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*Full Length Research Paper*

# Promotion of household renewable energy technologies in rural communities: Challenges and experiences in Sub-Saharan Africa

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**It has been recognised that renewable energy technologies have an important role to play in an effort to achieve sustainable livelihoods and socio-economic development in rural communities. Several technologies ranging from wood/charcoal stoves, bio-gas digesters to solar photovoltaic's for electricity generation are used in households and rural communities in the Sub-Saharan Africa. This paper highlights the energy crisis facing Sub-Saharan Africa and efforts of some organizations involved in promoting the renewable energy technologies in Tanzania, Zimbabwe and Kenya. Key issue on the promotion of solar PV systems and the new developed low-cost tubular bio-gas systems have been discussed to highlight the challenges at hand. It is argued that more efforts need to be put in place to popularize the technologies and participatory methods which involve medium scale entrepreneurs be encouraged in trying to alleviate the energy problems in rural communities.**

**Key words:** Renewable energy, alternative energy, energy solutions, energy crisis.

## INTRODUCTION

Poverty in a developing country has many facets, and one of them is how to cope with limited means and the use of inefficient technologies for crop production and lack of household energy technologies. In most rural communities in Sub-Saharan Africa (SSA), poverty can mean, among other things, having to rely primarily on wood and or dung for cooking, heating and lighting. In order to meet their household energy needs, the majority of the rural based and urban poor, clear vast tracks of land with its natural vegetative cover and this have devastating ecological consequences. It has been estimated that Africa is experiencing a net loss as much as five million hectares of tropical forests every year (Owino, 1999). SSA therefore, thrives on a very fragile environment, threatened by deforestation and rampant soil erosion. The traditional use of firewood has resulted in scarcity of this resource and has negatively impacted on food production and food security at the household level. A number of researchers have shown that households modify their eating habits, often skipping meals or opting for less nutritious meals when there is scarcity of firewood. Even when a range of foods are available, the poor households are often unable to process these foods due to lack of energy for food. The seasonality of food in most ecological zones underscores the need for energy (for food storage and processing) to ensure regular food supply to household (Conner and Scheik, 1997). An enormous variety of household energy consumption patterns are to be found in the rural areas of developing countries. Rural households use energy for many purposes.

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The types and amount of energy used depend on the availability of energy from different sources and the cost of the energy. In most Southern African countries, it is common to see spoilage of produce despite the abundance of solar energy that can be used to process the produce (Davies, 1995). Development and promotion of renewable energy technologies do not only reduce time spent on various household activities but can promote efficiency in agricultural production and improve social status and income. For rural households, grid electricity remains inaccessible and unaffordable to the bulk of the rural people. In recent years, grid energy has been unable to meet the energy needs of most African countries including countries in the SSA due to poor planning and rapid expansion of the industrial and urban sectors. Renewable energy sources such as solar, wind and bio-gas systems tend to be the most appropriate solutions to energy demands and in sustaining rural and peri-urban livelihoods. This paper highlights some of the constraints, challenges and efforts by various organizations in disseminating renewable energy technologies in SSA.

#### MATERIALS AND METHODS

A rapid appraisal on the status of utilization of renewable energy technologies was conducted and case studies documented from the following countries: Tanzania, Kenya, Malawi, Zimbabwe and South Africa. The renewable energy technologies which were investigated can be grouped into: biomass, wind and solar energy which can be developed for heating, lighting, drying, cooking, small scale irrigation through pumping of water and power generation for household activities such as sewing, refrigeration and powering radio and televisions (TVs).

## RESULTS

South Africa first experienced energy crisis in January, 2008. The energy crisis affected the economy negatively. Although, South Africa has access to alternative energy sources and many small to medium scale renewable energy projects, the government has not fully explored how these forms of energy can be incorporated into the national grid to deal with the energy crisis. Currently, South Africa does not have energy policies and strategies for provision of integrated sources of energy in rural areas (Maliwichi et al., 2009). Most SSA countries are poor to sustain tangible energy infrastructure as they are crippled with high energy import bills. In Tanzania, for example, it has been estimated that the importation of the fossil fuels in various forms, cost the nation about 70% of its foreign exchange earnings (Kiriama, 1999). Fuel is a major expense in poor households, be it in terms of time, energy, money or both. Eberhard (1996) have reported that in the Mahlabatini district of KwaZulu Natal, the average time spent collecting wood varies between 9 h per household per week in the highlands and about 7 h in the valley lowveld areas. The average distance travelled to collect one head-load varies between 8.3 and 3.6 km. Similarly, Liuma-Maliwichi (1989) found that lack of firewood for cooking and heating was one of the main problems facing rural women in Malawi. Women travelled once a week or a fortnight to collect firewood for family use. The amount of time spent on this household chore per trip was as follows: 51% spent about 2 h, 29% spent about 4 h and 16% spent more than 6 h. The use of energy in agricultural sector has not been extensively studied. An attempt to document energy utilization levels in agriculture was done by Zimbabwe Energy Accounting Project (ZEAP).

The project estimated the following percentage consumption of various sectors in Africa (Figure 1). It is interesting to note that the highest energy demand is in household activities and probably in rural areas the energy consumption rate can reach as high as 80%.

## RENEWABLE ENERGY TECHNOLOGIES

### Biomass

Among the 70% of the population who live in rural areas, firewood, crop residues and animal dung are among the popular biomass fuels. Urban dwellers tend to rely on charcoal. Energy from biomass can also be used in the form of wood fuel or by microbial processes in the generating of bio-gas. To improve the wood-fuel efficiency, a number of designs of cook stoves have been developed both in Tanzania and Kenya. In comparison with the traditional charcoal stoves, the “Dodoma” stove developed in Tanzania have shown that it can save up to 50% of wood and charcoal used and in terms of energy, the stove can save up to 80% of energy and hence more efficient than the traditional cooking systems (Figure 2). The improvement in wood-fuel efficiency allows a farmer to have more time to spend in agricultural production and other income generating activities. In Kenya, two main wood and charcoal stoves have been developed and promoted in recent years. These are the Maendeleo stove and the ceramic charcoal stove.

Maendeleo stove is an improved stove designed to replace the three stones commonly used in the rural areas (Figure 3a and b).

### Bio-gas

Bio-gas is a gas produced from organic materials such as

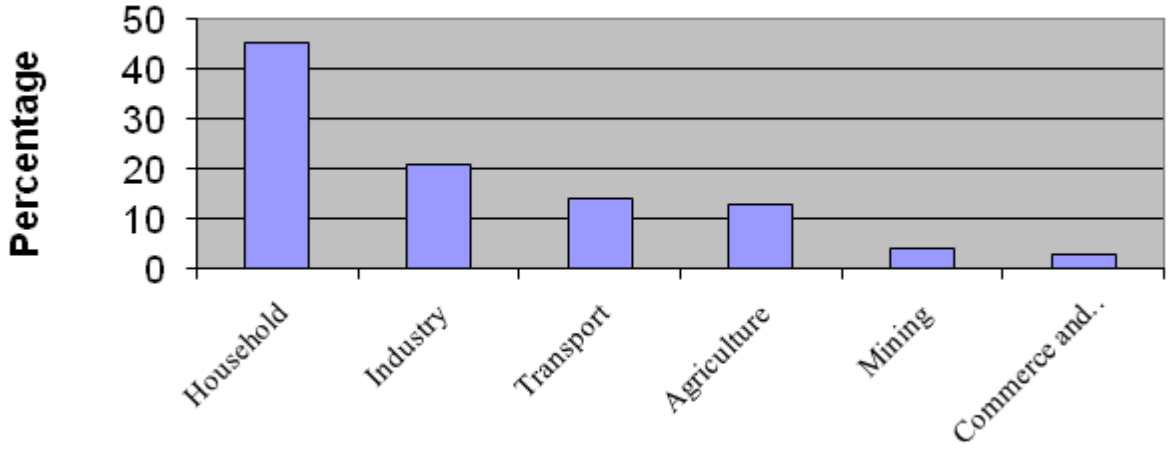


**Figure 1.** Distribution of energy consumption in Africa. Source: (FAO,1995).

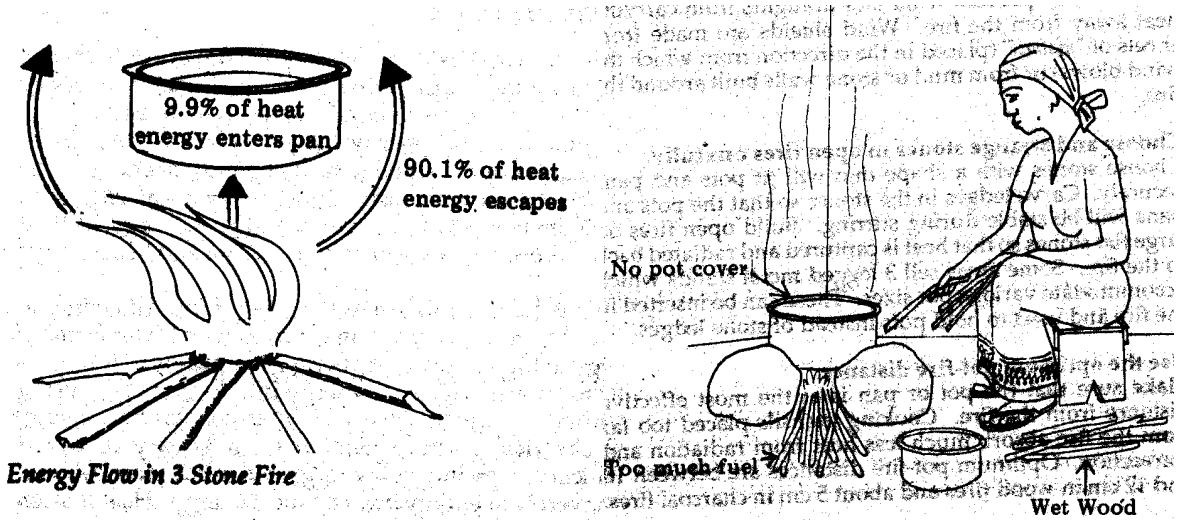


**Figure 2.** How energy is wasted using the traditional cooking methods.

animal manure, kitchen remains, crop straws and leaves after decomposition and fermentation under airtight (that is no light and oxygen) conditions. This is sometimes called ""anaerobic" condition. The airtight pit or containeris called the “digester”, and the process of decomposition and fermentation is referred to as “digestion” (Figure 4a and b). The products of ‘bio-gas’ systems are seen as possible alternative solutions to two serious problems in rural areas:

a) As an energy source, the methane gas produced ($CH_4$) can provide the much needed household fuel for cooking and lighting without the need to purchase expensive kerosene or coal and conserves the natural resources that is from cutting trees to get firewood and;

b) The digested sludge, the liquid slurry which is very rich source of soluble nitrogen is a good source of fertilizer that can improve soil fertility and agricultural productivity on the farm.

The ‘bio-gas’ technologies have several advantages under crop-livestock farming system and in protecting the environment in a particular area. Silayo (1992) and Simalenga and Gohl (1996) have cited the following major advantages:

a) They provide an alternative to firewood and thus reducing the rate of deforestation.
b) They improve crop-livestock farming system through nutrient recycling.
c) They improve women welfare by reducing workload of

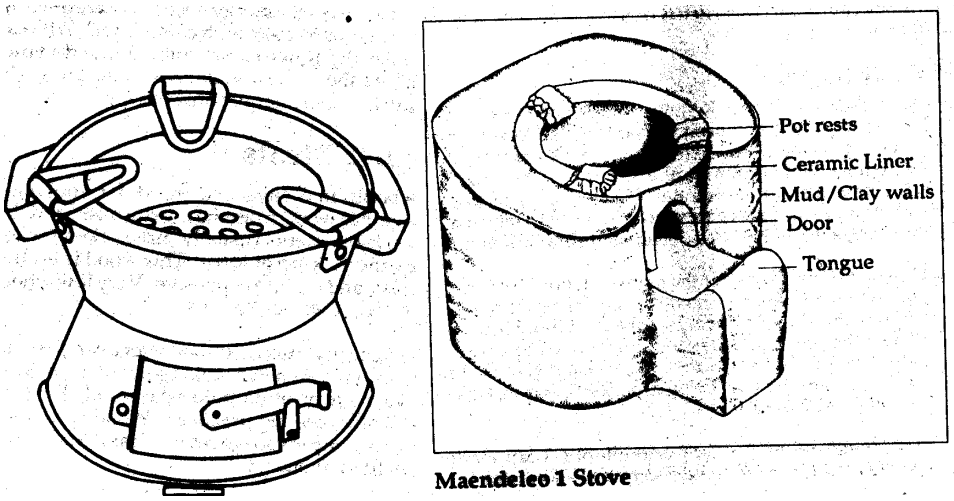


**Figure 3.** The ceramic charcoal stove (a); and the Maendeleo woodstove (b).

collecting firewood everyday.
d) They provide cleaner working environment and improve the health of women (otherwise exposed to harmful smoke and fumes) and provide non-polluting and smokeless kitchen.
e) As a renewable energy, they provide reliable power supply and they are environmentally- friendly technology.

One of the major constraints of the conventional bio-digesters is the initial capital input involved. In Tanzania, for example, construction cost of one bio-digester can cost up to USD 2000.00 (Cortsen et al., 1995). However, the introduction of the low cost plastic tubular bio-digester (Figure 4b) has reduced the cost to USD 70.00 (Simalenga and Gohl, 1996).

## Solar energy

The energy we derive from wood fuel, petroleum, paraffin, hydroelectricity and even our food originates indirectly from the sun. Solar energy is captured and stored by plants. We use this energy when we burn firewood or eat food. The sun also powers the rainfall cycles that fill rivers from which we extract hydroelectricity. Petroleum is made up of fossilised remains of plants and animals that collected energy from the sun thousands of years ago. Solar energy is a potential source of power to generate both heat and electricity and can be used for various applications ranging from solar drying, water heating and providing electricity for lighting and powering TVs and radios (Figure 5). With the abundant sunshine available in the region, solar electricity is a realistic alternative to costly extensions of grid power or generators in Africa. The sale of solar electric systems can also create jobs for installers in rural areas as well as opportunities for urban and cottage industries. There are a number of types of equipment which can be used to collect solar energy. These include flat plate panels which harvest solar energy for heating water and solar concentrators (mainly used for solar cookers) which focus the rays of the sun into high energy beams for raising heat (Figure 6). Solar energy is radiation. To make use of it, we must convert it into a form that is of use. Solar energy can be directly transformed in three useful forms:

a) Solar to chemical: Green plants transform solar energy to chemical energy in sugar and cellulose by the process called photosynthesis. Unfortunately, people have not yet developed a way to directly transform solar energy into chemical energy and photosynthesis remains a secret of plants.
b) Solar to heat: Solar heating devices transform solar energy into heat which is used for drying, water heating, cooking, generation of steam and distilled water.
c) Solar to electric: Solar electric devices transform solar energy into electricity for lighting, powering radios, television, refrigerators, pumping water etc.

## PROMOTING RENEWABLE ENERGY TECHNOLOGIES IN SSA

When a technology is introduced in a particular environment for the first time, there are a number of factors which determine whether or not its use may spread from a narrow base to a wider clientele. In general,

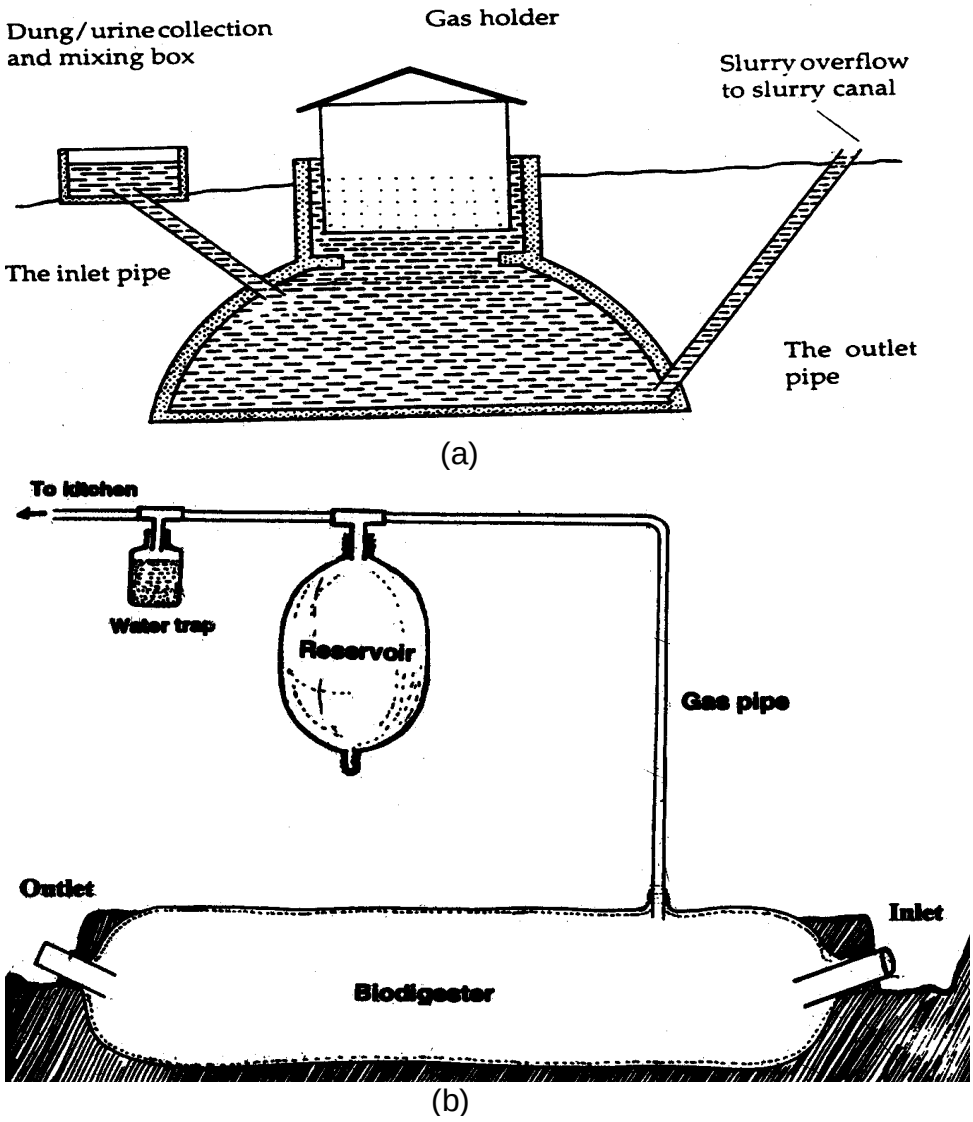


**Figure 4.** The floating drum bio-gas plant with cylindrical top bio-digester (a); and the Tubular bio-gas plant (b).

dissemination occurs in two main ways: via the market route or via the non-market route. We would expect private enterprises to pursue the market route. The motive for this type of dissemination is profit and the clientele is restricted to those with the ability to pay. Government and private non-profit organizations (NGOs), on the other hand often have different objectives. These may be related to the provision of education and health services or may include attempts at alleviating social or economic disadvantages for some groups in particular. Here, the market may not be the best way to channel dissemination. The two modes of promoting and disseminating renewable technologies in SSA are in use as discussed in examples highlighted as follows:

a) In Tanzania, a biogas extension project managed by CAMARTEC (Centre for Agricultural Mechanization and Rural Technology) and funded by GTZ has been able to install a total of 1000 biogas plants to various end users. These include: schools, church organizations and individual farmers.

b) Another NGO called SURUDE has been able to promote the use of low-cost plastic tubular biogas plants in Tanzania. A total of 400 small plants to meet daily household energy needs have been installed. SURUDE

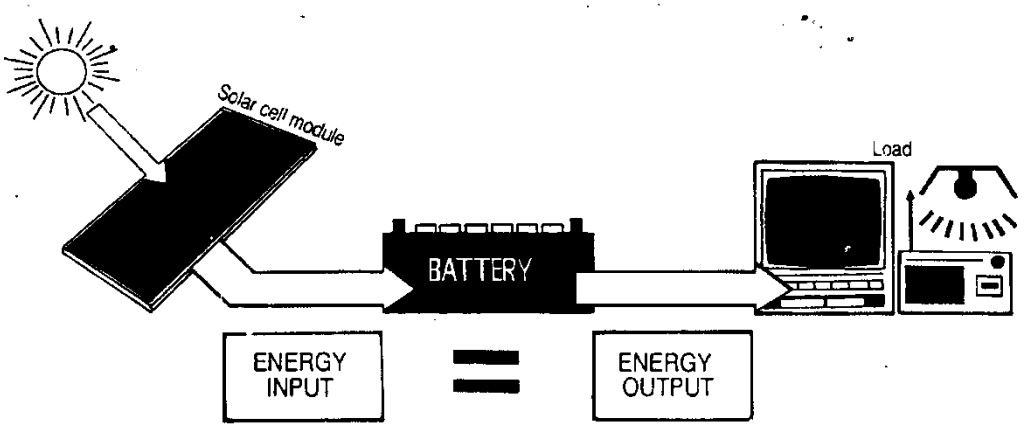


**Figure 5.** Solar electric (PV) system.

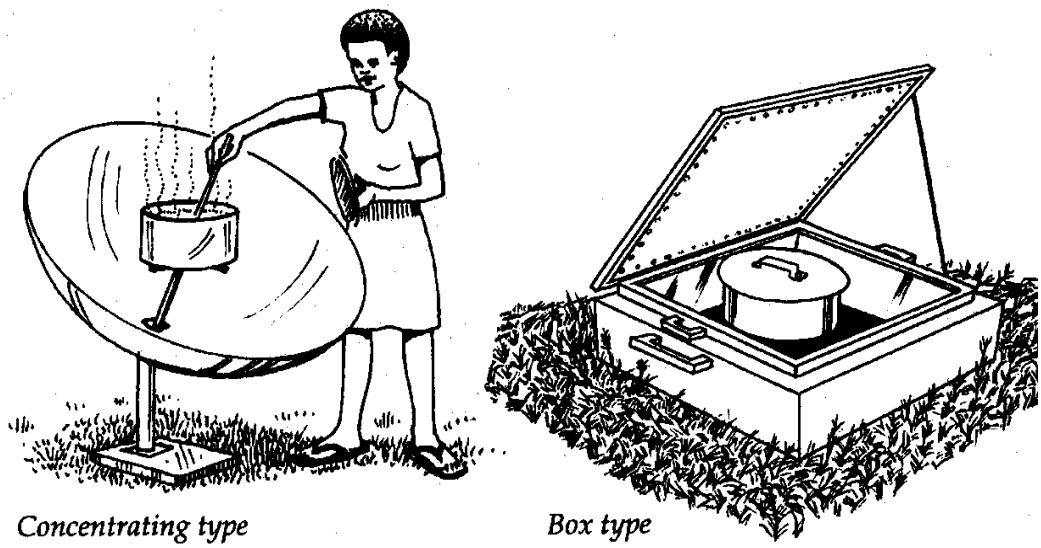


**Figure 6.** Examples of solar concentrators technologies used as solar cookers.

has also managed to extend their training and dissemination programme to Kenya, Uganda and Zimbabwe, Lekule (1996).

c) Over the past decades, over 1 million ceramic jiko's have been produced in East Africa and over 600,000 of them are in use in Kenya. The ceramic stove which is being promoted by Foundation for woodstove Dissemination (FWD) has effectively replaced the traditional charcoal stove made up of clay and used in oil drums. The ceramic stove has made the cooking safer, improved kitchen air quality and led to a reduction in respiratory and eye diseases.

d) Another improved stove that is designed to replace the three-stone hearth commonly used in the rural areas in East Africa is the "Maendeleo stove". The stove was developed in Kenya by GTZ and Intermediate Technology Development Group (IT). The stove has an improved combustion efficiency of 30% and fuel savings of about 50%. The stove has mainly been promoted by government extension workers and by 1996, a total of 250,000 Maendeleo stoves have been disseminated countrywide (Karekezi and Ewagata, 1996).

e) The global environmental facility (GEF) solar project offers services that include a credit scheme and technical support to end-users, technical training to participating solar companies and NGOs in order to develop a sustainable market in rural areas. The GEF solar photovoltaic (PV) project has successfully

disseminated over 2000 PV systems in Zimbabwe (GEF, 1996).
f) In Kenya more than 40,000 solar electric systems have been installed despite little coordinated government efforts or donor support. Private companies and initiatives such as those of Energy Alternatives for Africa (Ltd) have mainly been responsible for these dissemination efforts (Hankins and Simalenga, 1995).

## DISCUSSION

### Issues and challenges in promoting renewable energy technologies (RETs)

Inadequate capital and systematic promotion strategies have been cited as the main limiting factors in advancing the adoption of renewable technologies and making such systems accessible to poor rural families in Africa (Simalenga, 1994). Most of the solar (PV) systems and biogas digesters have a relatively high initial cost. In an attempt to document appropriate energy technology programs in Southern Africa, Eberhard (1986) reported that out of 59 organizations only 26 were operating in South Africa. Out of these 26 organizations, 4 were reported as the only organizations dealing with energy technologies for poor communities in the rural areas. This shows that most organizations would like to promote RETs for profit gains while most of the rural communities remain unreached. Another challenge in promoting RETs is the institutional framework and co-ordination mechanisms between grassroot community-based organizations, NGOs and Aid agencies promoting RETs. Most African countries do not have well defined renewable energy policies to implement and allocate resources for renewable development programmes. RETs should be integrated in a national energy plans and granted financial support. The methods used in promoting dissemination can by itself be a hindrance if organization and systematic dissemination are not well articulated. Factors such as differences in wealth, religion, customs and climate can present a barrier to the adoption of technologies. Mass dissemination of any technology is best done through the market route. Donor and Government intervention in the field of RETs should be aimed at building an infrastructure and local entrepreneurs for market dissemination. Support is therefore required for training, demonstrations to create awareness, credit facilities, research support to provide proper designs, policy formulation and networking. Professional organizations such as Association for Family Ecology and Consumer Sciences can play a leading role in training, creating awareness and provide a platform for lobbying for positive change. Most of the population in the Sub-Saharan Africa live in rural areas and most of the rural population are poor.

Most of the energy consumed by this major segment of the rural population is used for cooking and most of them have little if any light available in the dark hours. Therefore strategic Government intervention is called for in helping the rural poor to improve their livelihood by providing cooking fuel and light using renewable energy technologies which are a non-destructive resource that has accompanying health and environmental benefits.

### Conclusion

This paper has tried to show that renewable energy technologies are appropriate for rural areas in meeting the household energy needs. Renewable energy technologies harness biomass, sunlight, wind or moving water. Many RETs are adaptable so that they can make use of variety of local materials. Local labour is also used extensively to manage RET systems. The following are some of the other advantages and benefits:

a) RET can increase rural employment and income generation opportunities: RET often require specialised skills and therefore many people need to be trained to install and manage the systems. This creates employment in rural areas.
b) RET can help to protect the environment: Renewable energy is a clean source of energy. Solar energy or biogas can be used to replace wood energy reducing the strain on tree resources. Biogas digesters produce fertilisers which improve soil fertility.
c) RET can improve the standard of living: RET can save work of collecting firewood and carrying water thus enabling people especially women to do other useful work. In South Africa alone, it is estimated that 60% of rural population is not connected to national grid. The use of Solar PV systems can therefore greatly improve the rural life and provide the necessary development.
d) RET can save money and help to become independent: The cost of grid electricity is increasing everyday and the use of renewable energies can improve the household savings for heating water, cooking, lighting and other appliances. Most solid fuel furnaces and stoves are grossly inefficient compared to oil or gas appliances for various reasons:

i) Wood burns at different temperatures because of the different amounts of water in it. Wet wood burns at a lower temperature and is therefore less efficient because of incomplete combustion.
ii) Forty percent (40%) of the energy in wood is unburned gas released as wood burns. This gas fails to ignite and release its energy because it starves for oxygen. To burn

these gases, an injection of a controlled amount of air just above the flame is necessary. This action increases the efficiency of the appliance.
iii) A lot of smoke out in the chimney indicates that wood energy is being lost and loss of efficiency.

These inefficient traditional methods of using wood can be improved by using innovative stoves as discussed in this paper. The Maendeleo or Dodoma stoves for example can use less that 1/3 of wood for the same heat produced and can produce 70% less particles pollution. Renewable energy technologies are, therefore, the promise for sustainable, clean, sources of household energy for the future generations. The reserve of fossil fuel is dwindling and the renewable technologies will become more advanced and more cost effective.

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