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Renewable energy as a future option for sustainable energy use and Rural development in Tanzania

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Abstract

The objective of this study was to analyse the feasibility of adopting renewable energy technologies such as Solar PV systems and improved wood-fuel stoves in rural households and the role of such technologies on sustainable energy use and rural development in Tanzania. To reach this objective, the study analysed the current status of energy supply and energy use in rural Tanzania. Furthermore, it analysed major problems hindering the energy supply and use in rural areas and how would these problems be addressed. Primary and secondary data sources were used to collect valuable information for this study. The results show that if initial costs are affordable, solar PV systems and improved wood-fuel stoves have a potential to be adopted by rural households. It is argued in this study that since short term plans for grid electrification of rural Tanzania may prove costly, the emphasis should be the promotion of affordable and environmentally friendly renewable energy sources. The supply of renewable energy technologies in rural areas will play a crucial role in raising the living standards of rural population. The study argues that dissemination of renewable energy in rural areas has a potential to protect the environment and may contribute to rural development.

Key words: Renewable Energy, Renewable Energy Technologies, Energy, Solar photovoltaic, improved wood-fuel stoves

List of Acronyms and Abbreviations

CLDs	Causal Loop Diagrams
et al.	et alii (and others)
etc.	et cetera (and other similar things)
i.e.	id est (that is)
ibid.	in the same source
km^2	kilometre(s) square
KWh	Kilowatt hour
m^2	metre(s) square
MW	Mega Watt
NGO	Non Governmental Organisation
PV	Photovoltaic
REA	Rural Energy Agency
REF	Rural Energy Fund
RETs	Renewable Energy Technologies
Sida	Swedish International Development Agency
TANESCO	Tanzania Electric Supply Company Limited
TV	Television
UNDP	United Nations Development Programme

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1.0 Introduction

Development of rural areas in Tanzania is very important if efforts to alleviate poverty are to succeed. It should be understood, however, that supply of energy in these areas is very crucial for such development to take place. The supply of energy to rural areas would create opportunities for better health care, education and income generating activities which are important for rural development.

The country's Development Vision 2025 stipulates the need to improve energy supply in rural areas and improvement of the welfare and standard of living of the rural population. Rural electrification has been a long time national interest as a prerequisite for socio-economic development. However, high costs have hindered grid electricity distribution in rural areas. The government through the Ministry of Energy and Minerals is addressing the problem by decentralizing power production and distribution. At the same time the Rural Energy Agency and Rural Energy Fund will also be established (Ministry of Energy and Minerals, 2003). Some projects on transformation of the solar photovoltaic (PV) market in rural Tanzania are now ongoing, in cooperation with donor agencies. The ongoing government effort to promote renewable energy in rural areas can stimulate socio-economic development.

The problems associated with rural household energy supply and use in Tanzania caught the government's attention when it started implementing various initiatives in the early 1970s and 1980s, by conducting surveys which aimed at evaluating the threat posed by an increasing use of firewood in the country. It was found out from these surveys that firewood was the major source of energy for cooking, space heating and in some cases for lighting in most rural households (Sawe et al., 2003). Subsequently, a number of studies have been done since then on rural energy problems by individuals, stakeholders and institutions. Through these studies it has been learnt that there is insufficient supply of energy in rural households due to the high cost of commercial energy and related appliances. The rural population forms about 75% of the total population in Tanzania which currently stands at 34.6 million and grid electricity is accessible to only 1% of the rural population (Ministry of Energy and Minerals, 2003). This implies there is still an urgent need to encourage and promote the supply of affordable energy sources in rural areas where the majority of the population live.

Biomass fuels such as firewood, charcoal and agricultural residues are dominant energy sources accounting for more than 90% of total energy used in the country (Reed, 1996). Petroleum accounts for 8% of the total energy consumed, while grid electricity is estimated to account for only 1% of the primary energy used in the country. Others including renewable energy sources such as solar, wind, geothermal, hydropower and biogas account for about 1% of the total energy consumed in Tanzania (Kimambo and Mwakabuta, 2005, Mwihava and Mbise, 2003).

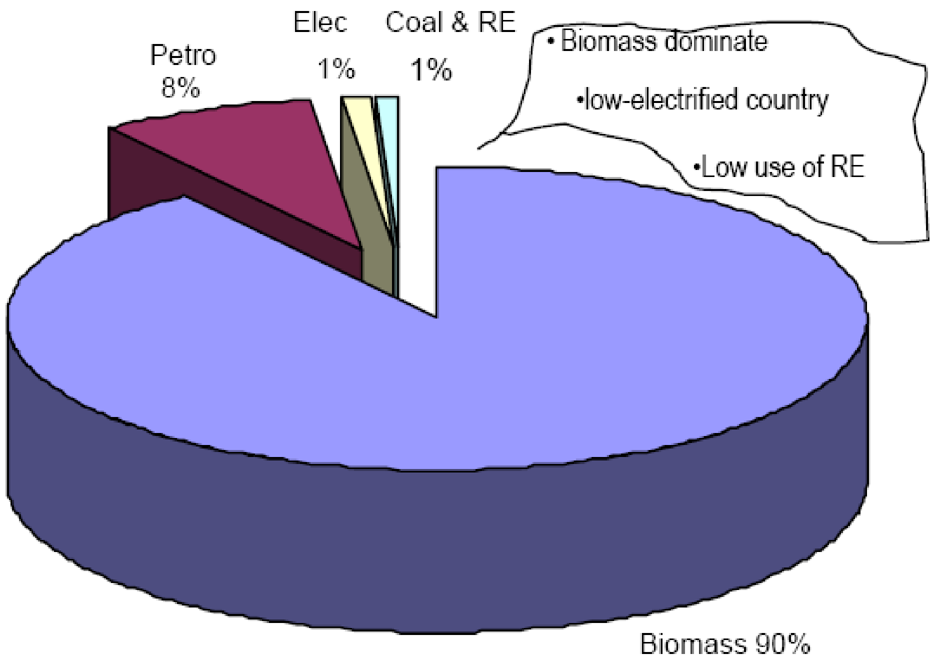

Figure 1: Total energy consumption in Tanzania, 2004

Source: Adapted from Kimambo and Mwakabuta, 2005

Such consumption pattern as shown (figure 1) shows that biomass energy is the major source of energy in both urban and rural areas. Reliance on biomass fuels can have severe consequences on both environment and human health. Efforts to promote affordable and clean supplements of energy sources have to continue so as to address such problems.

Grid electrification of rural areas in Tanzania could be hard to achieve in a short time due to the dispersed nature of rural settlements in most of the regions. Sparsely populated areas have made it difficult and it may prove too costly if all rural areas in Tanzania were to have access to grid electricity. This is due to not only the cost of production and maintenance but also the low purchasing power of the envisaged rural customers (Ministry of Energy and Minerals, 2003). Considering such barriers, plans for transmission of grid electricity in all rural areas seems to be a long term strategy which may take many years to fulfil.

This study analyses the feasibility to adopt renewable energy technologies in rural Tanzania which can supplement grid electricity when long term plans for rural electrification through grid electricity by the government are underway. Studies have shown that rural areas grid electrification problems could be solved with decentralized long term renewable energy sources which may play a crucial role in providing energy services in such areas and also would be environmentally friendly (Miller,2004, Karekezi,2002, Biswas et al., 2003).

1.1 Objectives

The broad objective of this study is to analyse the feasibility of adopting renewable energy technologies such as Solar PV systems and improved wood-fuel stoves in rural households and the role of such technologies on long term energy use and rural development in Tanzania. The study focuses on Magu district as an example that represents energy supply challenges and problems in rural Tanzania. The study will specifically seek to answer the following questions:

- What is the current status of energy supply and energy use in Magu district?
- What are the major problems related to energy supply and use in Magu district?
- How would these problems be addressed?
- What is the existing knowledge on solar PV systems and improved wood-fuel stoves among the households in Magu district?

1.2 Conceptual framework

The conceptual framework of this study is based on system thinking. System thinking has been used in the study so as to understand the relationship between energy supply and rural development. Furthermore, system thinking has been used to understand social, economic and environmental factors which may influence the linkage between energy supply and rural development. By understanding the connections, it may be easier to design alternative solutions to rural energy problems and development.

"*System thinking is a science based on understanding connections and relations between seemingly isolated things. The concept is used to understand the causal relationships and feedbacks of a problem*" (Haraldsson, 2004). In order to map the understanding of a problem and making it transparent and visible for others, Causal Loop Diagrams (CLDs) are used (Haraldsson, 2004). The CLDs can be used to understand the trend of an issue or a problem in a system and through them we can develop strategies to deal with the identified problem/issue (ibid.). Haraldsson (2004) further explains that in the CLD "*the arrow shows causality between variables. A plus sign near the arrowhead indicates that the variable at the tail of the arrow and the variable at the head of the arrow change in the same direction. A minus sign near the arrowhead indicates that the variable at the tail of the arrow and the variable at the head of the arrow change in the opposite direction".*

CLD for energy dissemination in rural Tanzania (Figure 2) is a mental model illustrating the importance to supply energy in rural areas. The Causal Loop Diagram is backed up with some theoretical approaches from the literature on energy and rural development.

The basic assumption in figure 2 is that the supply of the energy source is dependent on the initial cost involved in acquiring it. Grid electrification of rural Tanzania is said to be rather a long term than a short term strategy due to the over all initial investment costs needed (Ministry of Energy and Minerals, 2003). However, environmentally friendly renewable energy technologies such solar photovoltaic systems and improved wood-fuel stoves can currently supplement grid electricity by providing energy services to rural households. The logic in the CLD is that if all available energy sources have higher initial costs, none of the energy sources would be sufficiently supplied in rural Tanzania. On the other hand, if any of the energy sources proves to be costly, only affordable energy sources available would be adequately supplied. Figure 2 illustrates how initial investment costs influence the energy supply in rural areas.

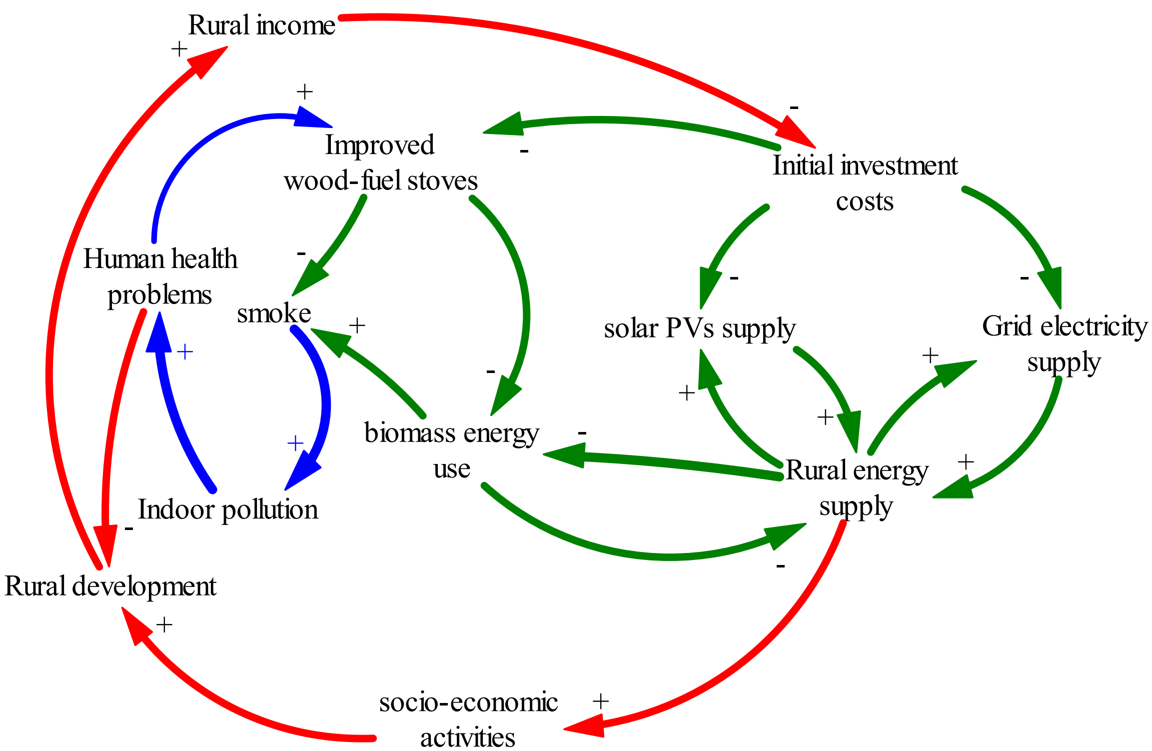

Figure 2: CLD for energy dissemination in rural Tanzania

The Causal Loop Diagram (Figure 2) illustrates the importance of energy supply in rural areas in accelerating socio-economic development. A higher initial cost of the energy sources is one of the factors hindering the energy supply in rural Tanzania. From (Figure 2), the higher the initial costs to supply grid electricity, the more likely that there will be less grid electricity supply and less rural energy supply. With inadequate rural energy supply, there will be less socio-economic activities which would lead to less rural development. Less rural development would lead to inadequate rural income and eventually this would affect those who need energy services since initial costs would be higher. The report, Energy After Rio, showed that the energy choice of households is highly influenced by income (UNDP, 1997). "*This means that poor people give greater weight to initial costs than what they give to the life-cycle costs. Thus, they tend to avoid efficient devices or convenient carriers of energy due to the high initial costs associated with them, giving preference to inefficient, but low cost devices and inconvenient energy carriers*" (Habtetsion and Tsighe, 2002).

On the other hand, the lower the initial costs to supply grid electricity would increase the grid electricity supply and rural energy supply. This would stimulate socio-economic activities and give room for rural development. The increased rural development would create opportunities for the rural poor to earn income which will allow them to exploit the available energy sources. Similarly, the higher the initial costs to supply solar photovoltaic systems, less solar PV systems will be available to rural households and this would lead to insufficient rural energy supply. Inadequate rural energy supply could affect the socio-economic activities and rural development. With less rural development, there will be less rural income and this would limit the ability of the rural households to acquire the energy services due to higher initial costs and vice versa.

Advocating energy supply for rural development, Laing and Rosseli (1999), argue that in order "*to develop optimally, a country must seek reasonable per capita energy availability, affordable energy prices and convenient conversion devices with little or no adverse environmental effects*". From (Figure 2), the lower initial costs to supply improved wood-fuel stoves (may be termed as conversion devices), the more the number of improved wood-fuel stoves that would be used by rural households. The increased use of improved wood-fuel stoves by rural households may reduce the biomass energy use. Smoke will be reduced as a result of less use of biomass energy sources and this would help reduce the risk of indoor pollution. The less indoor pollution, the less human health problems associated with pollution. At the same time, improved wood-fuel stoves will emit less smoke and this will also reduce the risk of indoor pollution. With less human health problems there would be more rural development.

Chambers (1983) argues that an increase in number of people with health problems causes increased demand for social services and less involvement of households in productive socio-economic activities. Martinussen (2004) shares this view by claiming that "*as a result of bad health conditions, the poor are generally less productive and continue to have little income and, consequently, their purchasing power remains highly inadequate*". It should be clearly understood that with the ongoing poverty reduction strategies in rural Tanzania, there is a need to consider human health as a basic factor that may determine the effectiveness of poverty reduction strategies.

2.0 Energy in Rural Tanzania

2.1 Rural energy supply

Tanzania is believed to be a country which enjoys abundant energy sources such as, biomass, solar, wind, hydro, biogas and geothermal. Biomass fuels are the main sources of energy consumed by the rural household activities such as cooking, heating and lighting. It accounts for about 95% of all the energy consumed by the rural household sector in Tanzania (Ministry of Energy and Minerals, 2003). The increasing rural population dependence on biomass fuels as the major sources of energy for cooking prompted the government to take measures to address rural energy problems. Realizing the importance of biomass energy, village afforestation programmes were established by the government in the early 1970s with the aim of increasing the biomass resources (Sawe et al., 2003). It was anticipated that biomass resources would contribute in meeting energy needs of the rural population and help restore unproductive and degraded lands. At the same time, this would increase soil fertility and water retention (Miller, 2004). However, it could be noted that afforestation alone could not offer the lasting solution for the rural household energy demand. This compelled the government to initiate other programmes to improve rural household energy demand and among such initiatives is the management of the natural forests. It has been envisaged that managing natural forests, unlike establishing forest plantations involves less costs in investment and local communities can easily get involved in management (Miller, 2004, Sawe et al., 2003). Research findings have shown that farm forestry which involves the planting of trees between crops and grasses on cultivated farms and forest management played an important role in alleviating firewood shortages in China, Nepal, Senegal and South Korea (Miller, 2004, Barnes et al., 1996).

In recent years, Tanzania's economy has undergone major reforms from a centrally planned economy to a free market oriented economy. The reforms include among other things allowing private sector participation in socioeconomic development and privatization of a number of state-owned bodies (Mwihava and Mbise, 2003). It is clear with such reforms, renewable energy technologies may have to compete with other conventional forms of energy. The national energy policy now allows independent power producers to generate electricity from different sources including renewable sources of energy, particularly for the rural population of Tanzania (Ministry of Energy and Minerals, 2003).

2.2 Rural energy use

Previous studies have shown that households are the main consumers of energy in rural areas. In most cases rural households use kerosene mainly for lighting. However, electricity is used for lighting by 1% of rural households who have access to grid electricity (Mwihava and Mbise, 2003). Electricity is also used to operate various rural household appliances such as television sets, radios and cell phone battery recharging. The rural households with no access to grid electricity use dry cells to operate their radios and sometimes, though not often, they use candles and electric torches for lighting (Kimambo and Mwakabuta, 2005, Ministry of Energy and Minerals, 2003). The amount of energy consumed from the commercial energy sources such as grid electricity and petroleum based fuels is very low. This might be due to the costs of such energy sources and inadequate supply of grid electricity to rural areas. As argued earlier in this study, grid electrification of rural areas in Tanzania may be hard to achieve in a short time due to the dispersed nature of rural settlements in most of the regions (Ministry of Energy and Minerals, 2003). It is therefore important for clean and affordable sources of energy alternatives to be promoted so as to address the current situation.

The supply of energy in rural areas will play part in overall rural development in Tanzania and this may be done by using renewable energy sources and technologies which are cost-effective and environmentally friendly. The use of renewable energy technologies such as improved wood-fuel stoves will reduce the risk of indoor air pollution which is said to be the major cause of respiratory illness in many rural areas (Miller, 2004). Alternative sources of energy in rural areas will also address the alarming rate of deforestation resulting from overdependence on firewood and charcoal (Elliott, 2004). Renewable Energy technologies which have shown some successes and are still at various stages of development and commercialization include solar thermal, solar photovoltaic, biogas, improved wood-fuel stoves, and wind turbines for mechanical power - mainly for water pumping (Ministry of Energy and Minerals, 2003).

2.2.1 Status of Renewable Energy in the country

The available Renewable energy sources are currently at various stages of being exploited. Renewable energy sources in the country include biomass, geothermal, hydropower, biogas, wind and solar. However, the focus has been on the use of wind, solar, micro/mini hydro and biomass sources. It is argued that technologies used in these renewable energy sources may easily be disseminated in the short time (Mwihava, 2002, Ministry of Energy and Minerals, 2003).

2.2.2 Wind energy and hydro

Areas identified as having wind potential in Tanzania are coastlines, the highland plateau of the Rift valley and around Great Lakes. Wind energy is used in activities such as water pumping for household use, livestock and irrigation. Studies have shown that less has been done on installation of wind turbines for electricity generation .The country's hydro potential is estimated to be around 4,500 MW. However, only 555 MW is estimated to have currently been developed (Mwihava, 2002).

2.2.3 Biomass

Biomass energy sources may be categorized in the form of firewood, charcoal, farm residues and animal wastes. Firewood is said to be the main source of energy in rural Tanzania whereby agricultural residues and animal dung are used in areas with severe firewood shortages (Mwihava, 2002). Firewood may easily be available and affordable to most of the rural households and will continue to be the dominant source of energy for the majority of the rural population for the foreseeable future (Ministry of Energy and Minerals, 2003, UNDP, 2000). The overwhelming dependence on biomass fuels for energy, may greatly contribute to environmental degradation through deforestation and soil erosion (Elliott, 2004).The rationale behind this study is that renewable energy technologies such as improved wood-fuel stoves and solar photovoltaic systems may help sustain the long term use of biomass energy and improve the rural household livelihoods. Improved wood-fuel stoves are "*usually designed in such a way that they increase combustion efficiency, reduce heat loss and decrease indoor air pollution*" (Karekezi, Lata and Coelho, 2004). Karekezi (2002) has noted that improved wood-fuel stoves have made significant benefits for the rural poor in sub-Saharan Africa for the past two decades. Studies in Zimbabwe show that improved wood- fuel stoves may contribute to income generating activities through efficient use of biomass fuels such as firewood (Mapako, 2004).

Table 1: Estimated number of improved wood-fuel stoves disseminated in selected sub-Saharan African countries in early 1990s

Country	Number distributed
Kenya	1,450,000
Burkina Faso	200,000
Niger	200,000
Tanzania	54,000
Ethiopia	45,000
Sudan	28,000
Uganda	52,000
Zimbabwe	20,880

Source: Karekezi, 2002

As it can be noticed in Table 1, by the early 1990s, Tanzania was still among the countries in sub- Saharan Africa with fewer improved wood-fuel stoves. Studies on renewable energy technologies show that initiatives to promote improved wood-fuel stoves were first implemented in 1986 in the country but as of now implementation remains to be in isolated cases (Mwihava, 2002).

Plate 1: A sample of an improved wood-fuel stove

Source: photo taken from the field

2.2.4 Solar Photovoltaic

One of the viable renewable energy sources is the electricity from sunlight. Electricity is formed when solar energy is converted by photovoltaic cells. Photovoltaic cells produce electricity directly from the sunlight (Miller, 2004). As grid electricity reaches about only 1 % of the rural population in Tanzania, the use of solar electricity seems to be an attractive option as the country enjoys the abundant sunlight. The country average annual solar radiation levels are said to range between 4.2 – 5 kwh/m^2 per day (Kimambo and Mwakabuta, 2005, Sawe et al., 2003), although the average annual daily solar insolation in most of the African countries is estimated to range between 5– 6 kwh/m^2 (Karekezi, 2002). Electricity from renewable energy sources such as Solar PV systems is very important for rural households since it is cost–effective over time and environmentally friendly if compared with other fossil fuels. Production of solar photovoltaic modules is said to have increased in the past few decades leading to a drop in PV costs and this has been referred as being a driving force towards the wide scale use of solar PV technology in Africa (Karekezi, 2002). In Tanzania, solar photovoltaic (PV) systems have been recently used for telecommunication, lighting, refrigeration, water pumping and powering electronic equipment at individual residents, schools and health centres/rural dispensaries (Mwihava, 2002).

Plate 2: Rural technicians installing a solar PV system at Ngasamo dispensary, Magu.

Source: UNDP project, Mwanza.

It should be understood that PV systems cannot substitute firewood or charcoal for cooking which is the major end use of household energy, as this might involve high costs which cannot be met by most of the rural households. For this study, Solar Photovoltaic systems are meant to supply electricity which can be used for lighting homes and domestic appliances, however, this electricity can also be used in a number of rural activities such as lighting schools, refrigeration in health centres, village water pumps and telephone facilities.

2.3 Rural energy problems

Programmes in the renewable energy sector have not been implemented according to expectations due to a number of reasons. One of the reasons for this situation is that as it has been in many countries in the world, projects involving large commercial and decentralized electricity generation from fossil fuels have been receiving considerable support from the government and key development cooperating partners. Technical and financial support for renewable energy projects has always been limited (Kimambo and Mwakabuta, 2005, Miller, 2004). Other problems are explained below.

2.3.1 Institutional Framework

One of the barriers has been inadequate institutional capacity for promoting Renewable Energy and coordination of Renewable Energy activities. It is argued that development of the Renewable Energy sector cannot be achieved by the private sector alone so there should be support from an efficient institutional framework (Mwihava, 2002, Laing and Rosseli, 1999). To achieve this, The Ministry of Energy and Minerals with the support of donors has undertaken a number of programmes aimed at harnessing indigenous renewable energy potential in the country. The recent initiatives by the government, NGOs and the private sectors are aimed at improving energy services for people in rural areas. The current initiative undertaken by the Ministry of Energy and Minerals is the formulation of the framework for a national programme to promote Renewable Energy Technologies (RETs) and the establishment of a Rural Energy Agency (REA) and Rural Energy Fund (REF). It is envisaged that the REA will support the current and future efforts to supply energy in the rural areas. On the other hand it will mobilize, coordinate and facilitate private and public renewable energy development in rural Tanzania. Rural Energy Fund (REF) will be managed and operated by the Rural Energy Agency. REF is meant to finance or subsidize various rural energy services such as renewable energy systems and rural electrification (Ministry of Energy and Minerals, 2003).

2.3.2 Cost

Affordability of RETs has also been one of the setbacks since the majority of the populations in rural areas are poor. An ongoing effort in marketing Renewable Energy technologies has to consider the strategies to address the affordability barrier. The majority of the poor rural households, which constitute a large part of the targeted population to be supplied by renewable energy, may only afford the expenses for Renewable Energy Technologies, if they could find financing since available household income can hardly afford cash payment for the desired energy technologies (Mwihava, 2002).

However, with the envisaged future possibility of financing and subsidizing rural energy services, many of the rural households may later afford the costs for Renewable Energy technologies. This may also ease the view from many energy analysts who have had the notion that domestic use of renewable energy may not be the best option to use as an entry point in disseminating Renewable Energy technologies in rural areas due to the involved initial costs.

2.3.3 Renewable Energy equipment

The slower response from the rural households to acquire renewable energy technologies may be due to the past negative experiences attributed from poor renewable energy equipment standards. This may have been the result of importation of sub-standard equipment, which does not meet the expectation of the rural households (Mwihava, 2002). Effective monitoring and guidelines on the quality, installation and use of renewable energy equipment is required when promoting the technologies to avoid such setbacks. Experience has shown that Renewable Energy technologies which meet the required standards have been promoted and successfully implemented in many countries (Karekezi, 2002).

2.3.4 Information

Due to poor information infrastructure and communication networks, the rural population has inadequate access to information in general. This may have caused many rural households to have insufficient information on the advantages of Renewable Energy technologies (Mwihava, 2002). With sufficient information, renewable energy technologies may easily be promoted in rural Tanzania.

3.0 Methodology

During the course of collecting data from the field, the 'case study' methodology has been used so as to get the primary information (Stake, 1995). Magu district has been used as a case study to analyse energy supply and use in rural Tanzania. Interviews were used as main sources of evidence from the case study. In this study, a total number of 25 households were interviewed in four villages. Due to long distances and time allocation, this study had to be confined to specific villages. The results from this study are based on the selected sample size and this should be considered when analysing them.

3.1 Sampling procedure and sample size

Experience has shown that the household has been the unit of production and consumption in rural Tanzania, hence in this context was used as an analytical unit for this study. A systematic sampling procedure was employed in picking the sample households. "*Systematic sampling involves the selection of every 15th name on the list or every 10th house on one side of a street and an element of randomness is usually introduced into this kind of sampling by using random numbers to pick up the unit with which to start*" (Kothari, 1990).This technique was preferred because it provided an equal chance for each household to be selected for inclusion in the sample (Kothari, 1990). The sample size of the households was selected from Magu centre, Bugatu, Ndagalu and

Ng'haya villages. Before selecting the sample size, information on household characteristics was collected. This included households socio-economic activities, household size etc. This was done so as to make the sampling process efficient (Merters, 1998). The households then were arranged according to the temporarily collected information before systematic sampling was done. This aimed at having representation of households with different characteristics in the sample. In each village 10% of the households were randomly selected for interviews. The sample size was selected from the list of households in each village. This resulted into a total sample size of 25 households. This sample size was selected so as to cope with my budget and time since a larger sample size would have involved more costs and time.

3.1.2 Questionnaire

The questionnaire was the formal way used to collect information at household level. The questionnaire was intended to collect information on household characteristics, source of energy use, problems related to energy use and awareness on renewable energy technologies. The questionnaire was designed and pre-tested prior to the field visit. The pre-testing enabled some modifications to be made on the original questionnaire to suit the study area. Due to this, some questions were dropped or reorganised.

3.1.3 Interview

The questionnaire was used in a form of interview with structured questions. Yin (1994) describes interviews as being an essential source of case study information. The interviews targeted the rural household heads both men and women who in most cases are regarded as main decision makers in the household. The household members considered in the study excluded all those who were not living or depending directly on the household. The fieldwork aimed at collecting information from rural households. Among the shortcomings encountered during my fieldwork is that many of those interviewed had conditioned responses. A number of research studies have been conducted in Magu district on various aspects. In such context, rural households have in a way been accustomed to offer conditioned responses that are likely to suit the researcher. This could lead to the insights obtained to be unreliable. To avoid this from happening, a number of probe questions were asked, a situation that resulted in a rather long interview session. It is argued that asking questions is a part of research and a tentative answer from the respondent may lead to new questions and eventually significant inquiry about how or why the world works as it does (Yin, 1994, Mikkelsen, 1995). The questionnaire was complemented by discussions with village leaders and direct observation. Discussions and direct observations were used as a way to cross-check the responses from interviews. Yin (1994) argues that "*by making a field visit to the case study site, you are creating the opportunity for direct observations*".

The subsequent days after my field visit, were spent gathering secondary data. This was done through visiting government officials in the Ministry of Energy and Minerals, country offices of donor agencies, libraries and local private dealers in Renewable Energy Technologies. Both primary and secondary data collection in Tanzania was done for 26 days. The field visit was conducted in 10 days and each interview lasted slightly longer than one hour. On average two interviews were conducted per day.

Criticisms of the methods

Interviews

- They may be biased if questions are poorly constructed. Interviewee may respond to the questions the way the interviewer wants to hear (Yin, 1994).

Direct observation

- This method has been described as time consuming. Due to selectivity a researcher may miss the facts (Yin, 1994).

Secondary data

- It may be difficult to retrieve needed data. Access to the data may be blocked. Reports collected during the study may reflect author's bias (Yin, 1994).

4.0 CASE STUDY –MAGU DISTRICT IN MWANZA REGION

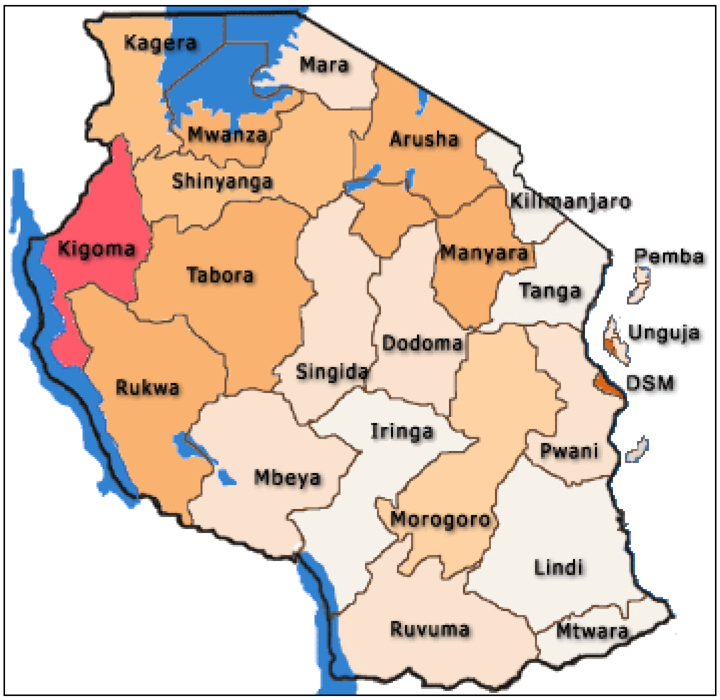

Figure 3: Map of Tanzania with administrative regions

Source: United Republic of Tanzania, 2005

4.1 Mwanza Region

Mwanza region is found in the northern part of Tanzania, located between latitude 1º 30´ and 3º south of the Equator. It also lies between longitude 31º 45´ and 34º 10´ east of Greenwich. It occupies a total area of 35,187 km². However, about 15,092 km² of the total area is covered by Lake Victoria and the remaining 20,095 km² is the dry land (The United Republic of Tanzania, 1997).

In the past Mwanza region enjoyed the abundance of forests but less than 10% of the forest cover is what has been left from the total land area due to the extensive clearance of forests for agricultural activities and firewood for domestic use. The annual harvest of firewood is estimated to have reached 171,000 tons annually in Mwanza region. By l990s, biomass energy was said to account for more than 97% of the total energy used in Mwanza region for domestic purposes (The United Republic of Tanzania, 1997).

This has led to acute shortage of forest products and environmental degradation. The supply of forest products such as firewood is getting scarce and experience has shown that some parts of Magu, for example; Kivukoni, Busega, Itumbili and Sanjo, households use farm residues and animal dung as sources of energy for cooking (The United Republic of Tanzania,1997). To address this situation, more efforts should be aimed at promoting alternative efficient sources of energy to rural households.

Figure 4, shows the areas covered by the forests in different districts found in Mwanza region. Geita district has a total forest area of 88.5 km². Ukerewe has 3 km² of total forest area. The area covered by forest in Magu is approximated to be 5.4 km². Sengerema has a forest area of 28.8 km². Kwimba has 4.1 km² of forest area while Mwanza town has no area covered by forest (The United Republic of Tanzania, 1997). Further agricultural encroachment or excessive utilization of timber and firewood in the existing forests may accelerate the current problems. Mwanza has been mentioned as one of the regions which are facing a shortage of biomass energy sources (Mwihava, 2002).

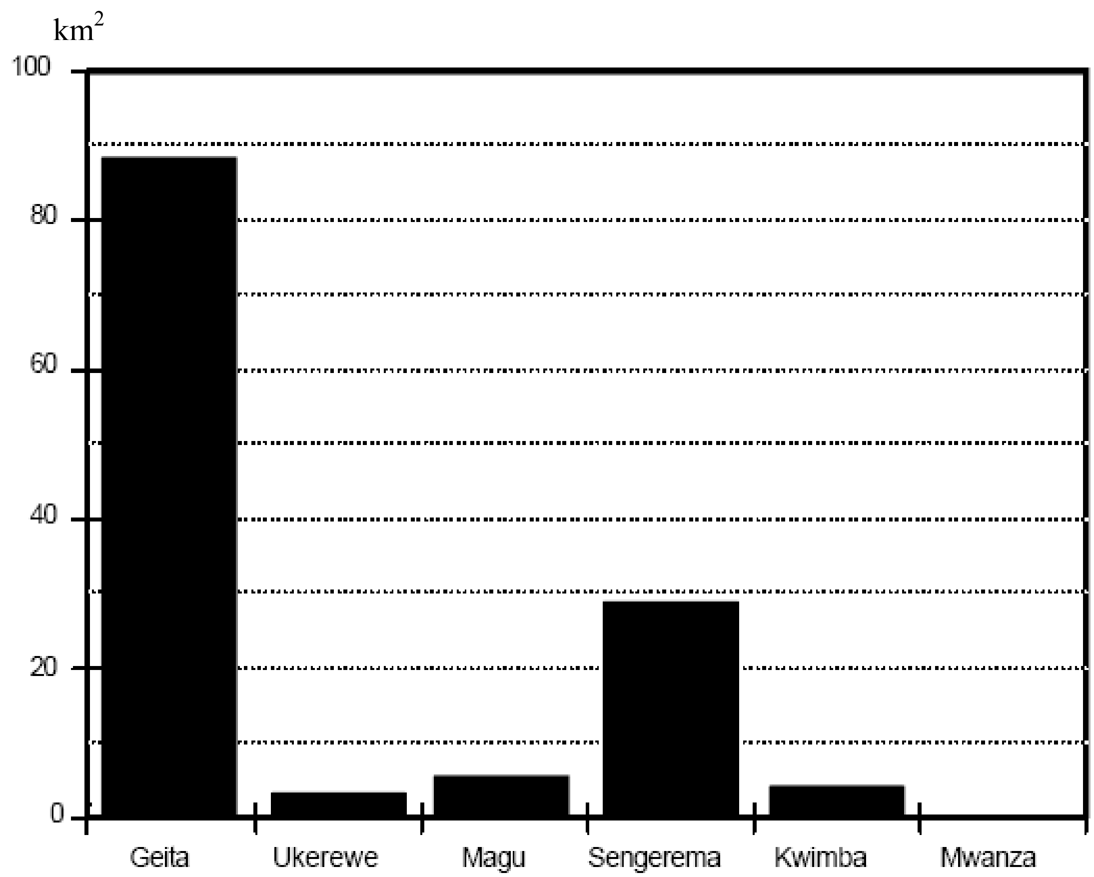

Figure 4: Areas covered by forest in Mwanza Region

Source: The United Republic of Tanzania: The Planning Commission, 1997

4.1.2 Study Area-Magu District

The study was conducted in Magu district which was chosen to be my case study. There are a number of reasons for selecting Magu district. Mwanza region along with other regions such as Dodoma, Shinyanga, Singida, Arusha, Kilimanjaro, Kagera and Mbeya have been referred as having fuel wood deficits in the country (Mwihava, 2002). This was the main reason why Magu district which is found in Mwanza region was chosen to be a case study as it may be considered to be representing rural energy problems. Findings from the study may give insights to general energy problems in rural Tanzania. The area was also selected for this study because I would not be able to visit all districts due to time and budget and Magu district could be easily accessible. Another reason is that Magu is one of the districts experiencing firewood shortage in Mwanza region. It can be clearly seen in (Figure 4) that Magu district is one of the districts where forest cover is diminishing (United Republic of Tanzania, 1997). Also the ongoing project by UNDP in collaboration with the Ministry of Energy and Minerals on Transformation of Rural PV Market in Tanzania influenced my decision to select Magu District as my case study area.

Magu district is a part of Mwanza region. It covers a total area of about 4,795 km² of which 3,070 km² is the dry land and 1,725 km² is covered by water. The district has the estimated population of about 416,113 and the average household size is 5.9 (The United Republic of Tanzania, 2005). The major socio-economic activities in the district include subsistence farming, livestock keeping, fishing and businesses. Main food crops include rice, maize, millet and cassava. Cotton is said to be a predominant cash crop in the district (The United Republic of Tanzania, 1997).

Map showing Magu District

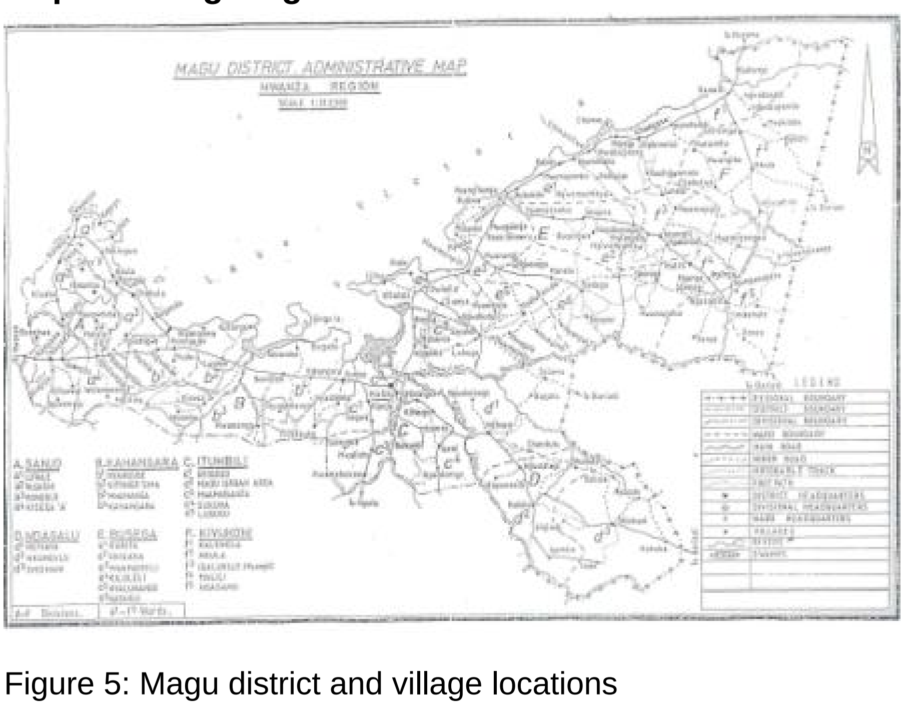

Figure 5: Magu district and village locations

Source: UNDP Project Mwanza (2005

5.0 RESULTS AND DISCUSSION

FEASIBILITY OF ADOPTING SOLAR PV SYSTEMS AND WOOD-FUEL STOVES IN MAGU DISTRICT

5.1 Energy supply

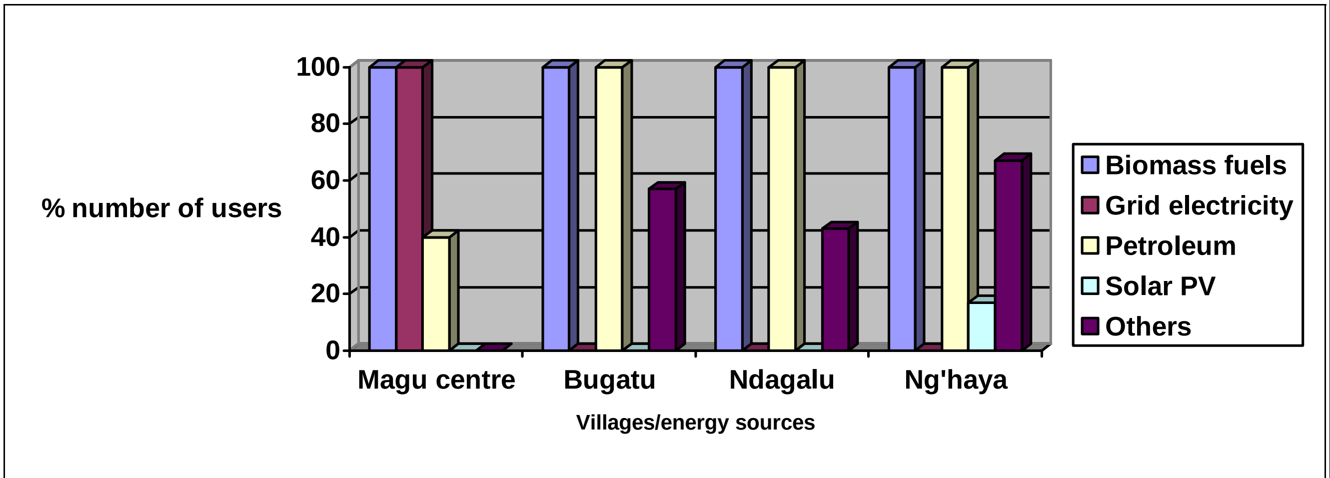

Figure 6: Energy supply in Magu and the number of users in percentage (%)

Figure 6 shows the source of energy supply for interviewed households in each village.

Magu centre

The results from this study (Figure 6) indicate that a large proportion (100%) of the interviewed households in Magu centre is using grid electricity and biomass fuels. This is because grid electricity is accessible at Magu centre. The location of Magu centre could be one of the reasons why it has been electrified. The centre is located along the main road which connects Magu district with nearby towns. Despite the fact that the households have access to grid electricity, it was found that biomass fuels continue to be their major source of energy for cooking. Grid electricity is mainly used for lighting and powering domestic electrical appliances as opposed to cooking activities. The adoption of solar PV systems for domestic use may supplement electricity from the grid as solar electricity could also be used for lighting and running domestic appliances such as radio and TV.

Figure 6 shows that 100 % of interviewed households in Magu centre were found to be using biomass fuels. The households that were found to be using petroleum fuels mainly kerosene accounted for 40% (Figure 6) of the interviewed households in Magu centre. Previous studies have shown that kerosene is mainly used for lighting purposes in rural areas (Kimambo and Mwakabuta, 2005). In this study it was found that, kerosene is specifically used for cooking and supplements biomass fuels for the households with slightly higher income when biomass fuels are scarce. The explanation for this could be the high cost of using grid electricity for activities such as cooking. Experience has shown that grid electricity which is supplied by Tanzania Electric Supply Company Limited (TANESCO) is subsidized by the government thus making it affordable to low income users (Kimambo and Mwakabuta, 2005). However, grid electricity prices can still be higher for the rural poor when compared with biomass fuels. The main reason behind is that biomass fuels such as firewood can be cheaply acquired by the rural households. Reliance on biomass fuels as energy sources for cooking is not confined to rural areas alone. Recent studies have shown that most of city dwellers in many developing countries depend on biomass fuels for cooking activities despite the fact that they are connected to grid electricity (Karekezi and Majoro, 1999, Miller, 2004)

The study results show that no household was found to be using improved wood-fuel stoves for cooking. This may have a bad implication on the human health in the area. Miller (2004) argues that "*the burning of wood, charcoal, dung and crop wastes in open fires or inefficient stoves results into indoor air pollution which causes human health problems*". The use of improved wood-fuel stoves in the study area may reduce the risk of human health problems by decreasing indoor air pollution. Chambers (1983) argues that an increase in number of people with health problems causes increased demand for social services and less involvement of households in productive socio-economic activities. However, none of the interviewed households in Magu centre (Figure 6) were found to be using energy from solar PV systems for their domestic use. Promotion of affordable renewable energy technologies is among the ways to reduce energy use practices which jeopardise the long term exploitation of the forest products.

Bugatu village

The study results show that 100% (Figure 6) of the interviewed households in Bugatu depend on biomass fuels and kerosene as their major source of energy. The households use biomass fuels mainly for cooking. Contrary to the households interviewed in Magu centre, the households in Bugatu were found to be using petroleum fuels such as kerosene specifically for lighting their homes and one household was found to be using diesel generator for operating the TV. Figure 6 indicates that none of the households were found to be using grid electricity as the source of energy. This is due to the fact that Bugatu has no access to grid electricity. The study has revealed that the more distant the village is from Magu centre, the more difficult it becomes to be electrified from the grid. The dispersed nature of the rural settlements has been noted as one of the setbacks for the grid electrification of rural Tanzania (Ministry of Energy and Minerals, 2003). The study also shows that solar PV is not used as a source of energy among the interviewed households (Figure 6). This is due to inadequate information on solar PV systems in the village. At the same time, 57% of the interviewed households in Bugatu (Figure 6) were found to be using other sources of energy to cater for their domestic use. These were mainly dry cells for powering radio.

Ndagalu village

Study results in Ndagalu show that 100% (Figure 6) of the interviewed households use biomass fuels for cooking while kerosene is used for lighting. The interviewed households have no access to grid electricity. Like Bugatu village, Ndagalu is also far from the grid electricity and it may take many years before the village gets connected to the grid. None of the interviewed households was found to be using a solar PV system. However, the study results show that 43% (Figure 6) of the interviewed households are using other sources of energy such as dry cells for radio and torches (portable battery powered electric lamps).

Ng'haya village

Similarly, study results in Ng'haya as it is shown in Bugatu and Ndagalu (Figure 6) show that 100% of the interviewed households are using biomass fuels and petroleum fuels(i.e. kerosene). All of the interviewed households in Ng'haya do not use grid electricity as their source of energy. The reason is that the village is not connected to the grid. However, 17% of the interviewed households in Ng'haya use solar PV systems as their energy source. Solar PV systems are used for lighting, power for radio, TV and cell phone battery recharging. At the same time, the results show that 67% of the interviewed households use other sources of energy such as dry cells.

5.1.2 Energy use

Figures **7a** to **7d** illustrate the total energy use from sample households in study area.

Magu centre

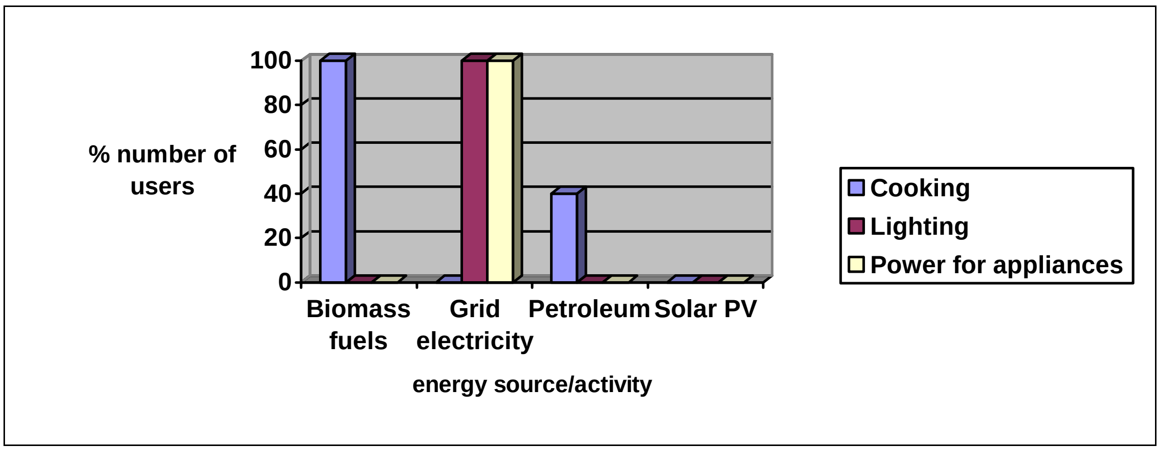

Figure 7a: Energy use in Magu centre

The results in (Figure 7a) indicate that a high percentage (100%) of the sample households from Magu centre mainly use biomass fuels for cooking. This corresponds to the results shown in (Figure 6) whereby interviewed households in each village were found to be depending on biomass fuels as their main source of energy. However, the study results (Figure 7a) have indicated that biomass fuels are not used for lighting purposes. The results (Figure 7a) also show that grid electricity is not used for the activity such as cooking. It can be seen from (Figure 7a) that 100% of the sample households are using grid electricity mainly for lighting and powering electrical appliances. On the other hand, 40% of households in Magu centre use petroleum fuels (kerosene) for cooking (Figure 7a). However, the study results show that the interviewed households in other villages (Bugatu, Ndagalu and Ng'haya) were found to be using kerosene mainly for lighting purposes.

To understand this difference, the study analysed the socio-economic activities of the sample households in all villages. The socio-economic activities were analysed because of their relationship to energy use. Household heads, for example, are the main decision makers for socio-economic activities and may influence decisions in adoption of certain innovations or technologies. The main socio-economic activities in the interviewed households are agriculture and business. The term business has been used to represent petty trade activities like owning a kiosk, local brewing, charcoal selling and others of this kind.

The study noted the relationship between household income and the type of energy sources used in the household. The interviewed households with low income were found to be very much relying on firewood as the major energy source for cooking in the household. In Magu centre households exploit more opportunities for business because of their geographical location as opposed to other villages. This implies that some of the households could afford to use kerosene for cooking when they fail to get hold of biomass fuels.

Bugatu

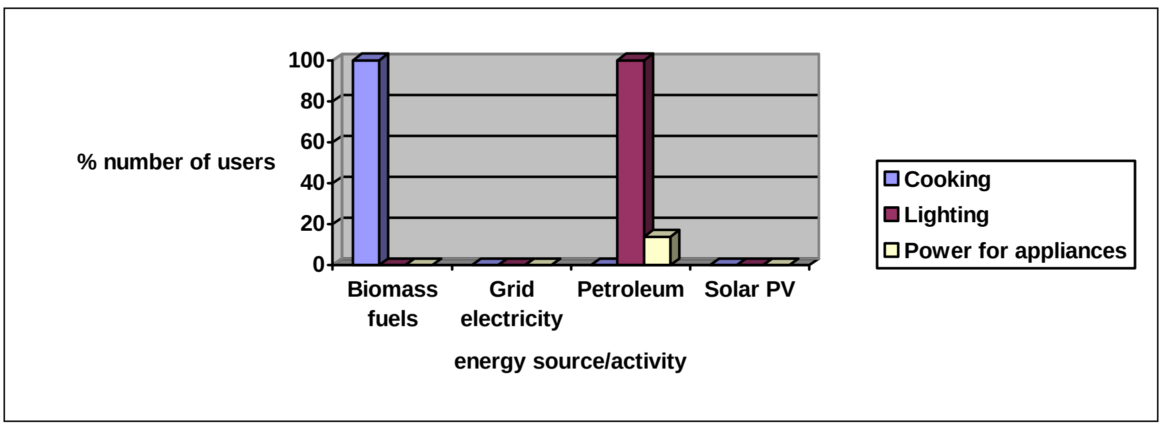

Figure 7b: Energy use in Bugatu

The study results (Figure 7b) have shown that 100% of the interviewed households in Bugatu village rely on biomass fuels for cooking. Similarly, results show that 100% of the households use petroleum fuels (kerosene) for lighting and only 14% of the households use petroleum fuels (diesel) for powering electrical appliances such as TV. The results also indicate that none of the interviewed households were found to be using either grid electricity or solar PV systems. The village is yet to be electrified to the grid.

Ndagalu

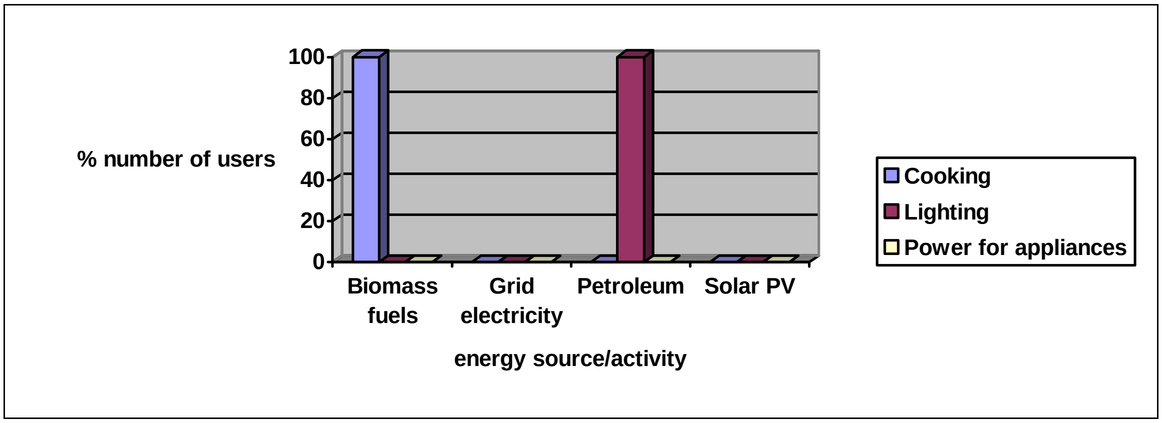

Figure 7c: Energy use in Ndagalu

The results in Ndagalu village (Figure 7c) indicate that 100% of the sample households depend on biomass fuels for cooking. The same percentage of the households (100%) were found to be relying on petroleum fuels mainly kerosene for lighting. Results (Figure 7c) indicate that grid electricity and solar PV are not used in the interviewed households. The village has no access to grid electricity.

Ng'haya

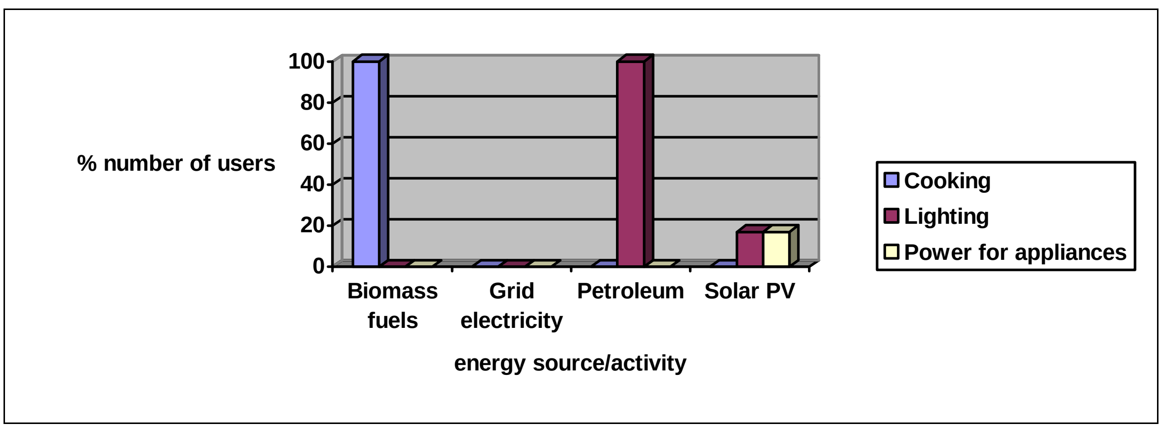

Figure 7d: Energy use in Ng'haya

The results (Figure 7d) show that 100% of the interviewed households use biomass fuels for cooking. Similarly, the number of households using petroleum fuels (kerosene) for lighting is higher, accounting for 100% of the sample households. However, unlike other villages a small proportion of the interviewed households were found to be using solar PV systems. Only 17% of the sample households were found to be using solar PV systems for lighting and powering electrical appliances (Figure 7d). The results further show that solar PV electricity was not used for cooking.

5.1.3 Problems related to energy use

Figure **8a** to figure **8d** illustrate the problems related to energy use from the sample households in the study area. Cost in this section refers to user cost i.e. cost resulting from using the energy source. It should be noted that some problems related to energy use such as human health problems and deforestation could not be covered during the field study. This is due to the nature of these problems which would have needed more time to be verified.

Magu centre

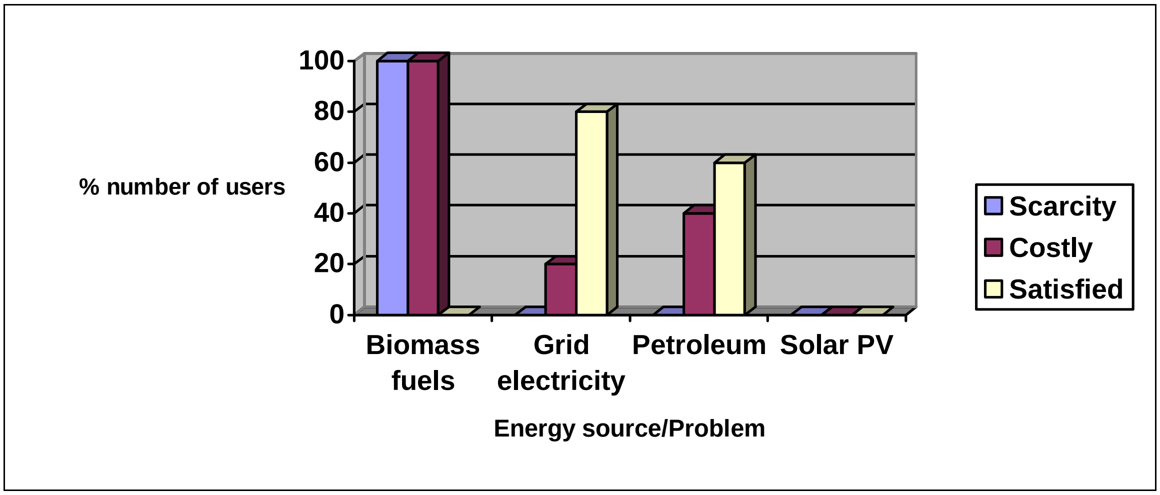

Figure 8a: Energy use and related problems in Magu centre

The results (Figure 8a) indicate that 100% of the interviewed households in Magu centre have shown their dissatisfaction on the availability of biomass fuels. At the same time, 100% of the households are concerned with the increasing cost of biomass fuels. The study results (Figure 8a) have shown that 20% of the sample households felt that grid electricity is costly and 80% of the households were satisfied with its use. The results have further shown that 40% of interviewed households said petroleum fuels (kerosene and diesel) were costly and 60% of the households felt satisfied with using petroleum fuels in their domestic activities.

The households have indicated that biomass fuels such as firewood and charcoal are becoming scarce in the area. The shortage of biomass fuels may be attributed to both population growth and poverty in the study area. It was found in this study that most of the households were comprised of many members. The age structure of the interviewed household heads was seen as ranging from 25 to 60 years. The average household size of the interviewed households in the study area was 6.2 people. Table 2 illustrates the household size distribution of the interviewed households in the study area. On the other hand Table 3 represents the population distribution of Mwanza region. The population is believed to have been increasing in the study area over years and this has exerted pressure on the available limited natural resources (Rowe et al., 1992).

Table 2: Household size distribution of interviewed households

Village name	Households interviewed	Average household size
Magu centre	5	5.2
Bugatu	7	7.4
Ndagalu	7	6.6
Ng'haya	6	5.7
Average	**-**	**6.2**

Table 3: Mwanza Region population

Male Population	1,459,570
Female Population	1,482,578
Total Population	2,942,148
Total Household Number	495,400
Average Household Size	5.9

Source: United Republic of Tanzania, 2005

The household size in the study area is almost similar to other rural areas in Mwanza region. The national population census conducted in 2002 reported the average household size of 5.9 in Mwanza region (United Republic of Tanzania, 2005). The rural household size was analysed because of its relationship to population distribution and natural resources. Population increase is considered to be one of the causes of deforestation, especially when the majority of the rural people are poor (Kaoneka and Solberg, 1994). Miller (2004) argues that "*poverty pushes poor people to use renewable resources unsustainably to survive*".

Successful conservation of forests requires improvement in the living standards of the rural population and this can be achieved through provision of environmentally friendly and affordable energy services. As it has been earlier argued in this study, (Figure 2: CLD for energy dissemination in rural Tanzania) the adoption of solar PV systems and improved wood-fuel stoves can improve the living standards of the rural households. Solar PV systems may substitute the use of kerosene for lighting. At the same time they could be used for powering domestic electrical appliances such as radio and cell phone battery recharging. In this way, the costs for petroleum fuels and dry cells can be avoided by the rural households.

On the other hand, the adoption of improved wood-fuel stoves can reduce the risk of indoor pollution which is said to cause human health problems. When rural households members are in good health, time and cost of going to health centres would be saved. At the same time improved wood-fuel stoves will minimize the excessive use of firewood. This will help protect the forests and save household time for collecting firewood. For the households buying firewood they will be also able to save money. The time and cost (money) saved could be used by the rural households in other socio-economic activities. More involvement of rural households in socio-economic activities will accelerate rural development.

Bugatu

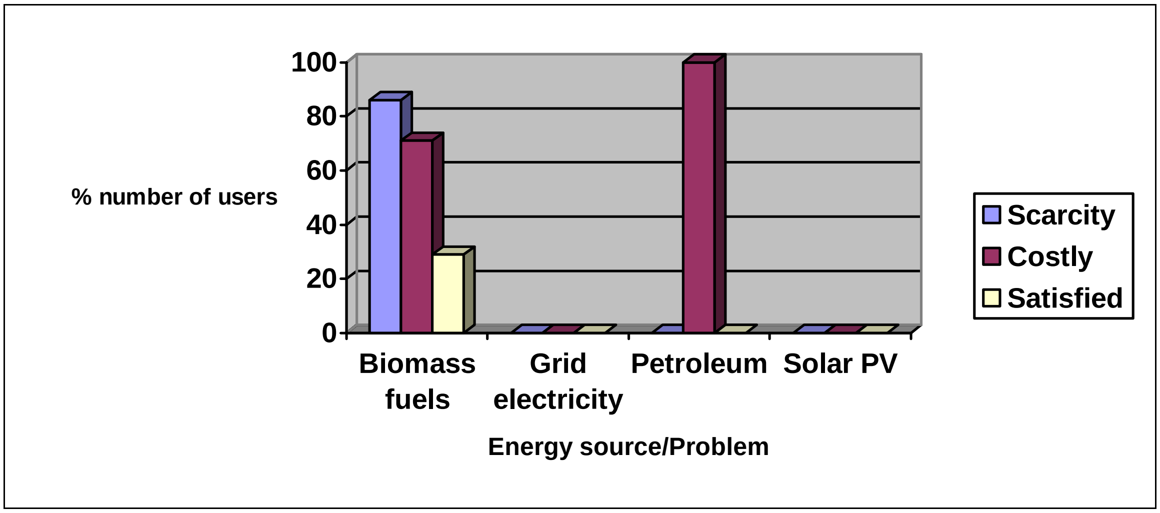

Figure 8b: Energy use and related problems in Bugatu

The results in Bugatu village (Figure 8b) indicate that 86% of the sample households do not get a desired supply of biomass fuels because they are scarce. At the same time, 71% of the households have raised their concern on the cost of biomass fuels. However, 29% of the households are satisfied with biomass fuels use. The village has no access to grid electricity and none of the sample households were found to be using solar PV electricity. The results have further indicated that 100% of the interviewed households in Bugatu felt that petroleum fuels (i.e. kerosene) were costly. The adoption of improved wood-fuel stoves in the study area will address the shortage of biomass fuels. Miller (2004) has noted that improved wood-fuel stoves are meant to increase the combustion efficiency since they burn biomass fuels more efficiently

Ndagalu

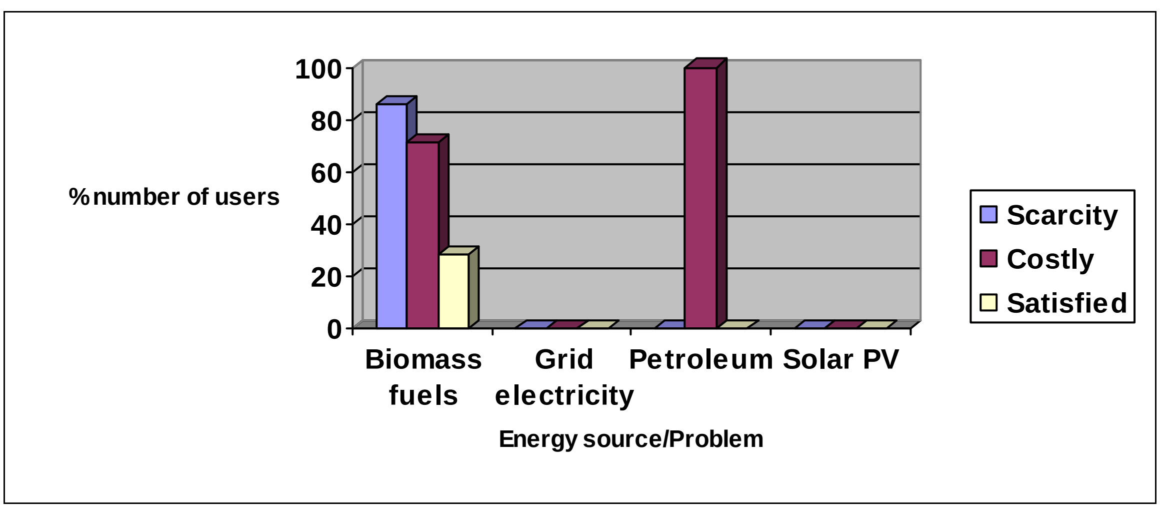

Figure 8c: Energy use and related problems in Ndagalu

The study results (Figure 8c) from the interviewed households in Ndagalu village are similar to Bugatu. The results show 86% of the households indicated the shortage (scarcity) of biomass fuels in the area and 71% of the households were not impressed with the cost of biomass fuels. However, 29% of the households were satisfied with the biomass fuels use. The results (Figure 8c) also indicate that none of the sample households use Grid electricity. This also applies to solar PV electricity since no household was singled out using solar PV systems as their energy source. On the other hand, 100% of the interviewed households indicated that petroleum fuels were costly.

Ng'haya

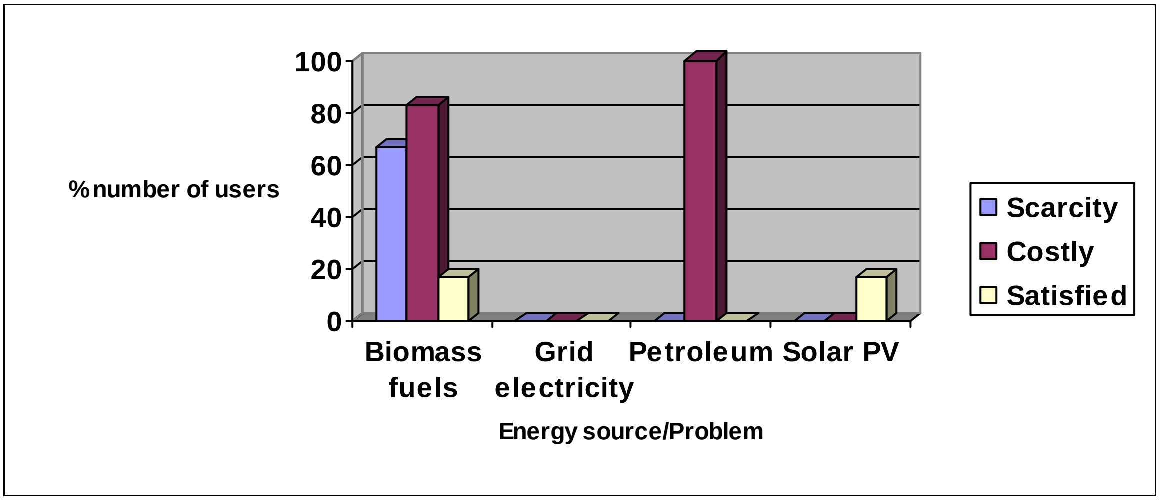

Figure 8d: Energy use and related problems in Ng'haya

Results (Figure 8d) show that 67% of the interviewed households in Ng'haya village indicated that biomass fuels are scarce. A large proportion of the households (83%) also indicated that biomass fuels were costly. Only 17% of the sample households were satisfied with biomass fuels use. Figure **8d** also shows that 100% of the households have indicated that petroleum fuels are costly. As shown in earlier results from Bugatu and Ndagalu villages (Figure 8b and 8c), none of the interviewed households in Ng'haya were found to be using grid electricity. However, 17% of the sample households who were found to be using solar PV electricity were satisfied with its use. The problems related to energy use in the study area can be reduced by the adoption of solar PV systems and improved wood-fuel stoves. Studies in Bangladesh have shown that adoption of solar photovoltaic systems can stimulate socio-economic activities and improve the living standards of the rural poor (Biswas et al., 2003).

5.1.4 Awareness on renewable technologies

Figure **9a** to figure **9d** illustrate the percentage number of sample households who have information on renewable energy technologies (RETs) and those interested in acquiring such technologies.

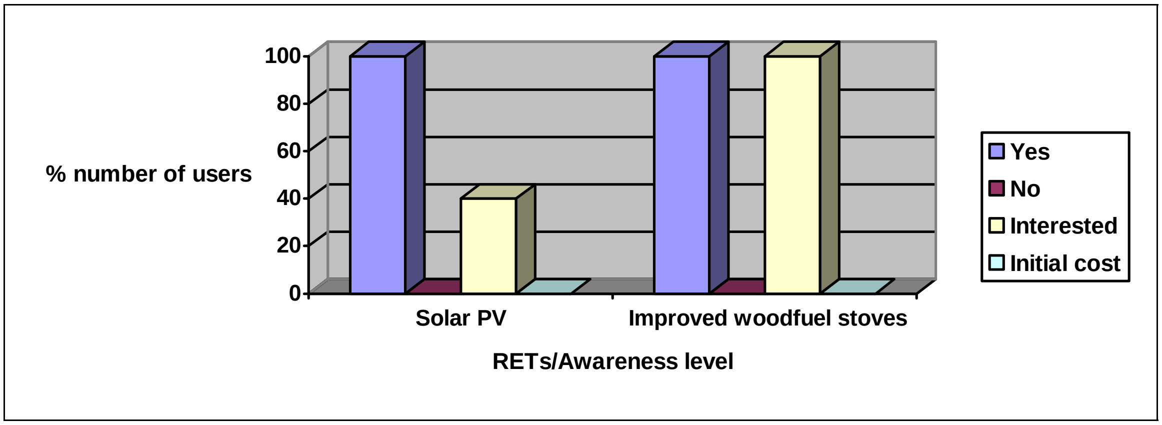

Figure 9a: Awareness on RETs in Magu centre

The results (Figure 9a) indicate that 100% of the interviewed households in Magu area have information on solar PV systems. The results have shown that most of the households got their information on media (i.e. radio). A small proportion of the households got their information from the ongoing UNDP project on Transformation of Rural PV Market. Having formal education and easy access to information is one of the reasons why most of the households in Magu centre had information on the advantages of solar PV systems. This is contrary to the results from other villages which are far from Magu centre where the majority of interviewed households were less informed about solar PV systems. The study has noticed a slight difference in education level among the household heads. A large proportion of the respondents have attained formal education.

Table 4: Education level among the household heads in percentage (%)

Education	Magu centre **n** = 5	Bugatu **n** = 7	Ndagalu **n** = 7	Ng'haya **n** = 6	**TOTAL N** = 25
No Formal Education	0	0	29	17	12
Formal Education	100	100	71	83	88

n = number of households

N= Total number of households

The household heads education was analysed because of the relationship between the levels of education and the use of renewable energy technologies. The educated household head becomes more aware of the potential benefit of using the technologies. Experience from other studies has shown the importance of education in influencing people's behaviour, perceptions and their life styles (Chambers, 1983).

Education facilitates attitude change among people and in a context of renewable energy, it may influence the knowledge and steps that the rural households take to use renewable energy technologies available.

The results indicate that only 40% of the sample households were interested in using solar PV. This is due to the fact that grid electricity meets most of the household energy needs in Magu centre. On the other hand, the results indicate that 100% of the households have information regarding the use of improved wood-fuel stoves and are interested in using them (Figure 9a). However, the interviewed households have no information on the cost of solar PV systems and improved wood-fuel stoves (Figure 9a). This can be the reason why the technologies are not used. The study also noted that there was inadequate marketing of improved wood-fuel stoves in the study area. As argued earlier, (Figure 2, CLD for energy dissemination in rural Tanzania) initial investment costs of a specific energy source may determine its supply in rural areas. Studies have shown that energy choice of rural households are very much influenced by their income which means they are likely to avoid efficient devices or convenient carriers of energy due to high initial costs associated with the specific energy sources (UNDP, 1997). Despite the advantage of lower life cycle costs, solar PV systems in the study area may only be adopted by many households if initial costs of their installation will be competitive.

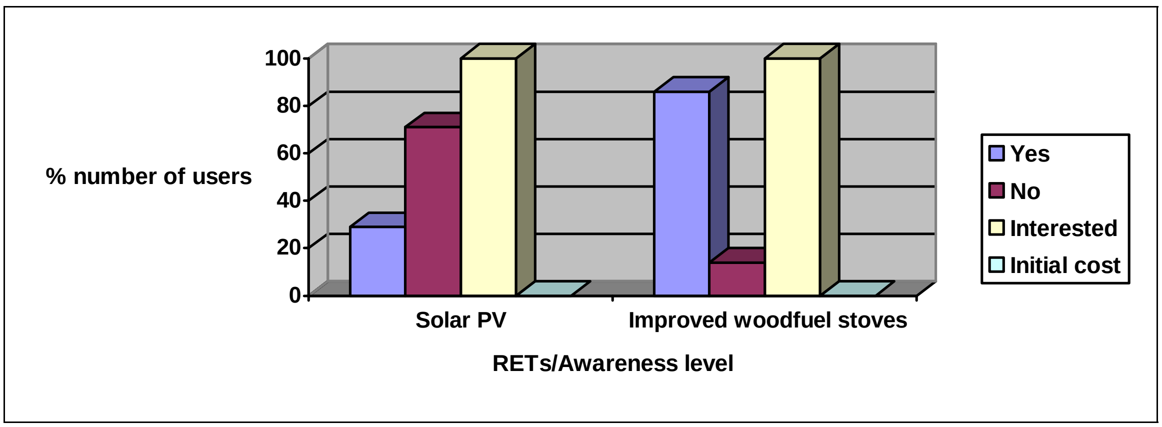

Figure 9b: Awareness on RETs in Bugatu

The study results in Bugatu (Figure 9b) indicate that only 29% of the interviewed households have information on solar PV systems. The other 71% of the households have never heard of solar PV systems. At the same time, 100% of the households have no information regarding the initial costs of both technologies. However, the results indicate that 100% of the households would be interested in using Solar PV systems. This can be related to the slightly higher costs of petroleum fuels such as kerosene which is specifically used by many households for lighting purposes. Similarly, 100% of the interviewed households would be interested to use improved wood-fuel stoves. On the other hand, **figure 9b** show 86% of the interviewed households have information on improved wood-fuel stoves and only 14% have not heard about the improved wood-fuel stoves. Studies in Ghana have shown that inadequate information is one of the problems hindering the adoption of renewable energy technologies. It was learnt that the majority of the population had less knowledge on Solar photovoltaic (Makume, 1999)

Ndagalu

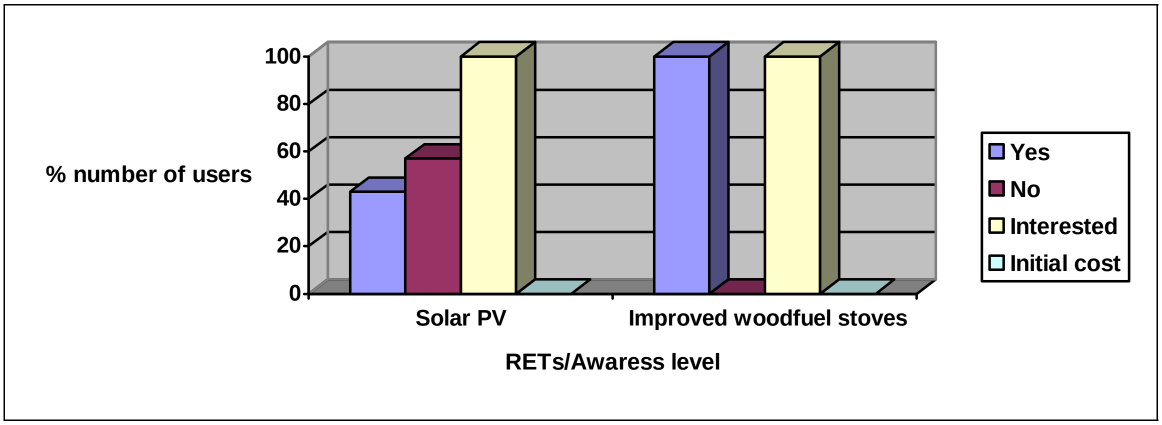

Figure 9c: Awareness on RETs in Ndagalu

The results in Ndagalu (Figure 9c) indicate that 43% of the sample households have information on solar PV systems. More than a half of the interviewed households have no information on solar PV systems and this accounted to 57% (Figure 9c). However, 100% of the households indicated they would be interested in using solar PV systems. Similarly, 100% of the sample households have information on improved wood-fuel stoves and are equally interested in using them. It was learnt that most of the households got information on radio and through an NGO called CARITAS which once promoted the use of improved wood-fuel stoves in the area. However, none of the sample households had information on the initial cost of either solar PV systems or improved wood-fuel stoves.

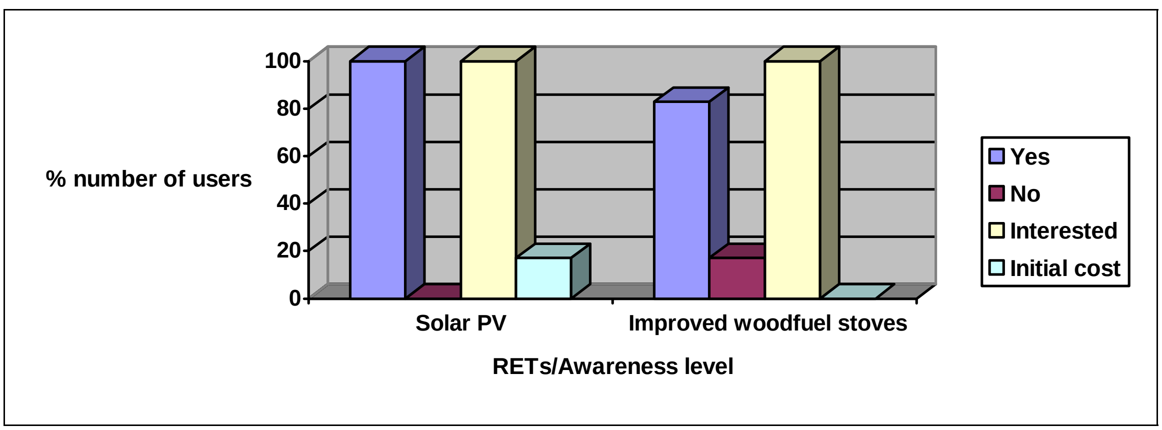

Figure 9d: Awareness on RETs in Ng'haya

The results (Figure 9d) indicate that 100% of the sample households in Ng'haya have information on solar PV and showed interest in acquiring solar PV systems. However, only 17% of the interviewed households had information on the initial costs of solar PV systems. Results also indicate that 83% of the households in Ng'haya have information regarding the use of improved wood-fuel stoves. The results (Figure 9d) indicate that only 17% of the sample households did not have information on improved wood-fuel stoves while 100% of the interviewed households were interested in using the stoves.

6.0 CONCLUSIONS AND RECOMMENDATIONS

- **Conclusions**

Solar PV systems have a potential for adoption by rural households in Tanzania. The study concludes that solar PV systems can be useful in lighting and powering domestic electrical appliances in households living in the villages which are far from the grid electricity supply. It further concludes that improved wood-fuel stoves can also be adopted by rural households. Improved wood-fuel stoves will have a high potential in cooking and can be used as a strategy for energy saving and cost reduction in household energy expenditure. The adoption of the technologies will improve the living standards, reduce indoor pollution and slow down deforestation rate. In most cases, the technologies are expensive for some poor rural households. Therefore, the extent of adoption of the technologies will depend on the initial costs of acquiring them. However, the adoption of solar PV systems and improved wood-fuel stoves alone will not significantly improve the energy services in rural Tanzania. Other available renewable energy technologies should supplement solar PV systems and improved wood-fuel stoves if any meaningful long term rural development in Tanzania has to be achieved.

- **Recommendations**

The study recommends the promotion of energy technologies which use less biomass fuels. Adoption of improved wood-fuel stoves in rural Tanzania can reduce an excessive use of firewood and could help in conserving the environment. Although the adoption of improved wood-fuel stoves is supposed be the household initiative, rural households should not be left to undertake this responsibility alone without government support, both technically and financially.

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Appendix

QUESTIONNAIRE FORM

Personal information

Name of interviewee……………………………………

Village/District……………………………………….

Age…………………………………………………...

Gender………………………………………………..

Education……………………………………………..

Family size……………………………………………

Occupation

- Formal employment; Yes☐, No☐, Position held…………………………..
- Farmer
- Other activities

Monthly income…………………

Date …………..……………….

Energy use background

a) Do you use energy for the following applications?

Activity	Energy source	Quantity/month	Cost/unit	Satisfaction level	Remarks
Cooking					
Lighting					
Water heating					
Irrigation					

b) Other energy applications

1.Power for radio				
2.Power for TV				
3. Crop drying				
4. Other appliances				

Do you experience any problems with your current energy sources?

- Yes□
- No □

If the answer is YES or NO; why

- 1……………………………………………………………………………..
- 2……………………………………………………………………………..
- 3……………………………………………………………………………..
- 4……………………………………………………………………………..
- 5……………………………………………………………………………..
- 6……………………………………………………………………………..

What improvements would you wish to see if you were to obtain optimum benefits from your energy use?

- 1………………………………………………………………………………
- 2………………………………………………………………………………
- 3………………………………………………………………………………

Renewable energy

Have you ever heard of solar electricity?

- Yes□
- No □

Have you ever heard of energy saving cooking stoves (majiko sanifu)?

- Yes□
- No □

If YES, where did you hear that from?

  - 1………………………………………….
  - 2………………………………………….
  - 3………………………………………….

Do you know where to get such energy systems?

- Yes□
- No □

Are you interested in using solar electricity?

- Yes□
- No □

Are you interested in using energy saving cooking stoves (majiko sanifu)?

- Yes□
- No □

If YES, why have you not gone for such energy options?

- 1………………………………………………………………………………..
- 2………………………………………………………………………………..
- 3………………………………………………………………………………..

RENEWABLE ENERGY USERS

What forms of renewable energy sources do you use?

Type of renewable energy	Where used

Where did you get the RE technology you are using?

- 1…………………………………………………………………………………
- 2...

When did you start using solar PV system(s)?

………………………………………………………………………………………..

When did you start using energy saving cooking stove(s)?

………………………………………………………………………………………..

What benefits have you gained so far from the use of renewable energy?

- Household
  1………………………………………………………………………………..
  2………………………………………………………………………………..
- Irrigation
  1………………………………………………………………………………..
  2………………………………………………………………………………..
- Economically
  1………………………………………………………………………………..
  2………………………………………………………………………………..
- Socially
  1………………………………………………………………………………..
  2………………………………………………………………………………..

What improvements would you wish to see if you were to obtain optimum benefits from your renewable energy use?

- 1…………………………………………………………………………………
- 2…………………………………………………………………………………

Do other people in the village use renewable energy?

- Yes□
- No □

What forms of renewable energy do they use?

- 1………………………………………………………………………………..
- 2………………………………………………………………………………..
- 3………………………………………………………………………………..