy and existing laws determine the role of different institutions with regard to biogas technology. The historical background of the current Energy Policy of Tanzania (2003) dates back to April 1992. Since then, the energy sector has undergone a number of changes;[4] this necessitates adjustments to this policy.

The National Energy Policy (URT, 2003) takes into consideration the need to enhance the development and utilisation of indigenous and renewable energy sources and technologies. It mentions renewable energies in general but does not specifically discuss biogas technology. The policy also identifies the need to establish norms, codes of practice, guidelines and standards for renewable energy technologies and the need to facilitate the creation of an enabling environment for the sustainable development of renewable energy sources. The point here is that once this policy statement is broadly interpreted, then some actions and strategic plans will be put in place to specifically address all challenges towards making biogas technology one of the most effective energy alternative sources in the country.

[4] These changes include changes in the role of the government from a service provider to a facilitator, liberalisation of the market and encouragement of private sector investment.

Despite this existing gap in policy and laws towards biogas technology uptake, an overview of other relevant laws goes a long way in providing basic environmental, social and investment guarantees, particularly to bio-energy development in Tanzania. For instance, wood-fuel is the main source of energy for both rural and urban communities in Tanzania. Therefore, legislation affecting this activity such as the Forest Act does provide a comprehensive regulatory framework governing access to and protection of forest resources.

Similar protection mechanisms can be found in the Environmental Management Act (EMA) that incorporates many of the principles of international environmental law. Like the Forest Act, EMA mandates the use of environmental impact assessment as a precondition to the granting of permits for natural resource use. EMA also governs quality standards for air pollution, water and soil, thus offering a good mechanism for pollution control in Tanzania. EMA further foresees the possibility of using economic instruments such as pricing, tax relief and subsidies for advancing environmental objectives. While no economic instruments are currently in place, these incentives made possible by EMA could promote the sustainable production of bio-fuels. In addition, under the existing legal framework, areas rich in biodiversity either receive total or partial protection under the law. Areas rich in biodiversity are declared protected areas where human activities such as crop cultivation are prohibited. In summary, it can therefore be correctly argued that having a national energy policy that proposes the well defined strategies on promoting production and use of biogas technology in the county is one step forward.

Among others, the prospects of biogas technology in purview of Policy and Law towards National Mode of pliability can be seen from the fact that the current National Energy Policy makes special attention to gender and environment. Para G of part 2.2 of the National Energy Policy (URT, 2003) clearly provides that:

> *Inferior energy practices, particularly among poor households in rural and semi-urban areas, are mainly affecting women. The search, collection, and use of fuel-wood are associated with heavy and often low-productive time-consuming work, mainly performed by women. It also represents a serious health hazard through smoke and carbon dioxide generated by application of inferior stoves/fuel types. The energy policy, therefore, introduces an institutional focus on improvement of rural and semi urban energy practices in order to reduce women workload and to involve them in the problem solving and decision-making processes on energy issues. Women are under represented on the supply side of commercial energy. The involvement of women at all levels of the sector shall, therefore, be prioritised to better utilise available potential competence and capacity. Training and incentives for increased female participation as decision-makers at all levels need to be encouraged.*

Furthermore, part of Para 2.2 of the National Energy Policy (URT, 2003) in respect to environmental issues provides that:

> *Crosscutting all energy sub-sectors and all relevant sources of energy are the environmental impacts of energy exploration, production, distribution and consumption. Environmental impacts and hazards shall be addressed by rigorous environmental management regimes on all energy activities and by applying the economic instruments*

for changing market behaviour. This will discourage any use of environmentally unsound energy technologies (energy inefficiency, unclean practices).

From the above observations, it has been established that the future of biogas technology in Tanzania rests on policy and legal instruments both of which should provide for spearheading the uptake of the technology.

Conclusion

It can be concluded that the uptake of biogas technology has remained low despite the potential and availability of favourable conditions and the long existence of biogas technology in Tanzania for a reasonable period since 1975. The challenges for low uptake as revealed by different studies are categorized into four major groups; socio-economic, technological, institutional and legal challenges. There must be collective efforts from biogas stakeholders and the responsible ministry to minimise the challenges and strategically plan for the future development of biogas technology in Tanzania.

Generally, Biogas technology has the potential of providing numerous environmental and socio-economic benefits such as reduced rates of deforestation, improved indoor air quality, sanitation improvement and saving time particularly for women to engage in income-generating activities. These benefits mediate the current crises caused by environmental degradation and climatic changes which require both regional and international efforts. Technologically, it is only when biogas technology fulfils the perceived benefits that it can then be an economic investment for the owner. From the legal aspect point of view, there are currently no umbrella legislation specifically governing the production, promotion and the use of biogas technology. It can be correctly concluded that legal provisions within Tanzania may foster more adoptive measures towards biogas technology uptake.

Recommendations

Rural electrification programmes in Tanzania with the current distribution speed, sparse population and low purchasing power of rural populations may remain a dream which will take many years to be realised for the rural population. Improved renewable energy technologies like biogas and realisation of its benefits would make this dream come true.

The intentional commitment of government institutions in biogas promotion is vital as learned from success stories of countries like Germany, China and India. The responsible ministry in Tanzania should improve policy environment in favour of biogas technology through setting appropriate energy policies, implementation strategies and coordination of implementers to ensure enabling environment for both project developers and targeted beneficiaries. Normally, the political leaders have a crucial role to play as they have political convincing power in both policy reviews and in promoting technology through media and through incorporating renewable energy technologies in their development plans. Promotion of financing schemes for biogas investment is crucial as customers will face difficulties in purchasing biogas plants in cash.

Capacity building and technological improvement is very important. It is recommended that biogas programmes should conduct training of local masons and technicians and sufficiently equip them. Training of local technicians is vital in ensuring availability of maintenance and

repair services within a reasonable radius, timely delivery and affordable costs. In addition, biogas projects should ensure availability of appliances at the local level. This could be done through collaboration with local business persons for spare parts to be available in local shops. Training of local technicians will ensure easy access to technical services as well as creation of employment to rural people. Furthermore, experiences from other countries such as India have shown that involvement of women in all stages of technology development resulted into the success of such programmes. It is recommended that project developers emphasize the training of women since they are the ones who operate biogas plants.

Regarding policies and laws, it has been observed that there is no specific law to deal particularly with the biogas technology in Tanzania. It is therefore recommended that the law making organs think of a legislating modal law that will ensure among other things, uptake procedures for biogas technology. Furthermore, jurisprudentially, it is only when there are legal sanctions that implementation of programmes and policies are maintained.

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