

Evaluating the Adoption of Biogas Technology as an Alternative Sustainable Energy for Cooking In Tanzanian Households

Wilson B. Kiunsi¹, Raphael Iddphonce Mkini²

Mbeya University of Science and Technology, Mechanical Engineering Department, P.O. Box 131 Mbeya Tanzania

Abstract: Households in Tanzania use a combination of energy sources for cooking and lighting, such sources may include firewood, charcoal, kerosene, LPG gas, and electricity. More than 90% of Tanzanian primary energy is supplied by biomass, and most of this energy source is used for cooking in households (URT, 2003; MEM, 2011). This high reliance on biomass material has created an environmental burden and threat of forest disappearance in the country. On the other hand, over consumption of forest has resulted to a number of other negative impacts such as soil degradation, water sources degradation, and disruption of rainfall patterns. This paper assumes that biogas production technology has the great potential to reduce the high reliance on biomass (forest and woodland in particular) and in turns mitigates the environmental impact resulted by over consumption of biomass. More than 85% of Tanzanians rely on agriculture activities as the main source of income, and there is a positive relationship between agriculture development and biogas production development particularly in the rural areas. The study reveals that there has been a dramatically increase of adoption of biogas production technology in the country since 2009 to date. Up to 2009 there were 103 biogas plants countrywide, and up to 2013 a total number of 3819 biogas plants were already built in the country, an increase of 3608% of actual biogas production across 13 Regions in Tanzania and this is done through 11 different Biogas Agents. Disseminating this technology to most families living in rural areas, and some living in urban areas will significantly conserve the environment, improve agricultural activities, hence improve the food chain, and create employment particularly to youths in these areas.

Keywords: Biogas Production Technology, Adoption, Rural Areas, Environmental Conservation.

1. INTRODUCTION

Most of the African countries spend a lot of their foreign exchange earnings to import fossil fuels (Karekezi, 2002; Kiplagat et al., 2011), while electricity access in many African countries varies between 10 per cent (Mshandete and Parawira, 2009) and 24 per cent (Barry et al., 2011). While rural areas lack the service of electricity, Murphy (2001) states that only the wealthiest rural residents can afford connections. Besides low affordability, the low access rate to electricity is possibly explained by the decentralized nature of human settlements (Hiremath et al., 2007), which implies high distribution costs for centralized power systems and a need for high technical, and managerial capabilities (Karekezi, 2002; Mbuligwe and Kassenga, 2004). After all, 94 per cent of the African rural population and 73 per cent of the urban population use low quality biomass energy sources in the form of firewood and charcoal as their primary source of energy (Bailis et al., 2005). Hereby, firewood is mainly used in rural areas, whereas the urban poor primarily use charcoal. The remaining households use a combination of kerosene, liquefied petroleum gas (LPG) and to a limited extent, electricity (Bailis et al., 2005).

Energy Situation in Tanzania:

In fact, majority of rural Tanzania population has no access to modern energy services. Modern energy is defined by REA (2008) as the energy that is based on petroleum, electricity or any other energy forms that have commercialized market channels, the energy that has a higher heating or energy content value than traditional biomass fuel, and that which may be easily transported, stored and utilized (*opp.cit*). According to the household budget survey done by REA in 2007, the proportion of households in Tanzania that are connected to the electricity grid increased slightly to 12% and coverage by the grid continues to be concentrated in urban areas, with rural coverage of only 2.5%.

Around 90% of Tanzanian energy consumption is met by biomass, primarily fuel wood and over 80% of this energy is used in rural areas (REA, 2008). The excessive dependence on fuel wood for energy has led to the continual depletion of forests, which in turn results, into shortage of fuel wood. Fontana and Natali (2008) in their study observed that nearly every household in Tanzania uses firewood for cooking; some households have in addition, kerosene or charcoal stoves. Fontana and Natali (opp.cit) further observed that an average Tanzanian household consumes about 7 kg of firewood per day and cooking is carried out mainly on traditional three stone fireplaces leading to severe health consequences mainly due to indoor air pollution.

According to URT (2003), one of the challenges facing the Tanzanian government is failure to reach rural households where only 2% of the population has access to modern energy services. Even for the population with access to electricity about 80% of the population has very low purchasing power hence opt to depend mainly on fuel wood as a cheaper and easily accessible source for cooking energy. Furthermore, in areas with electricity, the energy supply is not reliable and unaffordable to the greater part of the population. In urban areas of Tanzania, according to Sawe (2009), only 37% of the population has access to electricity, and poor families spend up to 35% of their income on energy.

2. METHODOLOGY

To achieve the objective of this study, a number of methods were considered in data collection and analysis.

2.1 Data Collection:

Data were collected through field visit, questionnaire, direct interview, and reviewing relevant information from literature.

2.2 Data Analysis:

The collected data were interpreted and compared with the current situation measuring the scale of adoption of biogas technology, environmental impact associated with deforestation, and challenges facing the technology implementation.

3. RESULT AND DISCUSSION

3.1 Biogas Production Technology:

Biogas is produced by methanogenic bacteria acting on bio-digestible materials in absence of oxygen in the process known as anaerobic digestion. Anaerobic digestion is basically a simple process carried out in a number of steps that can use almost any organic material as a substrate. It occurs in digestive systems, in marshes, rubbish dumps and septic tanks (Harris, 2005). Biogas is mainly composed of 50 to 70 percent methane, 30 to 40 percent carbon dioxide and low amount of other gases like Hydrogen (5-10), Nitrogen (1-2), water vapor (0.3) and traces of hydrogen sulphide (FAO/CMS, 1996), see figure 3.1.

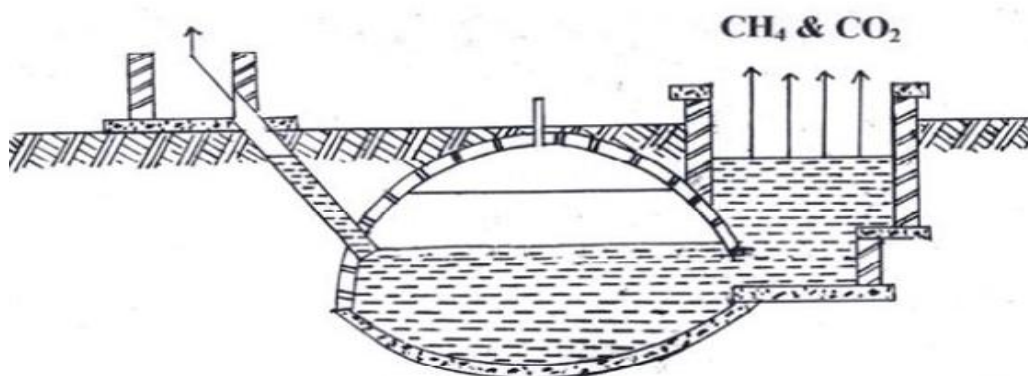


Figure 3.1: CH₄ and CO₂ Emission Form Conventional Biogas Plant (Source: Flavin, 1989)

It takes 1–2 cows, 5–8 pigs, or 4 adult humans to supply adequate daily feed-stocks for a single-household bio-digester (Brown, 2006). The daily input of dung and urine from a single cow produces 1–2 kilowatt- hours of electricity or 8–9 kilowatt hours of heat. In most African applications, a household biogas installation provides sufficient energy for cooking and some lighting. Production of energy is influenced by factors such as microbes, plant design, construction materials, climate, chemical and microbial characteristics of inputs, and the inter-relationships among these factors (FAO/CMS, 1996).

The Need for Biogas in Tanzania:

With a Purchasing Power Parity (PPP) of US\$ 1300 per capita and 37% of the population living below the poverty line, Tanzania belongs to the poorest countries worldwide. This is, among others, reflected in the low share of commercial energy use; see Table 3.1.

Table 3.1: Energy sources and their use in Tanzania (Source: Schmitz 2007)

Energy Consumption by source	TJ	Percentage
Coal and coal products	126	0.00%
Crude oil and natural gas liquids	26293	4.20%
Hydroelectric	7829	1.20%
Primary solid biomass (fuel wood, charcoal)	589460	93.70%
Biogas and liquid bio-fuels	14	0.002%
Others	5485	0.90%
Total	629,207	100.0%

From Table 3.1, almost 94% of the country’s energy requirement is met by biomass, primarily wood fuel and over 80% of the total energy consumption is used in rural areas. The high consumption of wood fuel contributes to deforestation and soil degradation. Nearly 80% of the national energy consumption is applied for domestic energy (cooking and lighting). Poor households spend a considerable higher share (up to 35%) of their income on domestic energy.

Domestic biogas contributes to sustainable development and reaching the UN Millennium Development Goals. Domestic biogas installations provide benefits in the fields of (rural) energy supply, agriculture, health, sanitation, gender and environment. The programme joins-in well with the development intentions of the Government of Tanzania. Notably, a national biogas programme will support realization of Government policies in the fields of energy, poverty reduction, livestock development, rural development and SME development.

Biogas Technology Adoption in Tanzania:

Technology adoption is a process through which an individual or organization decides to full use of an innovation in their daily business (Rogers 1995). Adopting a technology according to Abukhzam and Lee (2010) depends on many factors which cause a prospective or targeted user to adopt or reject the technology. These factors as mentioned by Manros and Rice (1986) include absence of users’ involvement, lack of understanding, technical difficulties, lack of training and inefficient support from top management and perceived technology complexity. These factors can contribute to technology adoption success or failure. According to Senkondo *et al.*, (1999) adoption encompasses incidence, intensity and rate of adoption. Incidence adoption is the percentage of people using a specific technology at a specific point of time, the intensity of adoption as the level of adoption of a given technology while the rate is the proportion of people who have adopted new technology overtime (wawa, 2012).

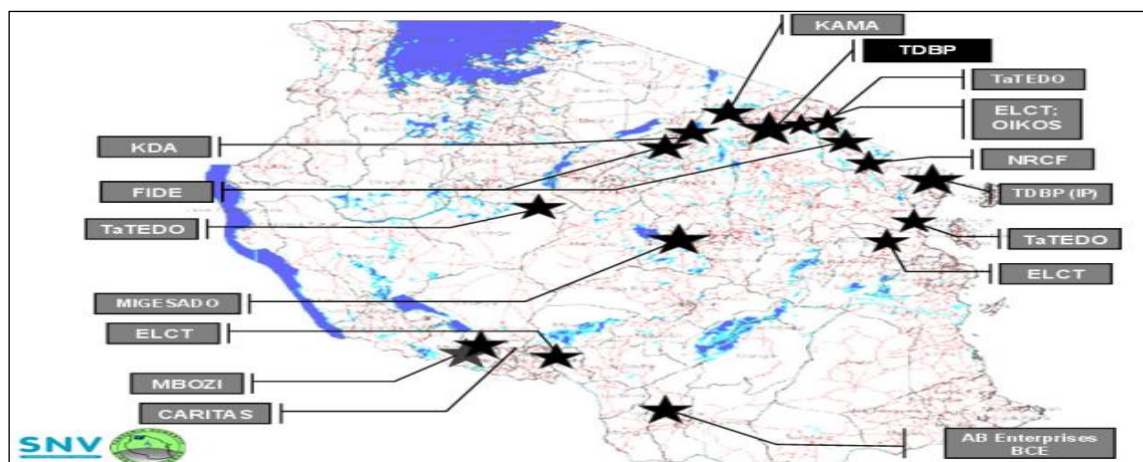


Figure 3.2: Spread Biogas Plants in Tanzania

Results in figure 3.2, shows the spread almost 14 agents are involved building biogas plants in Tanzania. The areas for biogas plants are scattered to different regions all over the country. These regions include Mbeya, Mwanza, Arusha, Kilimanjaro, Ruvuma etc. However some of the central parts in Tanzania are not involved by main programme.

Table 3.2: Biogas Plants Built by different Agents in different Regions

ORGANIZATION	REGIONS	BIOGAS PLANTS
TDBP	4	1153
FIDE AND BCE	2	547
ELCT	8	389
NRCF	1	252
MIGESADO	1	336
KDA	1	230
CARITAS/KMB	2	494
OTHER BCF	6	593

In other developments, the targets and actual Biogas Plants between 2009 and 2013 are presented. Results as shown in

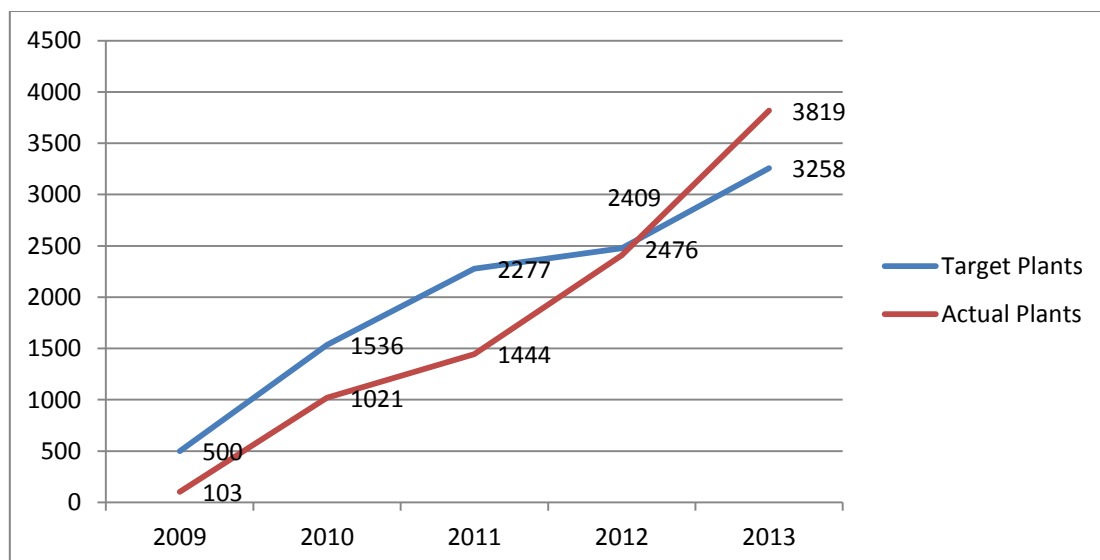


Figure 3.3: Target and Actual Biogas Plants between 2009 and 2013; source

Results in figure 3.3 shows that between year 2009 and 2013, actual biogas plants constructed by agents indicated in Table 3.2 were 103 and 3819. From figure 3.3 reveals the sum of 3716 Biogas plants were built within a period of less than 4 years. This is an increase of 3607.8%, whereby targeted biogas 3258 and actual constructed biogas plans were 3819; this was 117% increase of biogas plants in 2013 alone. This gives evidence clearly that adoption of biogas technology in Tanzania is increasing.

Significance of Biogas Technology Adoption in Tanzania:

With an average consumption rate of 15 million tonnes of firewood annually by 80% Tanzanian families living in rural areas, the estimated 33.5 million hectares of forest and woodland in the country are under a threat of disappearing (National forest policy, 1998). This calls for urgent interventions to introduce most Tanzanian households relying of firewood and charcoal to other sustainable energy sources such as biogas to meet their energy demand for cooking. It is reported by Household budget survey (2007) that 73.1% of Tanzanian households use firewood for cooking, and 22.7% use charcoal. Both these sources of energy are from forest and woodland. Adding the 22.7% households that use charcoal for cooking to firewood consumption annually, a terrible figure is resulted which reveals the adverse impact on the forest and woodland in the country. According to the National forest policy (1998), there was a projection for deforestation of between 130,000 to 500,000 hectares annually, and this is now reflected in the current firewood and charcoal consumption rate per year in the country.

This adverse environmental impact requires to be combated in every possible way, and among the possible ways is the implementation of biogas technology. Biogas technology has got the potential of mitigating environmental impact associated with deforestation by providing alternative sustainable energy source for cooking in Tanzanian households. This technology has been acknowledged as being simple since it does not require imported knowledge or components. Among other benefits apart from producing biogas, it generates organic slurry as byproduct which contains nutrients for soil conditioning to improve soil fertility which is cheaper than expensive industrial fertilizer.

On the other hand biogas technology is one of the few technologies that utilize biomass wastes as valuable resources to generate energy source and improves sanitation. Other benefits of biogas technology include reducing women's workload, saving time consumed for firewood collection and increase of income by saving money spent for purchase of other energy sources.

Moreover, it creates job employment to youth in the rural areas (see figure 3.4), and reduces indoor pollution avoiding respiratory and eye diseases caused by the smoke inherent to traditional cooking.



Figure 3.4: Biogas Plant Construction in Tanzania

4. CONCLUSION AND RECOMMENDATION

This study presents the adoption of biogas technology in Tanzania. The study reveals that there has been an increase of biogas production technology adoption in the country largely. Since the use of biogas is much associated to rural areas their impact is much more to those areas which have direct significance to agriculture which many people depend. Youth employment, agricultural economic developments are some of benefits which has a positive impact to rural areas.

Although the technology adoption has not encountered an objection from many Tanzanians, the initial investment cost for constructing the biogas plant has remained to be the biggest challenge. It is estimated that an average cost of between Tsh. 1,500,000 to 2,000,000/= is required to construct a biogas plant (6.0 m^3) capable of meeting energy demand of a normal Tanzanian family (of 6 people). However the government through its agency (Tanzania Domestic Biogas Programme, TDBP) has been trying to subsidize the plants constructions, but virtually very few Tanzanians are still capable of acquiring this technology. This is reflected by the target which was set that they should be 12,000 biogas plants already constructed countrywide by the end of 2013, and the actual plants by then were 3819 only, more than 68% lag the targeted goal. This calls for the donors, government and its agency (TDBP) to review its implementation strategies to make most families afford the construction cost. This among other strategies can be designing and constructing low cost biogas plants, and offering more training to equip people with skills of constructing biogas plants. Doing this, targeted groups will be able to participate in most activities involving biogas plants construction by themselves, and hence reduce the construction cost by more than 70% of the total construction cost which would inspire many families to adopt the technology.

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