 J. Hum. Ecol., 24(3): 175-189 (2008)

Promoting Renewable Energy Technologies for Rural Development in Africa: Experiences of Zambia

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KEYWORDS Households. Renewable Energy Technology. Rural Development Institutions. Markets

ABSTRACT The need to meet the growing energy demand from Zambia's growing economy and the large number of un-electrified households has been the major driver towards the introduction of renewable energy technology in the country. This study is based on a review of planning and policy documents, a household questionnaire survey and interviews with energy institutions, planners and rural development organisations. The paper examines Zambia's efforts to exploit renewable energy technology. The paper reveals a growing interest in renewable energy among policy makers and planners. Attempts have been made to integrate renewable energy technologies in development policy and plans. The study also shows that the use of renewable energy in rural Zambia is limited mainly to solar energy technologies with minimal exploitation of wind energy technology. However, household use of solar energy technologies in the form of solar home systems is limited to an elite group of rural population that is mostly in formal and / or government employment. The challenges of renewable energy use in Zambia include inadequate policy provision and implementation, lack of awareness among rural households about the benefits of renewable energy, the high cost of technology and the undeveloped nature of renewable energy markets.

1. INTRODUCTION

The growing interest in renewable energy technologies (RETS) has been stimulated by global awareness that fossil fuels are not infinite and the recognition that the use of fossil fuels constitutes one of the major sources of green house gases that contribute towards global warming. Ever since the industrial revolution, global energy production and consumption has been on the rise. It is estimated that global energy demand will increase by a factor of 2-3 (see Table 1). The US Energy Information Administration (EIA, 2006) projects a strong growth for world wide energy demand over a 27 year projection from 2003 to 2030. This demand is largely driven by the world economic growth which is increasing at an annual average rate of 3.8 percent per year. The total world consumption of marketed energy will expand from 421 quadrillion thermal units (BTU) in 2003 to 722 quadrillion BTU in 2030, representing a 71 percent increase in the projected period (EIA, 2006).

While world energy consumption may rise by 71 per cent in the projected period, the EIA further projects that consumption in developing nations will grow by 121 per cent during this period. It is also expected that energy related emissions will grow by 40 per cent from 1990 to 2010 and will grow by 72 per cent from 1990 to 2020. It is these worrying trends that have boosted the drive towards renewable energy use in the industrialised countries, especially within the framework of the Kyoto protocol that places mandatory reduction in carbon emissions for countries that are party to it.

Today, renewable energy technologies are growing at a tremendous speed and are playing

Table 1: World energy consumption 1990-2030 (In Quadrillion Btu)

Region	*1990*	*2030*	*Annual percentage change (2004-2030)*
OECD America	100.8	157.6	1
OECD Europe	69	86	0.3
Non OECD Europe	67.2	72.1	1.4
Asia/Pacific(OECD)	26.6	45.3	0.7
Middle East	11.3	36.9	2.2
Asia/Pacific(Non OECD)	47.5	219.7	3.1
Africa	9.5	23.9	2.2
Latin America	14.5	39.5	2.2

Source: US Energy Information Administration (EIA, 2006)

Table 2: Global renewable energy capacity in 2005.

	Existing at end of 2005	*Growth rate (%) in 2005*
Power Generation		
Large hydro power	750 GW	1.5-2
Small hydro power	66GW	8
Wind turbines	59GW	24
Biomass Power	44GW	-
Geothermal power	9.3GW	3
Solar PV grid connected	3.1GW	55
Solar PV, off-grid	2.3GW	15
Solar thermal power	0.4GW	-
Ocean(tidal power)	0.3GW	-
Hot water/heating		
Biomass heating	220GWth	
Solar collectors	88GWth	
Geothermal heating	28GWth	9
Transport fuel		
Ethanol production	33 billion litres/year	8
Bio diesel production	3.9 billion litres/year	85
Rural (Off-grid Energy)		
Biomass cooking stoves in use	570 million	-
Household –scale biogas digesters in use	21 million,	-
Household scale solar PV in use	2.4 million	-

Source: International Energy Agency (IEA, 2007)

an important role in power generation, heating, transport fuels and rural off-grid energy supply (IEA, 2007). Table 2 shows the renewable energy capacity and growth rate in 2005. Bio-diesel, grid connected photovoltaic and wind turbines experienced the highest growth rates.

Large hydro power makes the largest renewable energy contribution towards global power production. However, environmental concerns of large hydro projects are increasingly blocking its growth. Attention is now increasingly being focused on the new renewable energy technologies (wind, solar, tide and geo-thermal) as illustrated in figure 1.

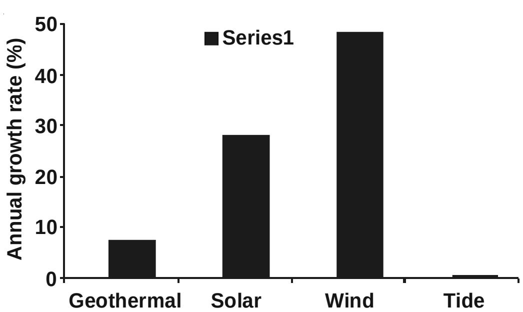

Fig. 1. Growth of new renewables supply 1971-2004
Source: International Energy Agency (2007)

Renewable energy (includes biomass and hydro) met 14% of the global energy supply in 2003. This share is projected to remain relatively constant through to 2030 as illustrated in figure 2.

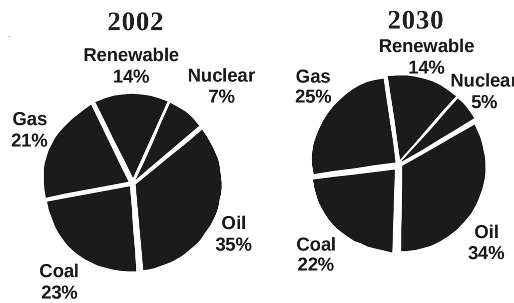

Fig. 2. Share of renewable energy in the global energy supply (2002-2030)
Source: United Nations Department of Economic and Social Affairs (UNDESA, 2005)

Fossil fuel which is expected to continue dominating the global supply of energy in the projected period, contributes a share of 79% and nuclear energy 7 % (UNDESA, 2005). The contribution of new renewables to the global energy supply stands at 1 % and is expected to increase to 2% by 2030 (UNDESA, 2005).

1.1 Africa's Energy Situation

While the long-term global impact of current fossil fuel use is a major worrisome factor for industrialised countries, most developing countries are pre-occupied with meeting the barest energy needs of their developing economies and populations. A great disparity in energy consumption exists between the developed and developing countries. The latter have 80 percent of the world's population but consume only 30 percent of the world's commercial energy (RECIPES, 2006). Ironically, many of these countries are richly endowed with energy resources.

Africa has 1.1 million GWH of exploitable hydro-power, 8 billion cubic meters of natural gas reserves and over 60 billion cubic meters of coal. This is in addition to a wealth of biomass, solar and wind resources. Only 7 percent of the hydraulic and 0.6 percent of geothermal energy potential is exploited. Africa has the highest mean annual solar radiation in the world per year. It is estimated that 95 percent of the daily global winter sunshine above 6 KWh/m^2 falls in Africa

(Ejigu, 2005). Yet, the majority of the continent's population, especially in sub-Saharan Africa, are without access to electricity and other modern forms of clean energy. The amount of electricity used in the industrialized countries is 150 times higher than that of Africa. Sub-Saharan Africa continues to rely heavily on low quality traditional sources of energy such as wood fuel. Seventy six percent (76%) of the population depends on wood fuel as a source of energy (ENDA, 2005).

Furthermore, there appears to be a positive relationship between national income and modern energy consumption in Africa. Countries with high GNP tend to consume more modern energy than countries with low incomes (Figure 3). The majority of African countries are low income countries and therefore consume less energy (Karekezi, 2002).

Furthermore, the energy sector in Africa shows regional diversity and can be best clustered into three distinct regions. The first is North Africa, which is heavily dependant on oil and gas. The second is South Africa which relies on coal while the rest of Sub-Saharan Africa is largely reliant on biomass. In 1997, South Africa and North Africa accounted for over 50% of Africa's total modern energy production (Karekezi, 2002).

Today, energy is acknowledged as an essential ingredient for the attainment of poverty reduction, especially within the framework of the Millennium Development Goals (MDGs). According to Bugaje (2004), a lack of adequate energy services is certainly a constraint on development. It limits the capacity to meet the basic needs of those who need energy to undertake essential domestic, agricultural and educational tasks, to support health services, and to initiate trade flows. This realisation has become a major driver towards increasing energy supply in Africa and the use of renewable energy technologies in particular. The projected increase in energy consumption in Africa from 1990 to 2030 provided in Table 3 vividly depicts the enormity of the energy challenge in Africa.

Table 3: **Africa energy consumption 1990 -2030(In Quadrillion Btu)**

Year	*1990*	*2003*	*2004*	*2010*	*2015*	*2020*	*2025*	*2030*
Consu-mption	9.5	13.3	13.7	16.7	18.5	20.6	22.4	23.9

Source: Energy Information Agency (EIA, 2007)

2. THE RESEARCH PROBLEM AND HYPOTHESIS

Achieving a sustainable energy future for all is a universal goal that is placed on the agenda

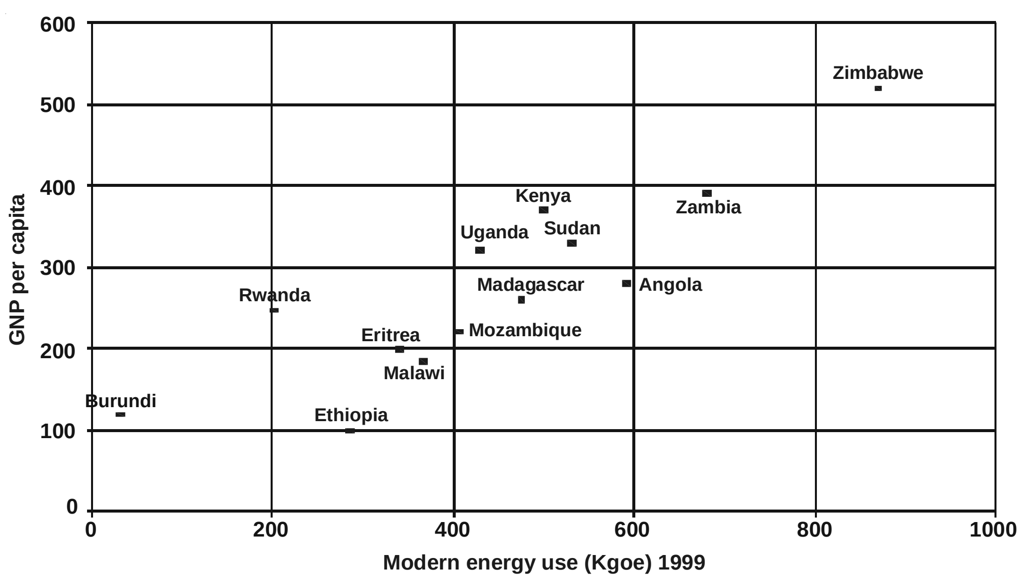

Fig. 3. Relationship between national income and energy
Source: Karekezi, 2002

of United Nations organisations by international consensus. Both Agenda 21 and the Johannesburg Plan of Implementation (JPoI) regard an efficient use and supply of energy that are reliable, affordable and less polluting as indispensable components of sustainable development. To achieve this goal, more and better integrated energy-environment planning and an increased use of renewable sources in the overall energy supply system are important elements that should be incorporated into any country's energy-environment development strategy (Najam and Cleveland, 2005)

Africa's energy situation illustrates the necessity and urgency of investing in development of decentralised renewable energy technologies for rural and poor communities. Zambia, like the rest of Africa, is no exception to this situation. Nearly 98% of rural Zambians that accounts for 65 percent of the country's population have no access to electricity; it heavily relies on biomass energy (CSO 2001). Furthermore, the cost of extending grid electricity to remote areas in the country is too high and the low demand for the rural areas can not justify the cost of electrification projects (Machungwa, 2005).

While statistics show that there is an increase in the use of renewable energy sources world over, in actual fact, the growth is dominated by a few players. A mere six countries account for 80 percent of the global solar and wind energy: Denmark, German, India, Japan and the United States of America (Sawin, 2004). Africa stands out as one of the least beneficiaries of renewable energy technologies as it accounts for only 1.8% of the global new renewable energy supply (IEA, 2007).

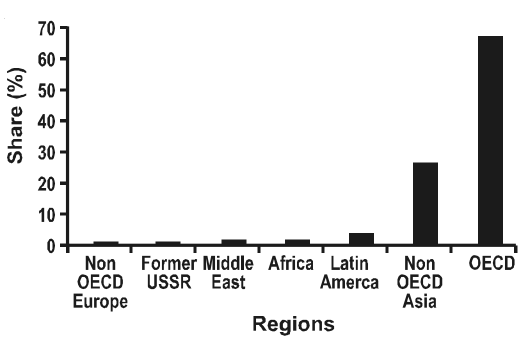

Fig. 4. Regional shares in renewable energy supply 2004.

It is clear that renewable energy technology development in Africa is still embryonic. Data on renewable energy development and adoption in Africa are extremely poor. This situation creates the need to investigate the state of renewable energy technologies in many African countries.

In Zambia, apart from a few studies commissioned by the Swedish International Development Agency (SIDA) on the state and dissemination of solar home systems, research on renewable energy has concentrated mainly on the technical aspects at the University of Zambia Energy Research Laboratory. Major bottlenecks in applying renewable energy technologies (RETs) in rural settings relate to communities' level of income, policy and planning implications, the nature of the supply networks, and information on RETs and knowledge about this technology. Lack of information on these and other factors weakens the drive towards application of RETS and consequently the future of sustainable energy remains gloomy. It is in this context that this study seeks to examine Zambia's efforts towards the promotion of renewable energy technologies and the quest for making sus-tainable energy available to rural Zambia.

Decentralised energy services provided by solar, wind and other renewable energy technologies should now be considered as an absolute necessity if the energy needs of remote rural areas are to be met.

3. MATERIALS AND METHODS

This paper examines Zambia's efforts towards the use of renewable energy technologies (RETs). It investigates the factors and dynamics relating to renewable energy potential, its adoption by households and institutions and its contribution to the socio-economic well being of the rural population. Communities' and households' knowledge on and use of renewable energy technologies are based on data collected in Lundazi, a district in the Eastern Province of Zambia

Both secondary and primary sources of information were collected and analysed. International and national literature on renewable energy was reviewed in order to identify the renewable energy trends and the main debates relating to renewable energy development in the world. The Zambia National Energy Policy, the

Poverty Reduction Strategy Paper, Zambia's principal development plans and the Lundazi district development plan were reviewed in order to determine the level of integration of renewable energy promotion in these documents.

With regard to primary data, household questionnaires and interviews were used. A questionnaire survey was administered to 80 households in Lundazi district in order to examine use of renewable energy technologies at the household level and factors relating to non-adoption of renewable energy technologies. Rural institutions, enterprises, staff of the district planning office, the department of energy and other energy stakeholders were interviewed to gain insight on institutional renewable energy use, policy orientation and the extent of renewable energy markets. Further more, focus group discussions were used to collect data in the study area. This data collection instrument helped unveil emerging issues in the area of renewable energy and community knowledge of renewable energy technologies.

4. ZAMBIA'S ENERGY RESOURCES AND CONSUMPTION PATTERN

Zambia is richly endowed with a range of primary energy sources, including hydropower, coal, woodlands and renewable sources of energy. The hydropower potential is estimated at 6,000 MW. However, the total installed capacity is about 1,700 MW. Hydroelectric plants represent 92% of the installed capacity and account for 99% of electricity production. Proven coal reserves are estimated at 30 million tones with several hundred million tones of probable reserves (GRZ, 2002). Petroleum is the only energy source that is imported. A limited amount of white products are also imported in the country. Solar radiation averages 5.5 kWh/m²/day with up to 3,000 sunshine hours annually, providing significant potential for solar thermal and photovoltaic exploitation. Wind speeds are however low, averaging 2.5m/s and 10m above the ground (Machungwa, 2005; CSO 2001).

Despite this range of energy resources, energy consumption is still very low in the country. The total annual consumption of all forms of energy in Zambia is in the range of 4.5 million Tonnes Oil Equivalent (TOE). The mining sector is by far the largest consumer of electricity (see Figure 5), accounting for 68% of the total consumption, followed by the government and service sector with 7%, industry and commerce with 4%, households with 19% and agriculture with 2 % (GRZ 2002).

The past six years have seen a tremendous increase in investment in the mining and other sectors of Zambia's economy because of the phenomenal increase in copper prices. This boom in economic activity has invariably caused a proportionate increase in demand for electricity. The country's Energy Regulation Board (ERB, 2006) has warned that the increasing demand for electricity by the mines and other sectors of the economy is running faster than previously anticipated. It is currently estimated that Zambia will run out of electricity supply by the year 2008 when electricity demand is expected to outstrip supply.

To keep up with this increase in demand,

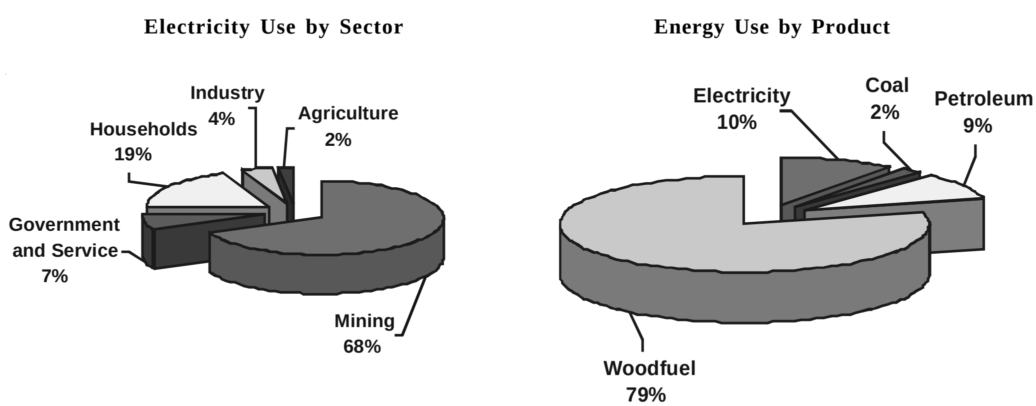

Fig. 5. Energy use by sector and product in Zambia

Zambia dearly needs to increase its current electricity generation capacity by 180 percent from the current 1,608Mw to 4,700 Mw. The estimated cost of this increase is U$2 billion. It may take five to seven years for a new hydro-power plant to be built (ERB, 2006). In addition to the challenge of meeting this huge energy demand, Zambia is faced with the challenge of satisfying the demand of more than 80 percent of its population for modern forms of energy that are environmentally benign and can significantly improve their socio-economic situation.

Only 16.7 percent of households in Zambia have access to electricity, while wood fuel in the form of firewood and charcoal is the principal source of energy in the country. Forty four (44) percent of urban households have access to electricity compared to 2.2 percent of rural households (CSO, 2001). The majority of the population heavily relies on charcoal and firewood for heating and cooking, while candles and kerosene are used for lighting.

The energy requirements of the growing economy and the rural energy needs are strong drivers for the exploitation of renewable energy technologies in Zambia. In addition, environmental and health concerns of utilisation of traditional biomass energy have strengthened this need for renewable energy technologies. Zambia has set a goal in its poverty reduction strategy paper to increase the access rate to electricity in urban areas to 70% by 2010. At the same time, it has been recognised that electrifying large parts of the rural population through conventional grid services cannot be attained. Extending grid electricity to households in rural areas can cost seven times more than supplying urban areas with grid electricity. It is estimated that for a country like Uganda, which has similar energy and economic characteristics as Zambia, it would take 250 years to supply all households with electricity at current rates of electrification (DFID, 2002).

4.1 Renewable Energy Potential in Zambia

According to the Department of Energy (DoE) of Zambia, renewable energy resources in the country comprise solar energy (thematic and photovoltaic); small hydro; biomass (agricultural waste, forest waste, industrial waste, energy crops and animal waste); geothermal; and wind. Large hydro electricity facilities are no longer considered renewable because of the resultant negative environmental impacts of such large scale undertakings. Similarly, considering the way firewood and charcoal are currently used, they can no longer be considered renewable. Their exploitation is causing severe forest degradation and can not therefore be regarded as sustainable energy sources. According to GRZ-MTENR (2002), one full time charcoal producer is capable of clearing 0.5 ha of forest land per year. In Southern Africa, the rate of deforestation is highest in Zambia (2.4%) and Malawi. Between 200,000 and 300,000ha of forested land is lost per annum (FAO, 2003). The dependence on wood as a source of energy in relation to the population growth rate is one of the major causes of this loss of forest cover (GRZ-MTENR, 2002).

In view of this, the Department of Energy considers renewable biomass energy sources to comprise forest waste, agriculture waste, energy crops and animal waste. Though renewable energy sources are increasingly being used, they still make an insignificant contribution to the total energy supply. The availability and potential for the utilisation of these renewable energy resources is summarised in Table 4.

Besides these renewable energy resources, Zambia has geothermal energy potential though it has not been examined in great detail. It has more than 80 hot springs which are associated with zones of major deep seated fault and fracture systems along which water circulates to great depths and is heated through normal geothermal gradients. Preliminary interpretations of geochemical data and estimation of subterranean temperature for some of the springs by the DoE point to the existence of potentially exploitable low enthalpy geothermal reserves in most parts of the country. At present, there is no geothermal exploitation in the country.

4.1.1 Zambia's Energy Policy and Renewable Energy Technologies

Energy policy development in Zambia has generally been slow. The 1994 energy policy represents the first comprehensive national energy policy in the country. The development of this energy policy was preceded by the establishment of the Ministry of Energy and Water Development in 1991. The establishment of the Ministry and the formulation of the energy policy were seen as important milestones in the

Table 4: Availability and potential of renewable energy resources and technologies in Zambia

Renewable Energy Source/Technology	*Opportunities/Use*	*Resource Availability*	*Potential Energy Output*
Solar	Thermal (Water heating) PV-Electricity(Water pumping, lighting, refrigeration)	6-8 sunshine	5.5kWh/m²/day (Modest potential for irrigation)
Wind	Electricity, Mechanical (Water pumping)	Average 2.5- 3m/s	Good potential especially for irrigation
Micro-hydro	Small grids for electrification	Reasonably extensive	Requires elaboration and quantification
Biomass (Biommethanation)	Electricity generation, heating and cooking	Animal waste, municipal and industrial waste, waste water	Potential requires elaboration
Biomass (Combustion and Gasification)	Electricity generation	Agro-waste, forest waste and sawmill waste.	Potential requires elaboration and quantification
Biomass (extraction, processing for transport)	Ethanol for blending with gasoline to replace lead as octane enhancer Bio-diesel for stationery engine	Sugarcane Sweet Sorghum Jatropha	15, 000 ha to meet current band
Biomass (for household energy)	Improved charcoal production Improved biomass stove	Sawmill wastes and indigenous trees from sustainable forest management	Reasonable extensive

Source: Zambia Department of Energy (DoE, 2005)

recognition of the sector's importance in national development. The energy policy is the basis for the development of the country's energy sector. The main objective of the policy is to promote optimum supply and utilisation of energy, especially the indigenous forms and to facilitate the socio-economic development of the country and maintenance of a safe and healthy environment (GRZ, 2002). The policy recognises the potential role renewable energy technologies such as solar energy can play in meeting the country's energy demand and provide for the following:

- Promotion of renewable energy technology.
- Promotion of wider application of Renewable Energy Technologies (RETs).
- Promotion of information dissemination on the use of RETs.
- Promotion of education, research and training in RETs at various levels.

However, the role of renewable energy is overshadowed by the dominant focus on hydro-electricity for which (unlike other renewable energy sources) there is a clear investment strategy and defined targets. This focus occurs despite the recognition that providing hydro-electricity to all remote areas in Zambia is practically impossible. Furthermore, 12 years since the formulation of the policy, implementation has been extremely poor. Very few demonstration projects have been established to showcase the viability of renewable energy technologies in the country. The University of Zambia and the National Council for Scientific Research which are involved in energy research are grossly under funded and are unable to effectively carry out their research projects. The training centre specifically established to provide training to energy practitioners (Kafue Gorge Training Centre) has no course on renewable energy technologies other than hydro-electricity.

4.1.2 Integration of Renewable Energy Technologies (RETS) in Zambia's Development Plans

The development plans based on the 1994 energy policy have equally put more emphasis on grid hydro-electricity at the expense of other renewable energy technologies. These plans include the Poverty Reduction Strategy Paper (PRSP), Transitional National Development Plan (TNDP) (2002-2005) and the recently launched Fifth National Development Plan (FNDP) from 2006 to 2010. The PRSP acknowledges the importance of harnessing renewable energy resources to meet the country's energy needs. However, no investment strategy or targets for renewable energy technologies are defined in the PRSP. Renewable energy technologies are again overshadowed by a heavy focus on hydropower. Furthermore, the PRSP does not clearly establish the link between energy and rural development.

The transitional national development plan (TNDP) set out the goals, objectives, strategies and activities for national development from 2002 to 2005. A critical look at the TNDP also shows that renewable energy technologies have in reality been ignored. There are four energy objectives in the TNDP (Table 5).

As can be seen from Table 5, the TNDP is quite vague when it comes to renewable energy development. Of the four objectives, two integrate renewable energy technologies in strategies, activities and programmes. RETs, other than hydro, are only recognised in the role they can play in reducing charcoal use and are consi-dered under the programme for intensification of awareness campaign on deforestation. Even when renewable energy technologies are mentioned as a strategy under objective 2, in terms of activities, the plan stresses on solar photovoltaic technology and efficient charcoal production. Although wind, solar thermal, geothermal and modern bio-energy technologies can contribute towards the attainment of the TNDP energy objectives 1, 2 and 3, they are not explicitly integrated in the energy strategies, programmes and activities.

In addition to meeting the said objectives, RETs can contribute to economic development through employment creation and business opportunities for the country's entrepreneurs. Furthermore, the inadequacy of the TNDP lies in the fact that the majority of the rural population does not use charcoal but wood fuel in its unprocessed form. It is quite worrying that the promotion of efficient production and utilisation of wood fuel in the plan is reduced to a strategy for reduction of charcoal use and not seen as an energy objective in itself.

The TNDP has now been replaced by the Fifth National Development Plan (2006-2010). The renewable energy objective of the FNDP is to provide and disseminate up-to- date information on RETs in order to increase awareness and promotion of these technologies. Although the FNDP explicitly points out its focus on bio-fuel development, it is rather unclear on other renewable energy technologies such as solar and wind. The plan has no specific strategies, programmes, targets or investment goals for solar and wind energy technologies. Clearly, renewable energy technologies have not been given the attention they deserve in the national energy policy and development plans. This is perhaps, one of the major hindrances to promoting a widespread use of RETs in Zambia.

5. USE OF RENEWABLE ENERGY TECHNOLOGIES: THE CASE OF LUNDAZI DISTRICT

Lundazi District is one of the largest districts in the Eastern province of Zambia. It occupies an area of 14,068 Km^2. The district has a population of 256,980 people and is predominantly rural with only about 20,248 people (7.8%) living in the urban area which constitutes the administrative centre of the district. The number of rural households

Table 5: Renewable energy integration in the TNDP

TNDP objective No	*TNDP objective*	*RET Strategies*	*RET Programmes*	*RET Activities*
1	Increasing electricity access from the current 20 percent to 35 percent	-	-	Development of micro-hydro grid power stations
2.	Reducing Production of Charcoal by about 400000 tonnes by 2010	Intensification of awareness of activities under deforestation	Encourage use of new and renewable energy Resources.	Efficient use and production of charcoal
			Promote efficient production and use of charcoal	Install Photovoltaic technologies
3	To increase electricity export by 300% by year 2010	-	-	-
4.	To supply and utilise petroleum in the most efficient and cost effective manner	-	-	-

Source: Author's analysis from TNDP (GRZ-MFNP, 2002) totals 46,738 (LDDP, 2005). Only the administrative centre is connected to grid electricity. Electricity in the district is imported from neighbouring Malawi.

The predominant source of energy for the rural population (92.8% of the total population) is firewood which is used for cooking, heating, baking and beer brewing. Candles (47%) and kerosene (53%) are used for lighting while human and draft animal power is used for agricultural activities. Solar energy technologies and wind machines constitute the only new renewable technologies being used in the district. Biomass energy is used in its unprocessed form. Geothermal and micro-hydro energy exploitation is non-existent in the district.

5.1 Solar Home Systems (SHS)

At the household level, solar home systems are the predominant renewable energy technology being used. One hundred and fifty (150) solar home systems have so far been installed through a government project supported by the Swedish International Development Agency (SIDA). The project has adopted the Energy Service Company (ESCO) approach in the dissemination of this technology. On the basis of this approach, the Lundazi energy service company was formed and the government leased the solar home systems to the company which in turn rents the solar home systems to users on a fee for service basis. The energy company is responsible for servicing the solar home systems and collects the fees on a monthly basis from the clients. The monthly fee for solar home systems is currently pegged at K45, 000.00 (US$12.0). The solar home systems have a capacity of 50 Wp.

More than 75 percent of the company's clients are government employees. At the beginning, the company had 18 peasant farmers and 18 small scale entrepreneurs as part of its clients.

At the time of this study only 3(16.7%) of the 18 small scale farmers were still clients of the ESCO. Eighty-seven (87%) of small scale farmers withdrew from the service. Similarly, only 5 (27.8%) of the small scale business persons are still clients of the energy service company. Further more, at the time of the study 20% of the systems were not operating and the clients had reverted to the use of candles and kerosene lamps. The battery was identified as the main constraint the clients faced in the use of the solar home systems. All the solar home systems that stopped working were due to the expiry of the battery. This problem emerged because most users connected much bigger electric appliances such as radio cassettes and colour TVs to the system.

At the moment, solar home systems in the district are the preserve of the elite rural working class. In fact, one third of the solar home systems are located in a national service camp and the monthly fee is paid by the government.

The energy service company has clearly failed to reach out to the farming communities because of their low incomes which can barely sustain the monthly rentals. The modal income of the rural communities is below 120,000 Kwacha (US $ 30) and well below the national modal income of 150,000 (US$ 37.50) – 300,000 (US$75.00). According to Ellergard and Nordstrom (2001),

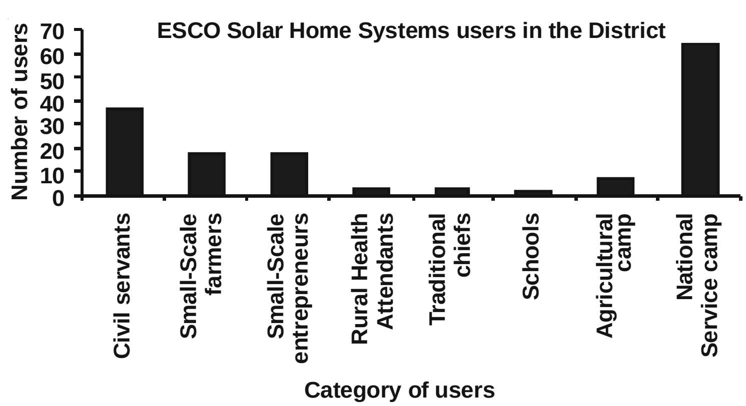

Fig. 6. ESCO SHS clients at the company's beginning (2001)

these households actually spend between K10,000 (US$2.50) and K20,000 (US$5.00) a month on energy.

In terms of willingness to pay, the majority of the households are willing to pay up to K10,000(US$2.50) only for improved energy services with only 13% ready to pay more than K30,000(US$7.50). This scenario has significant implications for the future of renewable energy technologies in Zambia. The solar energy users on the other hand have modal incomes between K920,000 (US$230.00) and 1,040,000 Kwacha (US$260.00). These elite constitute less than 2% of the total rural population and have similar characteristics as the urban middle class.

Despite the fact that solar home systems are at the moment the exclusive preserve of the rural elite, their adoption by rural dwellers has demonstrated their applicability in rural settings and possibility to help raise awareness of the systems usefulness to rural households. Today, the Lundazi energy service company has more than 300 prospective clients on their demand list. Further more, the households have reported several benefits they derive from using the solar home systems. More than 50% of the respondents identified improved lighting, radio and TV powering as the main benefits of the SHS. Improved lighting has enabled the household members to undertake activities in the night. For example, school children are able to study and prepare their exercises.

Gustavson and Ellegard (2004), who carried out a detailed study of the impact of solar home systems on rural livelihoods in Nyimba, a district in eastern province of Zambia, also point out that 50 % of solar users interviewed identified improved lighting as the major benefit of solar home systems. Furthermore, 58 % mentioned studying at night as an activity they could not do before the installation of solar home systems. For users involved in small scale businesses, improved lighting has helped them to extend their working hours and thus improve their daily sales. Solar home systems are proving to be a revolutionary technology in Zambia’s remote rural areas. It has great promise in facilitating a change in lifestyles in a significant manner. World-wide trends indicate that the photovoltaic industry is one of the fastest growing industries, with 35% average global market growth forecast over the next decade. It is also estimated that in 2020, solar energy can provide electricity to over one billion people worldwide and create 2 million jobs in production, installation and maintenance (EPIA, 2006)

5.2 Household Use of Solar Thermal Technologies and Other Renewable Energy Technologies

The results of the survey indicated that no households have access to solar cookers, solar water heaters, and solar driers and improved cooking stoves. In addition, the majority of the respondents (87.5%) indicated they did not even know about solar thermal technologies nor seen any. While most of these technologies are mentioned in the energy policy of Zambia and are known in some parts of the country, it is clear that they are not common. Awareness on the use and the availability of these technologies are clearly inadequate. Consequently, the population continues to rely on charcoal and firewood despite their grave environmental and health impacts.

5.3 Renewable Energy Technologies and Rural Institutions

The institutions that use renewable energy technologies in Lundazi district include the health sector, education and natural resources management sectors. Solar energy, which is the most exploited, has found various applications in these sectors. Table 6 provides an overview of the use of solar energy in Lundazi.

5.3.1 Health Institutions and Solar Energy

Lundazi District has one Public General Hospital, two missionary hospitals, an urban clinic and 24 Rural Health Centres. The General Hospital and urban clinic are both connected to grid electricity, while only one health centre bordering Malawi is connected to hydro-electricity. The latter is the only non-urban health centre that is connected to grid electricity basically because the line servicing the main town from Malawi passes right above the health centre. The lack of energy to power refrigerators for drug storage and microscopes for Tuberculosis (TB) detection was a major hindrance to the delivery of quality health services in the district. According to the district health authorities, solar energy’s equipment and

Table 6: Existing solar use in Lundazi: Community level

Sector	*Powered Facilities*	*Benefit*
Health	Solar Refrigerators, Solar radios, Solar Microscopes, Solar Geysers	Improved health services
Education	School lighting, Teachers housing lighting	Improved education services and teacher motivation
Water	Drinking Water Pumping	Improved drinking water quality
Communication	Telecommunication and TV Transmitter	District access to National TV services
Natural Resources	Solar Fencing	Reduced conflict between man and wildlife, Management
Income Generating	Community group owned lodge	Improved lighting for clients and increase in income availability

Source: Field Data, 2007

Table 7: Health facilities powered with solar energy in Lundazi District

Facility solar powered	*Number*
Rural Health Centres	17
Staff Houses	27
Hospital Refrigerators for Drug storage	16
Microscopes	09
Solar Geysers	2
Radios (for messaging)	24
Solar Powered Water Pump (Panels stolen)	1

Source: Field Data from Lundazi District Health Board, 2007

facilities are having a significant impact on the health sector (Table 7)

The use of solar refrigerators allows the district to store vaccines for distribution to rural health centres. Therefore, vaccines can easily be accessible to rural populations without going to the urban health centres. The district, like all other parts of the country, has high rates of child and maternal mortality. For example, the maternal mortality rate stood at 649 deaths per 100,000 in 1996 and increased to 729 per 100,000 in 2002. One measure taken to reduce child mortality is compulsory vaccination against polio, tuberculosis (TB), measles and many other diseases.

Tuberculosis is one of the diseases that are causing a great stress on the public health system in Zambia. In 2000, the prevalence rate was 512 per 100, 000 population. The use of solar powered microscopes in the district has ensured an increase in detection of TB. The microscopes are used to test for sputum. In the past, people avoided TB testing as the centre was at the district hospital which is quite far from remote areas, some areas being as far as more than 100km from the district hospital.

With the acquisition of solar powered microscopes, a 25% to 30% increase in the number of people tested has been observed in health centres that are solar powered. Testing and Treatment of TB patients in their respective clinics have contributed towards the increase in TB cure rate from 62% to 72% in the area.

Solar powered radios are used to improve communication in the health sector. They are important for communicating important information on emergencies such as raptures of uteruses where pregnancies are concerned. The radio is also important in terms of referral cases and consultations, especially that all these health centres do not have ambulances and have to radio the district office to send a vehicle to transport referred patients. According to the district authorities, of all cases in the health centres, one out of two uterus rapture prevention is due to the direct use of radio messages. In terms of consultations, none of the 24 health centres has a resident doctor. The health officers in charge of these health centres use radio messaging to consult the doctors based at the district general hospital.

Solar energy is also seen as a morale booster for health staff because electricity generated through solar PVs has greatly improved their working and living environment. All the health staff interviewed expressed happiness and indicated that the environment was clearly more motivating than before. The staff indicated that the use of solar home systems has enabled them to have access to facilities such as TV, video, radio and light for reading. One of the respondents is even connected to digital satellite television right in the remote setting about 70Km from the urban centre.

5.3.2 Education and Solar Energy

The Ministry of Education in the district was among the first sectors to realise that the use of solar energy can greatly improve pupil's learning and working conditions. According to the district education officer, solar energy can help students to study at night, enable boarding students have access to improved lighting and facilitate the use of radio and TV. Further more, solar energy can be used to power science laboratories, ICT equipment and other teaching aids.

However, compared to the health sector, which has 70% of rural health centres powered by solar energy, less than 45 % of the rural educational institutions have access to solar energy technologies or any new renewable energy technology besides wood fuel. This gap in the performance of the two ministries can perhaps be explained by the fact that while the Ministry of Health has only 24 rural health centres, the Ministry of Education has 143 education facilities to provide solar energy. A survey conducted by the Energy Regulation Board (2006) in the same area indicates that solar energy is enabling students to study longer hours in the night and some schools have recorded improved examination results and increased enrolment because solar energy is acting as an attraction of students to schools that have electricity.

5.3.3 Solar Energy and Other Sectors

The Zambia Telecommunications Company (ZAMTEL) was the first to use solar energy technology in the district; it has a transmitter that is powered by solar energy. This technology has enabled the district not only to access telecommunications services but also to have access to the National Television network that is dependant on the ZAMTEL satellite transmitter. This is a significant contribution towards improving communication and rural development.

In addition, solar fencing is a technology that is being used in the Valley area by the Wildlife Conservation Society (WCS). This area is located more that 80 Km from the town centre and has no access to the grid electricity. Solar energy is used to light WCS staff houses and fence gardens of farmers living close to the game management areas to keep off wild animals. Solar fencing in the area has helped to reduce the conflict between humans and animals. Apart from solar fencing solar energy holds great potential for water heating and providing air condition in tourism facilities in the area. The use of solar energy will significantly help to develop the tourism industry in the district and boost rural development.

5.4 Wind Energy Exploitation in the District

Apart from solar energy, the only other renewable source of energy that is being exploited in the district is wind energy. So far, the district has five wind powered water installations using wind mill technology. Three of the installations are installed at health centres and are used to pump water for the health centre and health staff houses. One wind machine is being used at a private farm about 10 km from the administrative centre. All the wind machines in the district are for pumping water only. While wind energy technologies hold great promise for use in agricultural irrigation and provision of clean drinking water, their use is dogged by the same problem as those of solar energy technologies. They are well beyond the purchasing power of the average small scale farmer and are therefore limited to institutional buyers.

While water machines hold great potential in Zambia for supplying water to households and farms, the DoE points out that wind energy in Zambia is not particularly suitable for electricity generation. Wind data collected at 10 meters indicate speeds of between 0.1 to 3.5 meters per second with an annual average of 2.5m/s. Compared to South Africa and Namibia, Zambia has few wind energy installations. In 2001, Zambia had only 100 installed wind machines country-wide against 30,000 and 100,000 machines for Namibia and South Africa respectively (Karekezi, 2001). Worldwide, the wind energy market is led by Europe with 65 percent of the total installed capacity (Global Wind Energy Council, 2006).

5.5 Bio-Energy Use in the District

The Lundazi rural population in the district is still using wood-based energy in its unprocessed form. Among the 80 households interviewed in this study, none currently has access to improved biomass stoves. Like solar thermal technologies, improved stoves or any modern biomass technologies are not known in the district. Only 11 (12.5%) of respondents indicated they were aware of improved biomass stoves. There are neither demonstration projects nor any awareness campaigns on biomass technologies in the district. Interest in modern biomass energy technology is relatively recent in Zambia. The realisation that biomass can deliver energy in many forms-liquid, gaseous fuels, heat and electricity-is the reason for the emerging interest. Figure 7 shows the many forms biomass energy resources can take through the transformation processes from raw biomass materials to bio-fuels, bio-electricity and bio-heating energy.

It is envisaged that biomass energy can contribute significantly towards poverty alleviation and lead to a reduction in importation of petroleum products. Zambia is also considering the exploitation of sugar cane, sweet sorghum and Jatropha as possible sources of bio-fuel (ERB, 2006). The need to develop bio-fuel has been articulated as a development objective in the FNDP and has received a budgetary allocation for 2007/2008.

6. KEY CHALLENGES OF RETs IN ZAMBIA

The examination of the renewable energy situation in Lundazi district reveals the following challenges:

- There is an increasing, but slow adoption of renewable energy in Lundazi district. The range of adopted RETs remains narrow with solar home systems leading in households. Wind energy is predominantly used for water pumping in rural institutions. Geothermal, micro-hydro, solar thermal and modern biomass technologies remain unexploited, both in the district and the country as a whole, despite enormous existing potential.
- There is a general lack of research and development in RETs and this is linked mainly to lack of funding of research institutions.
- Unlike other sectors of the Zambian economy, few initiatives exist for awareness raising and information dissemination of RETs. This situation can partly be explained by the incapacity of the department of energy itself which is more or less a Cinderella department. It has no presence at the provincial and district levels. Consequently, there is a general lack of awareness of RETs in the district.
- The prices of RETs are a major inhibiting

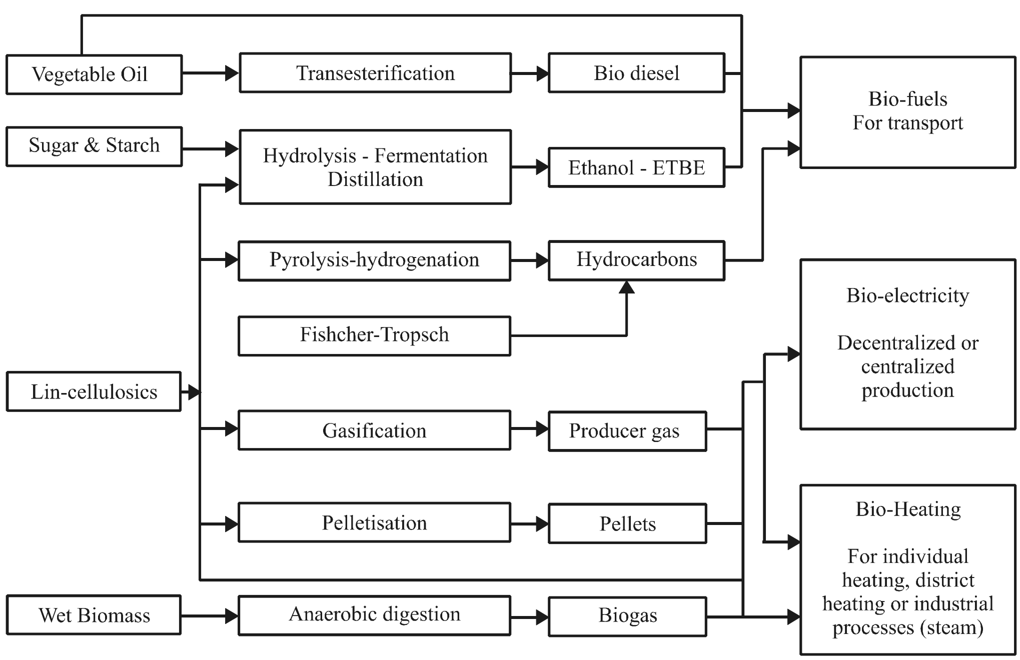

Fig. 7. Biomass conversion process to bio-fuels
(*Source:* EUBIA, 2006)

factor in the dissemination of these technologies. Today, the price of solar photovoltaic system averages around US$ 900-1000 for a 50 Wp Solar home system and US$ 1200 for a 100 litre capacity solar geyser. Further more, a wind machine costs over US$ 2,500. On the other hand, the modal income of Zambian households is between ZK 150,000 (US37.5) and ZK 300,000.0 (US$75.0). While the price of most RETS on the world market and in Zambia has experienced a general fall, the reduction is largely insufficient to induce the rural population to actively engage in the renewable energy market.

- Dissemination of RETs is also hindered by inadequate policy, poor integration of renewable energy in development plans and inadequate commitment to effective policy implementation.
- For RETs such as solar thermal technologies and solar home systems, there are no active manufacturers in Zambia. All components of solar energy technologies are imported from countries such as Japan, France and South Africa. In addition, companies that deal in renewable energy technologies are located in the main cities on the Copperbelt and Lusaka Provinces and lack distribution networks in the countryside. There are no retail outlets for RETs in Lundazi district. Most retailers do not perceive RETs as viable business opportunities.

7. RECOMMENDATIONS

In order to overcome the above mentioned challenges, the following recommendations are proposed:

- Promotion of RETs should not just be limited to solar home systems and wind machines for pumping water. Studies need to be conducted on how best to exploit geothermal energy, small hydro, biomass and solar thermal technologies.
- To stimulate research and development in renewable energy technologies, government should create an R &D fund for RETs to be used by the University of Zambia Energy Research Centre and the National Council for Scientific Research. The research should be centred on development of appropriate and affordable RETs for rural areas. In addition, collaboration between researchers, policy makers and planners should be strengthened for the common purpose of promoting RETs.
- The DoE needs to be restructured, strengthened and extended to the provinces and districts in order to make it more responsive to the energy needs of the population. More renewable energy demonstration projects should be implemented in the rural areas. The applicability of these technologies and awareness raising on energy resources should form important elements of promotion activities.
- The ESCO approach allows for the most affordable payment system for RETs like the Solar Home Systems. This should be strengthened by targetting subsidies towards low income households.
- The national energy policy and plans need to the establish annual investment goals, strategies and targets for RETs deployment to rural areas. Energy planners need to be actively involved in development planning at all levels (national, provincial and district) for RETs to be properly integrated in development planning.
- The government needs to create incentives for the private sector's participation in RETs in rural areas. Further efforts should be targeted towards the involvement of credit or financial institutions in financing renewable energy projects

8. CONCLUSION

It is clear that Zambia has enormous renewable energy resources that can play a significant role in meeting the energy needs of the country. Decentralised RETs such as solar energy have proved to have a wide range of applications in households, health, education, natural resources management and telecommunications sectors. Though the exploitation of renewable energy is still in its infancy, there is no doubt that these technologies can play a significant role in the development of rural areas. Despite the fact that RETs are poorly integrated in development plans, there are signs of a growing desire by energy policy makers and planners at the national level to integrate RETs in policies and plans in Zambia. The Zero rating of customs duty for solar energy technology components, the scrapping of licence fees for solar companies and this year's budgetary consideration for biomass energy exploitation are clear signs of government's recognition of renewable energy in Zambia.

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