Renewable Energy in Africa: Prospects and Limits

Republic of Senegal **United Nations**

RENEWABLE ENERGY DEVELOPMENT

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for

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Executive Summary:

Africa has substantial new and renewable energy resources, most of which are under-exploited. Only about 7% of Africa's enormous hydro potential has been harnessed. Existing estimates of hydro potential do not include small, mini and micro hydro opportunities, which are also significant. Geothermal energy potential stands at 9000MW, but only about 60MW has been exploited in Kenya. Estimates further indicate that a significant proportion of current electricity generation in 16 Eastern and Southern African countries could be met by bagasse-based cogeneration in the sugar industry. Based on the limited initiatives that have been undertaken to date, renewable energy technologies (RETs) could contribute significantly to the development of the energy sector in eastern and southern African countries.

Renewable energy technologies (RETs) provide attractive environmentally sound technology options for Africa's electricity industry. RETs could offset a significant proportion of foreign exchange that is used for importing oil for electricity generation in most countries. In addition, renewables are modular and are well suited for meeting decentralized rural energy demand. The modular nature (i.e. can be developed in an incremental fashion) of most renewable energy technologies and the low investment levels makes them particularly suitable for capital-constrained African countries. Most renewable energy technologies utilize locally available resources and expertise, and would therefore provide employment opportunities for the locals.

The success of RETs in the region has been limited by a combination of factors which include: poor institutional framework and infrastructure; inadequate RET planning policies; lack of co-ordination and linkage in the RET programme; pricing distortions which have placed renewable energy at a disadvantage; high initial capital costs; weak dissemination strategies; lack of skilled manpower; poor baseline information; and, weak maintenance service and infrastructure.

The following policy options could contribute to the development and dissemination of successful RETs programs in the region:

- Long term RETs policy programmes within government
- Careful selection of RETs that are appropriate to Africa, and implementation of sustained capacity building programs
- Instituting innovative financing mechanisms and tapping into financing opportunities such as CDM and micro-credit institution.

To ensure that Africa's energy community is able exploit the unique opportunity that NEPAD provides for the development of renewables in Africa, the following multi-pronged strategy is proposed:

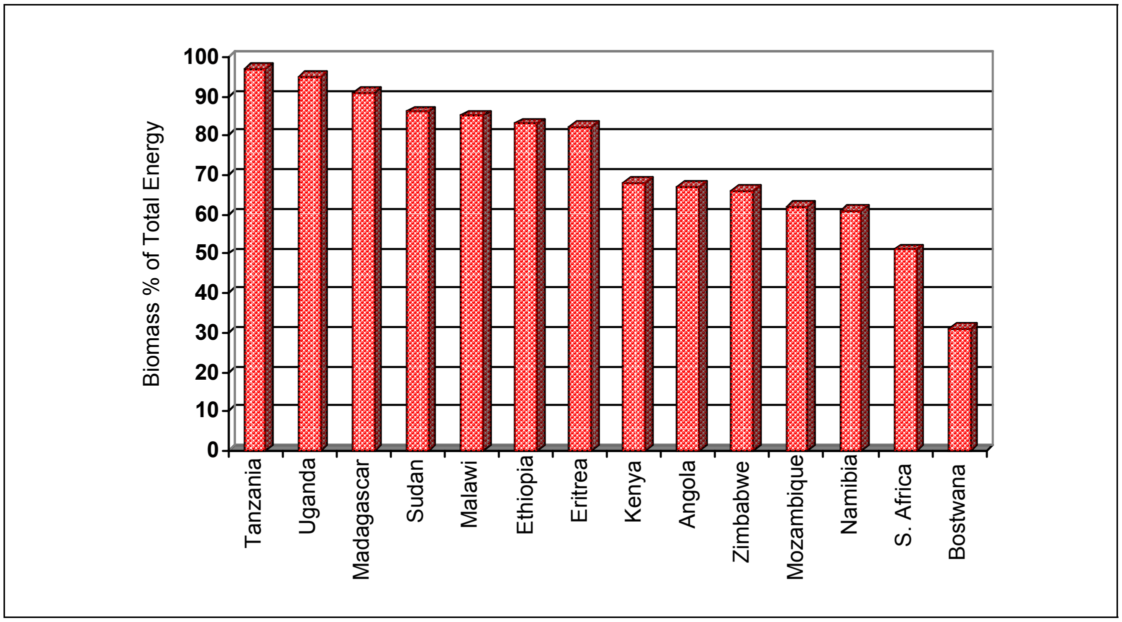
- A near-term fast track program (1-5 years) that would aim to implement low-risk and low-cost near term initiatives.
- A long-term track program (5-10 years) that is built around major renewable energy sector initiatives that are currently taking place.

1. Introduction

1.1 Status of Africa's Energy Sector

Africa's energy sector is best understood as three distinct regions. North Africa, which is heavily dependent on oil and gas, South Africa, which depends on coal and the rest of Sub-Saharan Africa, which is largely reliant on biomass (Karekezi, 2002a). Figures for Eastern and Southern African countries indicate that a high proportion of total national energy supply is derived from biomass energy (Figure 1). Biomass energy, which refers to a wide range of natural organic fuels such as wood, charcoal, agricultural residues and animal waste, is often used in its traditional and unprocessed form. Even oil-rich sub-Saharan African countries continue to rely on biomass energy to meet the bulk of their household energy requirements: in Nigeria, it is estimated that about 97% of the household energy needs are met by biomass (IEA, 2001).

Figure 1: Biomass Energy as a percentage of total energy for selected Eastern and Southern African countries

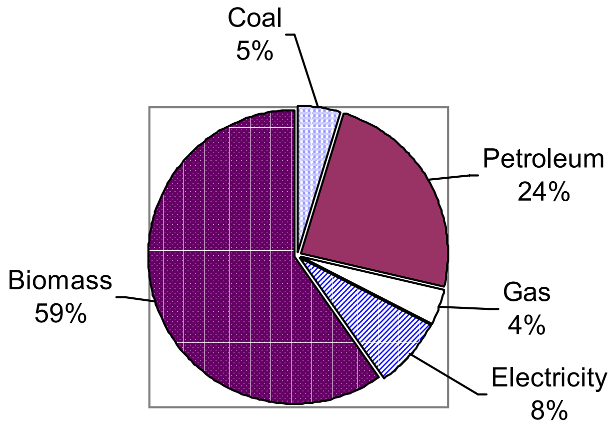


Source: AFREPREN, 2002

Traditional biomass energy use has serious environmental drawbacks. The indoor air pollution from unvented biofuel cooking stoves is a major contributor to respiratory illnesses in highland areas of sub-Saharan Africa. Reliance on biomass (especially in the form of charcoal) also encourages land degradation. In some areas, for example around major cities like Lusaka, Zambia Dar-es-Salaam, Tanzania and Nairobi, Kenya, charcoal demand appears to contribute to degradation of the surrounding woodlands and forests (Karekezi, 2002a, Kantai, 2002)

Consumption of modern energy in sub-Saharan Africa (excluding south Africa) is very low. Between 1980 and 2000, per capita consumption of modern energy in east and southern Africa has remained small and stagnant, falling from an average of 317kgoe (kilogrammes of oil equivalent) to 292kgoe (World Bank, 2003). The low levels of modern energy consumption prevalent in sub-Saharan Africa are even more striking when one considers electricity consumption. Excluding South Africa, per capita consumption of electricity falls from 431kWh to 112kWh (World Bank, 2003). The total energy demand for Sub Saharan Africa is approximately 267 Mtoe comprised of 54% traditional energy (80% if South Africa is excluded), 27% oil, 14% solid fuel, 3% hydropower and 2% gas (Figure 2).

Figure 2: Total Primary Energy Demand in 1999 for Africa (Including South Africa)



Source: IEA, 1999

1.2 Electricity:

South Africa accounts for 45% of total electricity generated in Africa, while North Africa accounts for 30%. This effectively leaves Sub Saharan Africa (where 80% of the continent's population resides) with only 24% of total electricity generated in Africa (Table 1).

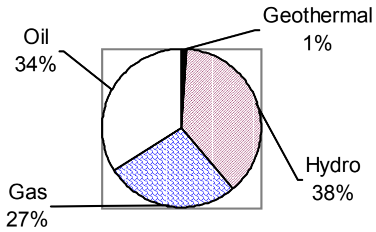
Table 1: Share of Installed Capacity

Region	***% Share***
South Africa	45
North Africa	31
Rest of Africa	24

Source: Karekezi and Kimani, 2002.

With the exception of South Africa, electricity in Africa is generated mainly from hydro and oil (diesel) sources as shown in the figure 3. Over 90% of South Africa's electricity is from coal.

Figure 3: Production of Electricity by Source in Africa (Excluding South Africa)



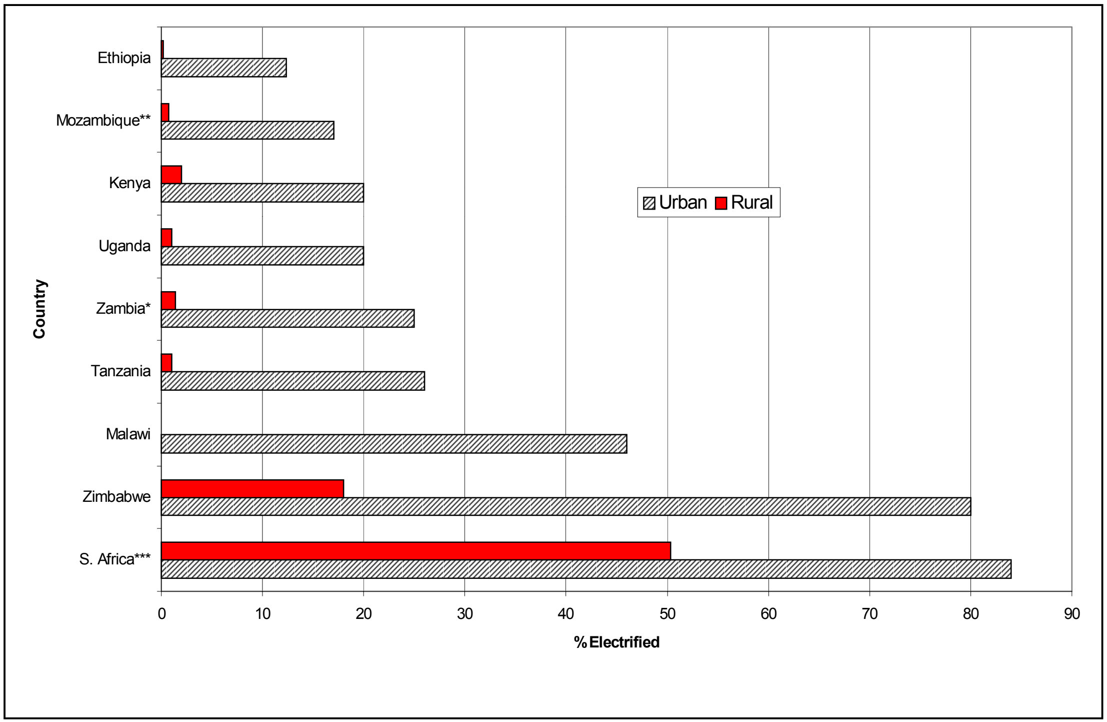
Source: Karekezi, 2002.

The conventional energy sector, and in particular the electricity sector has not lived up to expectations. The sector is mainly characterised by unreliability of power supply; low access levels; low capacity utilisation and availability factor; deficient maintenance; poor procurement of spare parts; and, high transmission and distribution losses among other problems (Karekezi and Kimani, 2002).

The power utilities in Africa have failed to provide adequate levels of electricity services to the majority of the region's population, especially to rural communities and the urban poor (Figure 4). Provision of electricity is largely confined to the privileged urban middle and upper income groups as well as the formal commercial and industrial sub-sector. The financial performance of utilities in most African countries is equally unsatisfactory.

Sub-Saharan Africa experiences very low levels of access to electricity with the highest levels recorded in South Africa and Mauritius (66% and 100% respectively). Electricity consumption is confined to commercial and industrial enterprises as well as high-income households.

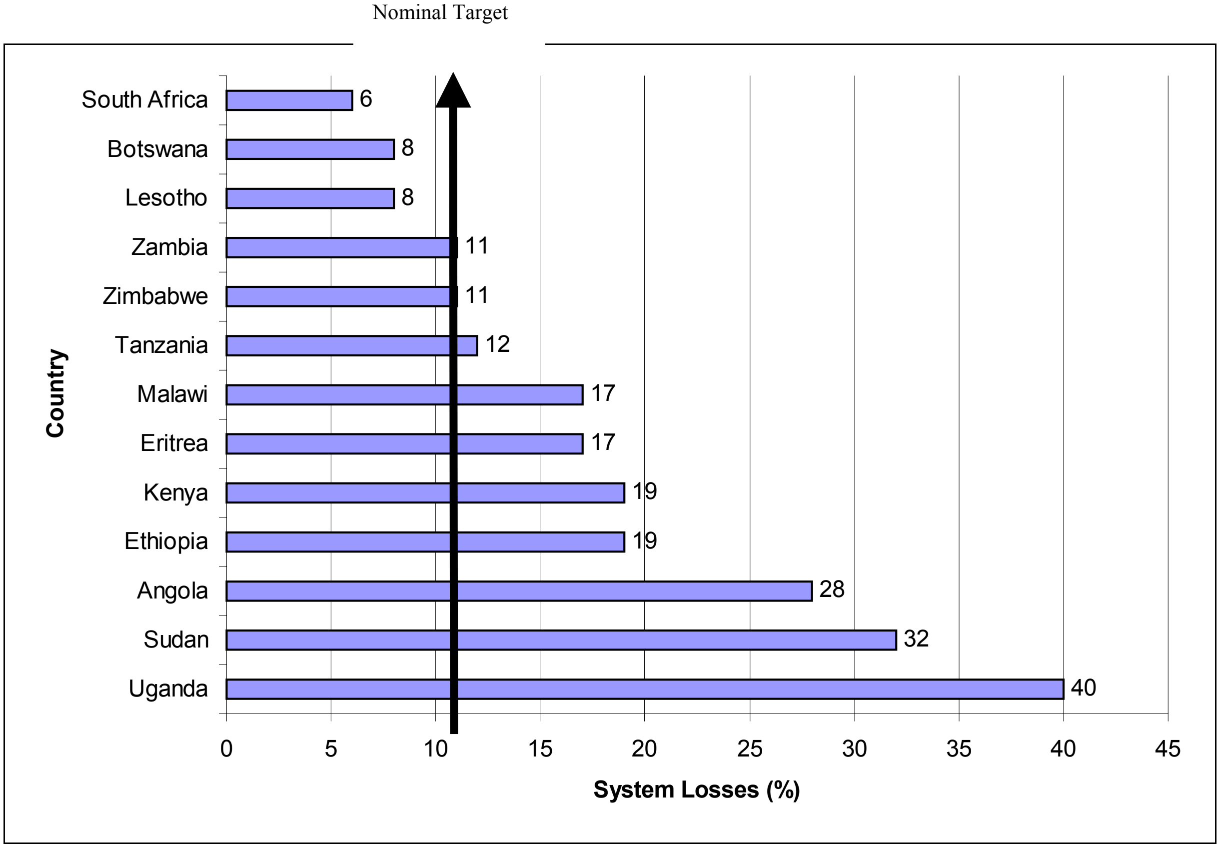
Figure 4: Urban and Rural Electrification Levels In Selected sub-Saharan African countries



Sources: Karekezi and Kimani, 2002, AFREPREN/FWD, 2001b; Teferra, 2000; Mapako, 2000; Kayo, 2001; Mbewe, 2000; Chiwaya, 2001; Dube, 2001; World Bank, 1996; NER, 2001

The electricity supply in most sub-Saharan African countries is characterised by high system losses when compared the international target of 10-12%. Some of the African countries record losses as high as 30% (Figure 5). The sector is also characterised by excess unskilled labour, poor management, shortage of trained staff, inadequate maintenance, spare part procurement mechanisms, inadequate financial performance, unbilled and unmetered electricity consumption.

Figure 5: Electricity losses in selected African countries



Source: Karekezi and Kimani, 2002.

1.3 Fossil Fuels:

Total oil production in 1997 stood at 8.1 million barrels per day mainly from West and North Africa. The total oil consumption was however 2 million barrels per day but is expected to double by the year 2010. North Africa accounts for 50% of Africa's gas reserves and Nigeria a further 30%. South Africa on the other hand accounts for about 90% of the continent's proven and economically attractive coal reserves. Substantial uranium reserves are located in South Africa, Zimbabwe and Namibia. Fossil energy mainly serves high-income households and energy intensive commercial and industrial sub sectors with the exception of kerosene mainly used by rural poor urban households largely for lighting.

The energy sector is characterised by large and increasing imports of petroleum products, which account for significant proportions of export earnings (an average of 20-40% for non-oil exporting sub-Saharan African countries). The transport sector is the major consumer of oil accounting for 60% of total consumption. The high oil import bill exposes sub-Saharan Africa's energy sector to the external energy price shocks. Renewables such as ethanol would assist in mitigating the negative impact of high fossil fuel imports.

1.4 Renewable Energy Technologies

Africa is endowed with substantial renewable energy resources. The region has 1.1 Gigawatts of hydropower capacity, 9000 Megawatt of geothermal potential and abundant biomass, solar and significant wind potential (Karekezi and Ranja, 1997). The renewable energy resource potential in Africa has not been fully exploited, mainly due to the limited policy interest and investment levels. In addition, technical and financial barriers have contributed to the low levels of uptake of RETs in the region (Karekezi and Ranja). There are, however, prospects for the widescale development and dissemination of RETs in the region.

Recent interest in renewable energy in Africa is driven by, among others, the following important developments. The first is the recent increase in oil prices, which, recently, peaked to US$ 33.16 per barrel (Economist: Jan, 98 - Dec, 2000) at a time when Africa's convertible currency earnings are very low due to poor world market prices and decreased volumes of its commodity exports. Consequently, it is estimated that in the year 2000, petroleum imports as a percentage of export earnings doubled from about 15-20% to 30-40% for a number of African countries (AFREPREN, 2001).

The second important development that has increased interest in renewables in the region is the recurrent crises faced by most power utilities in the region. For example, in year 2000 alone, Ethiopia Kenya, Malawi, Nigeria and Tanzania faced unprecedented power rationing which adversely affected their economies. The rapid development of renewables is often mentioned as an important response option for addressing the power problems faced by the region.

Two important global environment initiatives have also stimulated greater interest in renewables in Africa. The first was the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil in 1992. At this Conference, an ambitious environment and development document entitled "Agenda 21" was reviewed by one of the largest gathering of Government Heads of States and, perhaps more importantly, was endorsed by a large number of multi-nationals companies. Agenda 21 sought to operationalise the concept of sustainable development. In addition, the Rio Conference provided the venue for the second important event, the signing of the United Nations Framework Convention on Climate Change (UNFCCC) by 155 Governments (United Nations, 1992). The Convention came into force in early 1994 after ratification by 50 States.

Renewables featured in both Agenda 21 and the Climate Change Convention (United Nations, 1992). Because of the important role of fossil fuels in the build-up of greenhouse gases in the atmosphere (it is estimated that the energy sector accounts for about half the global emissions of green-house gases) and concomitant climate change concerns, renewables are perceived to constitute an important option for mitigating and abating the emissions of greenhouse gases (Socolow, 1992).

The above perspective was, however, not initially shared by the many energy analysts in Africa. In contrast to the industrialized world which is worried by the long-term global environmental impact of current patterns of energy production and use, African countries are largely pre-occupied with the immediate problems of reversing the persistent decline of their centralized power systems as well a meeting the long-standing and pressing demands for a minimum level of modern energy services for the majority of their poor - many of whom have no electricity and continue to rely on inefficient and environmentally hazardous unprocessed biomass fuels.

Although the contribution of African countries to global greenhouse emissions (GHGs) is, on a per capita basis, much smaller than that of industrialized countries (some projections, however, indicate a much higher contribution in the future), there is growing realization that Africa is likely to be dis-proportionately affected by the impacts of climate change. Of particular concern is the dependence of the poor in Africa on rain-fed agriculture, which is believed to be already under threat from unpredictable weather patterns triggered by what appears to be climate change. The recent floods that adversely affected southern parts of Africa appear to indicate that the impact of climate change may already be a reality.

In spite of the growing evidence of climate change, the position of the African energy community on the climate change question has not been unanimous. Support for renewables was, at best, lukewarm on the part of energy experts from oil-exporting African countries such Algeria, Angola, Cameroon, Nigeria and Libya. In spite of the continued divergence on the part of African energy analysts on how to respond to the climate change challenge, the consensus around the further development of renewables appears to be growing. The challenge of engendering a consensus on renewable energy development appears to be less onerous than that faced by the African energy efficiency community.

More recently, renewables featured high on the agenda of the Johannesburg World Summit on Sustainable Development (WSSD) in 2002. In the UN-led implementation plan of action for the WSSD, dubbed WEHAB (which stands for Water, Energy, Health, Agriculture and Biodiversity), top priority was given to the renewables and other alternative forms of energy services (WEHAB Working Group, 2002). One of the targets proposed at WSSD was for every country to commit itself to meeting 10% of its national energy supply from renewables. Although the 10% target was not agreed to at the summit, there was general consensus that countries should commit themselves to promotion of renewables.

2.0 Renewable Energy Technologies (RETs) in Sub Saharan Africa:

2.1 Large Scale Renewables

Large Scale biomass Energy

Large-scale biomass utilisation encompasses direct combustion for process heat; ethanol production; gasification; heat cogeneration; biogas production; and, briquetting. The best-known large-scale biomass energy systems with sound economic track records are cogeneration-using biomass as fuel stock and the production of ethanol as a substitute for petroleum fuel.

Cogeneration is used by agro-based industries to meet their power requirements. Some of the industries involved include paper and pulp, sugar, wood and rice industries. Cogeneration offers substantial opportunities for generating electricity and/ or heat energy with limited capital investments, while avoiding the negative environmental effects of increased fossil fuel combustion. Industries can be located in remote areas not linked to the grid for electricity. Extra electricity can be made available to other users through mini-grids with the national grid. For industries close to the grid, sale of surplus to the national utility would increase their income.

Sugar cane production in the world amounts to 88.5 million tonnes, which is equivalent to 885 million tonnes of cane. On the basis of 100kWh of electricity exported to the grid per tonne of cane using latest state of the art technology, around 88,500GWh electricity can be potentially exported from the cane sugar industry (Deepchand, 2002).

In 1995, sugar mills around the world had over 400 MW of cogeneration capacity that was exporting almost 300 MW to the utility grids. At the beginning of the year 2000, sugar mill cogeneration had reached almost 1,100MW installed and operating. Another 450MW is under construction (Deepchand, 2002).

Sugar is produced in a number of Eastern and Southern Africa countries. It is a major agricultural export for Ethiopia, Malawi, Mozambique, Madagascar, Swaziland, Zambia and Zimbabwe. The potential for electricity generation from bagasse is high since cogeneration equipment is almost uniformly an integral component of sugar factory designs. It is estimated that modest capital investments combined with judicious equipment selection, modifications of sugar manufacturing processes (to reduce energy use in the manufacture of sugar) and proper planning could yield a 13-fold increase in the amount of electricity generated by sugar factories and sold to the national Mauritian power utility (Baguant, 1992).

Estimates show that up to 16 Sub Saharan African countries can meet significant proportions of their current electricity consumption from bagasse-based cogeneration in the sugar industry (Table 2). Mauritius meets over 20% of its electricity demand from cogeneration.

Table 2: Cogeneration (Bagasse) Potential for Eastern and Southern Africa

Country	*Installed Capacity (MW) 1997*	*Electricity generation (GWh) 1997*	*Co generation potential*	
			Electricity generation (GWh)	*% of national electricity generation*
Burundi	33	117	9.53	8.15
Ethiopia	420	1610	150.33	9.34
Kenya	842	4637	530.33	11.45
Madagascar	220	599	114.77	19.16
Malawi	242	1022	250.80	24.54
Mauritius	348	1365	586.67	42.98
Sudan	500	1328	643.50	48.46
Tanzania	655	2195	100.83	4.59
Uganda	183	1131	173.43	15.33
Zimbabwe	1961	11,506	686.40	5.97
Total	5404	25510	3247.19	12.73

Source: Deepchand, 2002; Karekezi and Kimani, 2002.

As a result of extensive use of co-generation in Mauritius, the country's sugar industry is self-sufficient in electricity and sells excess power to the national grid (Baguant, 1992). Sugarcane is a key player in the Mauritian economy. It is the backbone of the agricultural sector and a significant convertible currency earner, as well as an important source of income for workers and small planters. A clearly defined government policy on the use of bagasse for electricity generation has been instrumental in the success of implementation of the energy cogeneration programme in Mauritius. Plans and policies have constantly been worked out over the last decade for the sugar industry in general. In all these plans and policies, the issue of energy generation from bagasse has always been given priority.

These measures have seen the growth of bagasse co-generation in electricity generation (Table 3). In 1998, close to 25% of the country's electricity was generated from sugar industry, largely using bagasse, a by-product of the sugar industry. In the next few years, it is expected that the sugar industry may be able to account for close to a third of the country's electricity needs. It is estimated that modest capital investments combined with judicious equipment selection, modifications of sugar manufacturing processes (to reduce energy use in manufactured sugar) and proper planning could yield a 13-fold increase in the amount of electricity generated from sugar factories and sold to the national Mauritius power utility.

Table 3: Evolution of Cogeneration (1988-1998)

Year	**Cogeneration**			**Total**		**Bagasse %**	
	Installed Capacity (MW)	**Bagasse GWh**	**Coal GWh**	**Installed Capacity (MW)**	**GWh**	**Installed Capacity (MW)**	**GWh**
1989	42	56	68	270	589	15.6	9.5
1990	42	53	45	270	668	14.3	7,9
1991	42	70	54	294	738	14.3	9,5
1992	42	84	43	284	808	14.8	10,5
1993	43	70	40	308	870	14.0	8,2
1994	43	76	46	308	945	14.0	8,1
1995	43	81	41	332	1047	13.0	8,0
1996	43	110	10	332	1151	13.0	10,3
1997	53	125	23	370	1252	14.3	10,0
1998	90	225*	62	397	1365	22.7	16,5

* includes 30 GWh produced in 1999 from crop bagasse.

Source: CEB reports, Commercial Scale Cogeneration of Bagasse Energy in Mauritius

Ethanol programmes that produce a blend of ethanol and gasoline (gasohol) for use in existing fleets of motor vehicles have been implemented in Malawi, Zimbabwe and Kenya. Available evidence indicates that these programmes have registered important economic benefits. At its height, the Zimbabwe alcohol programme was capable of producing about 40 million litres and there are plans to increase annual output to 50 million litres (Scurlock and Hall, 1991). In the Zimbabwe ethanol programme, 60 % of the whole plant was locally produced and significant staff development took place (Scurlock, et al, 1991). The plant has been in operation for twenty years with few maintenance problems (World Resources Institute, 1994; Karekezi and Ranja, 1997).

The total investment cost of Kenya's ethanol plant is estimated to be US $ 15 million. At its peak, plant production averaged about 45,000 litres per day (Baraka, 1991). The plant used surplus molasses that were an environmental hazard because of the past practice of dumping surplus molasses in a nearby river. The ethanol was blended with gasoline at a ratio of 1:9. Since it was commissioned, Kenya's ethanol programme has continued to register annual losses mainly due to the prevailing low Government-controlled retail prices (which have since been liberalized); inadequate plant maintenance and operation; resistance from local subsidiaries of multinational oil companies; and, unfavourable exchange rate which has significantly increased the local cost of servicing the loan that financed the establishment of the plant. In an attempt to break even, the plant has had to export 13.3 million litres of crude ethanol (Kenya Times, 1991). The plant has, however, generated an estimated 1,000 rural jobs (Baraka, 1991).

The large number of cane processing industries in Africa indicates significant potential for expanded ethanol production and co-generation (Dutkiewicz and Gielink, 1991, 1992; Eberhard and Williams, 1988; Scurlock and Hall, 1991; Baraka, 1991; Karekezi and Ranja, 1997). The long-term prospects of widespread use of ethanol, however, are unclear because of uncertainties pertaining to the performance of the cane sugar industry and the world market for molasses as well as the world market price of petroleum fuels (Karekezi, 1994; Karekezi and Ranja, 1997).

Geothermal Energy

Geothermal energy is the natural heat from the earth's interior stored in rocks and water within the earth's crust. The main source of this energy is the constant flow of heat from the earth's interior to the surface. This heat creates the molten rock, or magma, beneath the surface crust. Volcanoes, geysers and fumaroles are the visible evidence of the great reservoir of heat, which lies within and beneath the earth's crust. The magma heats the surrounding rock structures and when underground water comes into contact with this heat, geothermal fluid is formed. This energy can be extracted by drilling wells to tap concentrations of steam at high pressures and at depths shallow enough to be economically justifiable. The steam is then led by pipes to drive electricity-generating turbines. At an international level, approximately 8,100 MW of geothermal power is generated, out of a global potential of 60,000MW (Mariita, 2002; Bronicki, 2001).

Geothermal power exploitation has numerous advantages over other energy sources. Among the benefits of geothermal power are the near zero emissions (true for modern closed cycle systems that re-inject water back to the earth's crust), and the little space required for geothermal power development compared to other energy sources such as coal fired plants (Table 4). Geothermal power plants require approximately 11% of the total land used by coal fired plants and 12-30% of land occupied by other renewable technologies.

Table 4: Land Uses for Different Energy Technologies

Technology	Land Occupied (m^2 per MWh a year for 30 years)
Coal (including pit coal mining)	3,700
Solar thermal	3,600
Photovoltaic	3,200
Wind (land with turbine and roads)	1,300
Geothermal	400

Source: Bronicki, 2001

Using today's technology, Africa has the potential to generate 9,000 MW of energy from geothermal power. Of this potential, only 57MW has been tapped in Kenya, and less than 2MW in Ethiopia.

Table 5: Geothermal Potential for Selected African Countries

Country	Potential Generation in MW
Kenya	2,000
Ethiopia	>1,000
Djibouti	230-860
Uganda	450

Source: BCSE, 2003.

Varying levels of geothermal exploration and research has been undertaken in Djibouti, Eritrea, Uganda, Tanzania, Zambia, Malawi and Madagascar but the potential for grid connected electrification is highest in Ethiopia, Kenya, Uganda and Tanzania. Government representatives from Ethiopia, Uganda, Tanzania and Eritrea have also expressed interest in using small scale geothermal plants for rural electrification mini-grid systems.

Kenya was the first country in sub Sahara Africa to exploit geothermal energy in a significant fashion. Presently, the country has exploited 57MW of its total potential and plans are underway to increase electricity generation from geothermal energy to 576MW by 2019 (KPLC, 2000). Ethiopia's geothermal power installed capacity is 8.5MW, although less than 2MW is available (Table 6).

Table 6: Level of Geothermal Power Exploitation in Kenya and Ethiopia

Country	Kenya	Ethiopia
Potential generation (MW)	2000	>1000
Installed Capacity (MW)	57	8.5
Available (MW)	57	<2

Source: BCSE, 2003; Fridleifsson, 2001.

Kenya has involved both the private and public sector in the development of geothermal energy (BCSE, 2003). Geothermal investigations in Olkaria in the Rift valley began in 1956 when two exploratory drilling was undertaken by a consortium of two companies. Two tunnels were drilled without any marked success. It was not until the end of the following decade that interest in geothermal power revived. Investigations were carried out between 1970 and 1972 and further work carried out on the two exploratory wells at Olkaria. Drilling started in earnest in 1973 and by 1975, four more wells had been drilled in the area. A feasibility study carried out to evaluate Olkaria's potential for generating electricity found that the geothermal field covered $80km^2$ and steam for 25,000MW years.

The present area covering $11km^2$ has steam for 400MW years. Out of the total 57MW installed capacity, Kenya Electricity Generating Company, KenGen- a public utility, has an installed capacity of 45 MW at Olkaria East commissioned in phases of 15MW in 1981, 1982 and 1985 respectively, and OrPower 4; an independent power producer has installed 12MW commissioned in 2000. The plants meet 5.5% of the total national electricity consumption.

So far, 103 geothermal wells have been drilled in Kenya for exploration, production, monitoring and re-injection with depths varying between 180 and 2,600m. Of these, 97 wells are in the Olkaria area and the rest in the Eburru Field. According to Kenya's Least Cost Power Plan adopted in 2001, Kenya plans to develop an additional 576MW of geothermal power by the year 2019 (BCSE, 2003).

Large Hydro Power

Africa has massive hydropower capacity, of which less than 7% has been harnessed. Plans are underway to exploit some of this potential. Mozambique, for example, is undertaking feasibility studies on the construction of a large hydroelectric dam on the Zambezi River. The planned capacity of the dam is 2000-2500MW (Mbendi, 1998). Another major potential power project in Africa is the extension of the Inga River hydroelectric scheme in the Democratic Republic of Congo, which could generate 50,000MW of power (Mbendi, 1995).

In overall terms, most countries in eastern and southern Africa rely heavily on hydroelectric power, as shown in the following table. South Africa, Mauritius and Zimbabwe are exceptions, with the bulk (83%) of its electricity being generated from thermal sources (mainly coal).

Table 7: Large Hydro as a % of installed capacity for African countries

Country	**Installed Capacity (MW)**	**Hydro power as % of Installed Capacity**
Mozambique	2,075	100%
Uganda	260	98%
Zambia	1,786	93%
Malawi	242	90%
Ethiopia	424	88%
Kenya	885	70%
Namibia	387	62%
Tanzania	655	58%
Zimbabwe	1,961	33%
Mauritius	425	12%
South Africa	38,517	0.01%

Source: AFREPREN, 2002

Hydropower has several advantages. It is a clean and emission free electricity generation technology, and is promoted as an environment friendly energy option. However, hydropower projects in the region are associated with huge loans, which lead to very high external debt levels (IMF/IDA, 2002). Due to the large amounts of capital involved in large-scale hydro projects, these projects are plagued with allegations of corruption.

Another drawback associated with hydropower development is the silting of dams, which reduces the amount of electricity that can be generated over time. In addition, hydropower development is affected by drought, which leads to huge shortfalls in electricity generation. For example, drought in Kenya in the year 2000 affected electricity generation leading to rationing of up to 8 hours daily. Ethiopia is currently undergoing extensive power rationing (up to 14 hours daily) due to the ongoing drought, which has reduced electricity availability.

2.2 Small scale Renewables

Small scale biomass energy

In terms of energy used per system, small-scale traditional bio-energy systems appear marginal but their importance lies in the very large number of end-users that these systems serve. Bio-fuelled cookstoves meet the bulk of cooking, heating and lighting needs of most rural households in Africa.

Charcoal is an important household fuel and to a lesser extent, industrial fuel. It is mainly used in the urban areas where its ease of storage, high-energy content and lower levels of smoke emissions, make it more attractive than wood fuel (Karekezi and Ranja, 1997). It is the primary fuel for the urban poor.

Traditional charcoal production, a major source of employment for the rural poor, relies on the traditional and rudimentary earth kiln which is considered to be a contributor to land degradation in many peri urban regions of sub Saharan Africa. Efforts to improve and modernise small-scale biomass energy constitute an important component of national energy strategies in many sub-Saharan African countries and could potentially yield major benefits to both the urban and rural poor.

In the last 20 years, substantial effort has been directed towards the modernization of small-scale biomass energy systems. Two of the most sustained efforts have been the development of an energy efficient charcoal kiln and an environmentally sound improved cookstove for rural and urban households in sub-Saharan Africa. Both these initiatives have delivered significant benefits to both the urban and rural poor. The informal sector, which provides employment to the urban poor, is the principal source of improved stoves. Urban improved stove initiatives deliver several benefits to the urban poor.

First, in terms of jobs created in improved stoves programs and second, in terms of reduced charcoal consumption through the use of improved charcoal stoves. The rural poor can derive similar benefits from rural improved stoves initiatives.

Table 8: Estimated Number of Improved Biofuel Cook stoves disseminated in selected Sub Saharan African Countries

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	20,800

Source: Karekezi and Rnja, 1997; Karekezi and Turyareeba, 1994; AFREPREN Data Base, 2000; Karekezi, 2002.

Another small-scale biomass energy technology that has attracted considerable attention over the last three decades is biogas. Conceptually, biogas technology appears deceptively simple and straightforward. The raw material is animal dung, which is plentiful in many rural areas of sub Saharan Africa: the technology appears not to be overly complicated; and it requires a relatively limited level of investment. The technical viability of biogas technology has been repeatedly proven in many field tests and pilot projects but numerous problems arose as soon as mass dissemination was attempted.

First, dung collection proved more problematic than anticipated particularly for farmers who did not keep their livestock penned in one location. Secondly, small-scale farmers with small herds were not able to get sufficient feedstock to feed the biodigestor unit and ensure a steady generation for lighting and cooking. Thirdly, the investment cost of even the smallest biogas unit proved prohibitive for most poor African rural households. Though evidence from many African countries is still limited, the general consensus is that the larger combined septic tank/biogas units that are run by institutions such as schools and hospitals are more viable than small-scale biogas digesters.

These factors have contributed to the low dissemination levels of the technology. There is some anecdotal evidence, however, that biogas technology can be successfully disseminated to the rural poor if it is conceived as both an energy as well as agricultural/health intervention.

Table 9: Small and Medium scale biogas units in selected sub-Saharan African Countries

Country	Number Distributed
Tanzania	>1,000
Kenya	500
Botswana	215
Burundi	279
Zimbabwe	200
Lesotho	40
Burkina Faso	20

Source: Karekezi and Ranja, 1997; Karekezi, 2002.

Solar Energy:

Direct solar energy can broadly be categorised into solar photovoltaic (PV) technologies, which convert the suns energy into electrical energy; and solar thermal technologies, which use the suns energy directly for heating, cooking and drying (Karekezi and Ranja, 1997).

Solar energy has for a long time been used for drying animal skins and clothes, preserving meat, drying crops and evaporating seawater to extract salt. Substantial research has been done over the years on exploiting the huge solar energy resource. Today, solar energy is utilised at various levels. On a small scale, it is used at the household level for lighting, cooking, water heaters and solar architecture houses; medium scale appliances include water heating in hotels and irrigation. At the community level, solar energy is used for vaccine refrigeration, water pumping, purification and rural electrification. On the industrial scale, solar energy is used for pre-heating boiler water for industrial use and power generation, detoxification, municipal water heating, telecommunications, and, more recently, transportation (solar cars) (Karekezi and Ranja, 1997; Ecosystems, 2002).

Solar photovoltaics have been promoted widely in the region, with almost every sub-Saharan African country having had a major PV project. Table 10 shows the dissemination of solar PV in selected countries.

Table 10: PV dissemination in selected sub-Saharan African countries

Country	Estimated Number of systems	Estimated kWp
Uganda	538	152
Botswana	5724	286
Zambia	5000	400
Zimbabwe	84,468	1689
Kenya	150,000	3600
South Africa	150,000	11,000

Sources: Nieuwenhout, 1991; Bachou and Otiti, 1994; Diphaha and Burton; 1993; Karekezi and Ranja, 1997, AFREPREN, 2001, Hankins, 2001; DBSA, 1999.

There is growing evidence that solar PV projects in the region have mainly benefited high-income segments of the population, due to the high cost of solar PV. Solar PV is unaffordable to majority of the population in sub-Saharan Africa, given the high levels of poverty (Karekezi and Kithyoma, 2002).

Solar thermal technologies that have been disseminated in African countries include solar water heaters, solar cookers (Kammen 1991; 1992), solar stills and solar dryers. With increased efficiency and reduced cost of solar water heaters, small-scale solar water heaters now have a payback period of 3 - 5 years (Karekezi and Karottki, 1989; Karekezi and Ranja, 1997). However, the diffusion of these systems has in recent years been slower than anticipated.

In sub-Saharan Africa, not much aggregate data on dissemination of these systems has been gathered (Ward et al, 1984; Karekezi and Ranja, 1997). The data available is from a few country studies. For example, in Botswana, about 15,000 domestic solar water heaters have been installed (Fagbenle, 2001). In Kenya, about 20,000 SWH units have been installed (Mbuthi, 2003). In Zimbabwe, about 4,000 solar water heaters are in use (AFREPREN, 2001). The bulk of the solar water heaters in use are bought by high-income households, institutions and large commercial establishments such as hotels and game lodges.

Table 11: Domestic Solar Water Heater Installed Capacity

Country	**Installed capacity (1000m^2)**
Botswana	50
Malawi	4.8
Mauritius	40
Namibia	24
Seychelles	2.4
South Africa	500
Zimbabwe	10

Source: DBSA, 1999, Mogotsi, 2000, Mandhlazi, 2000, Mapako, 2000, AFREPREN, 2002

Wind Energy:

Much of Africa straddles the tropical equatorial zones of the globe and only in the southern and northern regions overlap with the wind regime of temperate westerlies (Grubb and Meyer, 1993). Therefore, low wind speeds prevail in many sub-Saharan African countries particularly in land-locked nations.

In sub-Saharan Africa, South Africa has been named as the country with the highest wind potential in the region. For example, wind speeds of 7.2 to 9.7 m/s have been recorded around Cape Point and Cape Alguhas (Diab, 1986). It is, however, difficult to specify a general mean annual wind speed for South Africa due to great variations within the country (Diab, 1986). The North African coast is another attractive wind speed region. Large-scale wind power generation projects that exploit this abundant wind regime are now underway in Morocco. Other countries in this region have relatively low wind speeds (table 4). Available data indicates that the next highest annual average wind speed in the region is 4 m/s in Djibouti (Milukas, et al, 1984).

Largely as a result of low wind speeds, the bulk of wind machines found in eastern and southern Africa are used for water pumping (Smalera and Kammen, 1995), rather than electricity generation. Wind pumping supplies water for household use, irrigation and for livestock.

Table 12: Wind Energy Potentials and Number of Wind Pumps for Selected Countries

Country	Potential (m/s)	Number of Wind Pumps
Botswana	2-3	200
Burundi	>6	1
Djibouti	4	7
Eritrea	3-8	<10
Kenya	3	272
Morocco	>10	-
Mozambique	0.7-2.6	50
Namibia	-	30,000
Rwanda	-	-
Seychelles	3.62-6.34	-
South Africa	7.29-9.7	300,000
Sudan	3	12
Tanzania	3	58
Uganda	4	7
Zambia	2.5	100
Zimbabwe	3-4	650

Sources: Diab, 1988; Stassen, 1986; Linden, 1993; Fraenkel et al ,1993; Kenya Engineering, 1994; IT Power, 198; Mosimanyane et al, 1995; Sampa, 1994; Sawe, 1990; Mwandosya and Luhanga, 1983; Turyahikayo, 1992; Razanajatovo et al, 1994., Karekezi and Ranja, 1997; Karekezi and Kithyoma, 2002

The dissemination of wind turbines for electricity generation in the region has been very low which is in part attributed to low wind speeds and high cost. Kenya has installed a few wind generators, which are connected to the grid (Kenyan Engineer, 1994). Morocco is one of the leading African countries in wind power development. Plans to install large wind power farms of the order of 50-100 MW in Morocco are at an advanced stage (Abramowski et al, 1999). Recent reports indicate that an installed wind power capacity of 50MW is already in place.

Survey data indicates that there are now more than 13,500Mwe of wind power installed capacity worldwide. Growth has been very rapid over the last few years, and a total of 4,000Mwe was installed during the year 1999 alone. Estimates suggest that the market will continue to grow and estimates between 5,000 and 9,000MW are expected over the last few years. The average rating of the more recently installed turbines is about 550kWe, and a rough guide to the number of grid connected wind turbines around the world is probably between 30,000 and 40,000. There are large markets currently in existence for wind energy in Europe, North America and India. All of these markets have benefited from some form of Government intervention.

Table 13: Estimated Wind Energy Installed Capacity

Region	Country	Installed Capacity (MW)
Europe	Germany	4,445
	Spain	1,522
	Denmark	1,748
	United Kingdom	343
Asia	India	1,077
	China	265
North America	USA	2,500
Other Countries		1,600
Total		13,500

Source: www.ewea.org; IREDA News, Vol. 10 No.4; Martin, 2001.

By contrast, Africa has seen little development of modern wind turbines. This is partly due to low wind speeds compared with many parts of Europe, Asia and the Americas. This is compounded by the low level of technical skills and awareness of the potential of the technology. Consequently, few projects have been undertaken in Africa, and there is only limited experience of wind energy for grid connected or mini-grid electricity generation. However, wind pumping and small-scale electricity generation have been developed in many parts of Africa.

Small Hydro Power:

Small hydropower is often categorized into mini and micro hydro, and refers to the harnessing of power from water at a small scale (capacity of less than 10MW). Small hydro has the advantage of multiple uses: energy generation, irrigation and water supply. In addition, small hydropower is a very reliable technology that has a solid track record.

Much of the unexploited potential for small hydro is in remote areas of Africa (Hydronet 3, 1994). Eastern and southern Africa is endowed with a large number of permanent streams, rivers and tributaries that provide excellent hydropower development potential. Small hydro utilization in the region is still very low (Table 5). There is limited information on small-hydro sites in the region.

Table 14: Small Hydro Power Utilisation in the region

Country	Harnessed (Small) (MW)
Uganda*	0.50
Mauritius	6.70
Kenya	6.28
Burundi	5.17
Somalia	4.60
Zambia	4.50
Tanzania	4.00
Lesotho	3.54
Malawi	1.52
Botswana	1.00
Rwanda	1.00
South Africa	0.40
Swaziland	0.30
Mozambique	0.10

* Other stations of total capacity 6.81MW are not operational

Source: Karekezi and Turyareeba, 1995; *Karekezi and Ranja, 1997*

Small hydro technology is best suited for rural areas where the grid cannot reach. Small hydro is considered more environmentally friendly; since it avoids the significant environmental impacts associated with large-scale hydro, including loss of habitat, change in water quality and siltation (Inversin, 1986). The potential for small hydro development in the region is high.

3 Barriers to the adoption of Renewable Energy in Africa

There is growing consensus among policy makers that efforts to disseminate RETs in Africa have fallen short of expectations. While it is recognised that RETs cannot solve all of Africa's energy problems, RETs are still seen as having a significant unexploited potential to enable Africa countries to meet their growing energy requirements. Renewable energy is already the dominant source of energy for the household sub-sector (biomass energy). If properly harnessed, it could meet a significant proportion of energy demand from the industrial, agricultural, transport and commercial sub-sectors.

Despite recognition that they are important sources of energy for sub-Saharan Africa, RETs have attracted neither the requisite level of investment nor tangible policy commitment. Although national and international resources allocated to developing, adapting and disseminating RETs in the last two decades may appear substantial, the total amount is still insignificant compared to that allocated to the conventional energy sector. The success of RETs in the region has been limited by a combination of factors which include: poor institutional framework and infrastructure; inadequate RET planning policies; lack of co-ordination and linkage in RETs programmes; pricing distortions which have placed renewable energy at a disadvantage; high initial capital costs; weak dissemination strategies; lack of skilled manpower; poor baseline information; and, weak maintenance service and infrastructure.

This chapter considers three major barriers to the adoption of renewables: Policy and legal barriers; technical barriers; and, financial barriers.

3.1 Policy and Legal Barriers

Experience in the region shows that the introduction and success of any renewable technology is to a large extent, dependent on the existing government policy. Government policies are an important factor in terms of their ability to create an enabling environment for RETs dissemination and mobilising resources, as well as encouraging private sector investment (Sampa and Sichone, 1995).

Most of the early policy initiatives on renewables in the region were driven by the oil crises of the early and late 1970s. In response to the crises, governments established either an autonomous Ministry of Energy or a department dedicated to the promotion of sound energy policies, including the development of RETs. For example, Zambia responded by outlining policy proposals in its Third National Development Plan (1979-83) to develop alternative forms of energy as partial substitutes for conventional energy resources. Unfortunately, once the energy crisis subsided, government support for energy development and RET activities diminished significantly. Now most of the remaining support is at rhetorical level.

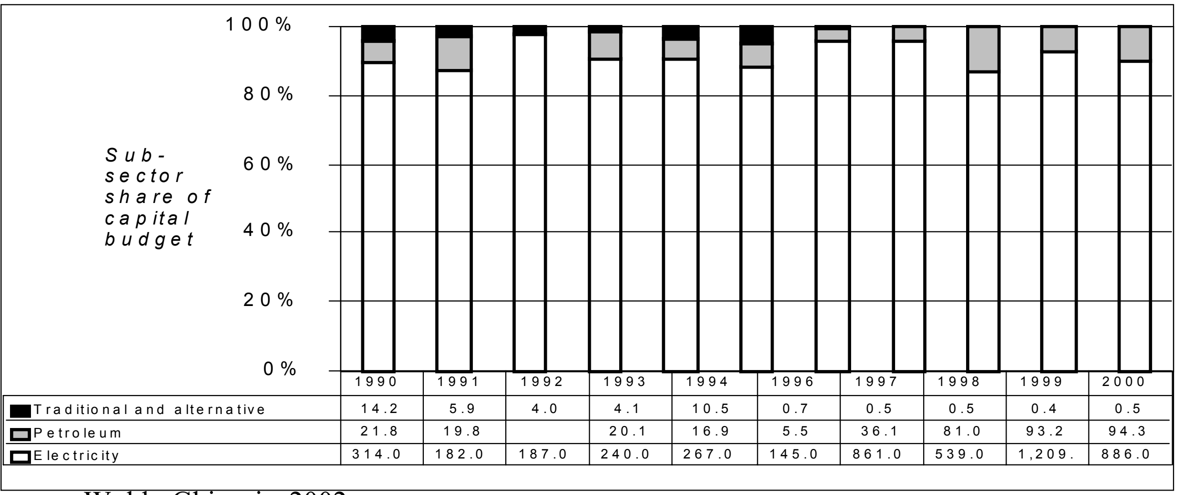
Most governments do not have a clear-cut policy on the development and promotion of RETs, which continue to be undertaken within an energy planning and policy vacuum. As a result, RETs development follows an *ad hoc* path, with no clear link to national power master plans, which are rarely available or out of date (Karekezi, 1988).

A survey carried out in Botswana revealed that about 57% of the respondents had no knowledge of government policies designed to promote the use of RETs (Mosimonyane, 1995). In Malawi the policy vacuum has meant that the majority of RETs dissemination efforts have not only been *ad hoc*, but have operated largely as informal sector activities outside the framework of government machinery, thus failing to mobilise the fiscal support of the central government and its major donors (Kafumba, 1994). A study on wind energy undertaken in Kenya showed that Dutch aid officials would have been interested in financing wind projects if there was an official wind energy policy strongly supported by the Government (IT Power, 1987).

Limited policy support for renewables is further demonstrated by the low budgetary allocations to renewables in most countries. Most countries place more emphasis on the petroleum and power sectors, which supply a small portion of the population, than on renewables (especially biomass) which supply a large portion of the population.

Very little expenditure is allocated to small and medium scale renewable energy technologies as compared to the conventional energy sector. For example investment trends in Ethiopia's energy sector reveal heavy investments in the electricity and petroleum sub-sectors. As shown in figure 6, investments in petroleum quadrupled from 1990-2000, while investments in electricity almost tripled in the same period. In contrast, expenditure on traditional and alternative energy (which includes RETs) has steadily decreased from about 1% of total expenditure in 1990, to 0.1% of total expenditure in the year 2000 (Wolde-Ghiorgis, 2002).

Figure 6: Energy sector capital budget shares % and total budget shares in million Birr for Ethiopia, 1990-2000



	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
■ Traditional and alternative	14.2	5.9	4.0	4.1	10.5	0.7	0.5	0.5	0.4	0.5
▨ Petroleum	21.8	19.8		20.1	16.9	5.5	36.1	81.0	93.2	94.3
☐ Electricity	314.0	182.0	187.0	240.0	267.0	145.0	861.0	539.0	1,209.	886.0

Source: Wolde-Ghiorgis, 2002

Only 2.9% of total forecast expenditure for the energy sector in Kenya was be allocated to renewable energy, as shown in Table 15 (Ministry of Energy 1987). In addition, the public investment plan indicates that only 1% of priority project investment for the energy sector was allocated to small and medium RETs in 1999/2000 (Ministry of Finance and Planning, 1998).

Table 15: Gross Expenditure Forecast for the Energy Sector, Kenya (1987-2000)

Sub-sectors	**TOTAL (Thousand Kenyan pounds)**
Administration Services	11,515
Planning Services	6,677
Solar And Wind Energy	4,423
Woodfuel Resources	74,321
Other Biomass Resources	2,057
Petroleum Exploration	32,118
Electric Power Generation	1,985,210
Transmission Lines/Substations	141,158
Distribution	178,550
Geothermal Exploration	80,200
Rural Electrification	224,081
Total Gross Expenditures	***2,740,311***

Source: Ministry of Energy, 1987

The Public Investments Plan for Uganda, which highlights priority projects for funding by Government, indicates that RETs were not considered priority investment projects in the energy sector portfolio. Out of 12 priority projects in 1994/95 – 1996/97, only 2 were RETs projects, accounting for only 0.3% of total estimated budget for that period (Ministry of Finance and Economic Planning, 1994).

Although the expenditure on renewable energy has been increasing over the years in Botswana, the bulk of expenditure is allocated to rural power supplies, which mainly involves the extension of the grid to rural areas. Table 16 provides time series data on expenditure in the energy sector in Botswana.

Table 16: Energy Sector Development Expenditure in Botswana (1997-1998)

	(Pula million, constant 1997/98 prices)						
Project Name	**1997/98**	**1998/99**	**1999/00**	**2000/01**	**2001/02**	**2002/03**	**Total**
Coal Development	2,00	2,00	2,00	2,00	2,00	5,00	15,00
Renewable Energies	0,65	0,97	0,25	0,25	0,25	1,34	3,70
Rural Power Supplies	24,00	25,00	25,00	25,00	25,00	11,00	135,00
TOTAL	26,65	27,97	27,25	27,25	27,25	17,34	153,70

Source: Ministry of Finance and Development Planning, 1997

The planned disbursement for the energy sector in Zambia indicates a heavy emphasis on electrification (mainly grid extension). Only about 2.5% of planned investments in the public investment plan are allocated to RETs, namely micro hydropower (1.5%), woodfuel efficiency (0.2%), and solar PV (0.8%) (Ministry of Finance and National Planning, 2002).

RETs programmes in Africa are unlikely to register significant development and dissemination without supportive government policies, which are backed by the requisite budgetary allocations.

3.2 Technical Barriers

The introduction of unfamiliar technologies such as RETs require the development of technical skills. The importance of technical know-how in the increased utilisation of RETs has been recognised in the region, but in spite of efforts by governments, there is a continuing shortage of qualified personnel (Baguant and Manrakhan, 1994). Technical knowledge is important in order to build over the long term, a critical mass of professional African policy analysts, economic managers and engineers who will be able to manage all aspects of the RET development process and to ensure effective utilisation of already trained African analysts and managers (World Bank, 1991). Trained manpower capable of developing and manufacturing renewable energy technologies is a prerequisite for their successful dissemination.

Government and ministries in Africa suffer from a shortage of qualified RETs personnel. In Kenya, for example, there is a lack of general expertise in all aspects of windpumps in the relevant ministries and NGOs (IT Power, 1987). In Zambia, at one time, only one engineer was responsible for co-ordinating all renewable energy activities of the government (Sampa and Sichone, 1995). A British-financed project to map out the wind regime in Seychelles was unsuccessful due to the absence of trained personnel (Razanajatovo et al, 1994). This deficit is largely responsible for the generally under developed research and technological capability and the poor management of renewable energy programmes.

Given the limited technical expertise in the formal sector, the situation in the informal sector presents a greater challenge. In the case of the informal sector, technical skills are largely mechanical. Thus, electrical technologies are more difficult to grasp for artisans in the informal sector, as well as majority of end users, especially in rural areas. This may explain the low uptake of electrical RETs such as solar PV and wind generators. These technologies are fairly complex, and with the shortage of technical skill, result in the reliance of expatriates or individuals based in urban areas. The departure of the outsiders often leads to the demise of the RET projects. This is exemplified by a case in Kenya, where an expatriate developed a low-cost, locally made control unit for PV lighting systems; on his departure, production stopped and has not resumed since (Karekezi and Maskhwe, 1991). Numerous examples of similar situations are common in the continent. The level of technical expertise existing in African countries is a key prerequisite for the successful implementation of RETs.

3.3 Financial Barriers

Financing plays a major role in the formulation of RET policies. Studies have shown that one of the main obstacle to implementing renewable energy projects is often not the technical feasibility of these projects but the absence of low-cost, long-term financing (News at Seven, 1994). This problem is complicated by competition for limited funds by the diverse projects and becomes critical if the country is operating under unfavourable macro-economic conditions. Governments and private enterprises must therefore seek creative ways of financing RETs projects. The challenge of financing projects for RETs is to develop models that can provide these technologies to consumers (including the very poor) at affordable prices while ensuring that the industry remains sustainable. As shown earlier, limited policy support for RETs in the region is indicated by minimal budget allocation to renewables at government level. Consequently, the private sector is left to bear the burden of financing RETs.

Most advanced and electrical RETs are not affordable to majority of the population in Africa who are poor, with national poverty levels of 50-70% (World Bank, 2001). This is especially true for RETs that have high cost imported components, than for those that can be locally manufactured and assembled using locally available components. RETs with high cost imported components place an additional burden on foreign exchange reserves of Africa countries, which are often minuscule and nearing exhaustion, and require expensive financing schemes and large subsidies (Karekezi and Kithyoma, 2002). These subsidies are not sustainable in the long run, unless the technologies provided are designed to include income generation.

Banking institutions have unfavourable requirements for RETs financing. Banking institutions normally lay down strict conditions for RETs investors and this deters potential users. Conditions required included a feasibility study conducted at the applicant's expense, due to the limited knowledge on renewables by banks. In addition, the banks required land titles as collateral, portforlios of project sponsors and managers, data on past and current operations, approximate value of existing investment, a valuation report, raw material procurement plans, and the marketing strategy for the finished product (Turyareeba, 1993b).

In cases where financing mechanisms are provided for end users, these are often not within the reach of the majority of the population. For example, the UNDP/GEF PV project in Zimbabwe benefited mainly affluent rural households, since over 80% of rural population could not afford the smallest system even at the cheapest rates. Stringent requirements for loan applications excluded the majority of the rural population from qualifying (Mulugetta et al, 2000; Mapako, 2001). In another study on the viability of PV in Manicaland, Zimbabwe, 65% of the rural population could not afford to pay the solar service fee (the lowest cost possible for providing PV-based electricity), while 91.5% could not afford a credit scheme (Cloin, 1998).

4.0 Overcoming the barriers to the adoption of Renewables in Africa

4.1 Policy and legal frameworks

Pro-active and long-term policy-oriented renewable energy programmes aimed at senior decision-makers in both Government and the private sector should be initiated. The innovative energy policy programme of the African Energy Policy Research Network (AFREPREN/FWD) provides a model example (Christensen and McCall, 1994). The policy programmes should be designed to demonstrate the economic and environmental benefits of renewables technologies to Africa's poor and propose short and medium term policy initiatives that would engender large-scale dissemination of renewables. Priority should be given to highlighting the real and tangible economic benefits (such as job creation and income generation) that renewable energy programmes can deliver to the region at both the micro and macro levels. For example, renewable energy technologies are generally more labour-intensive than conventional and centralised energy projects and can help to address problems of employment of the urban and rural poor. Empirical data and information on this would possibly result in higher budgetary allocations to the development of RETs.

Of particular interest to policy-makers in sub-Saharan Africa would be revenue neutral policy and institutional measures. For example, it is possible to make the case that the loss of revenue associated with the removal of duties and taxes on renewable energy technologies such as windpumps can be recouped from the long-term savings in imports of petroleum fuels that require scarce convertible currencies as well as from the income and sales tax remittances from a large and functional windpump industry.

4.2 Appropriate technology, technology transfer and building local capacity

The choice of renewable energy technologies for dissemination and development in sub-Saharan Africa should take into account the existing technical knowledge and local industries. Technologies that improve existing methods and build on already established industries are likely to be successfully disseminated. In addition, these technologies can become self-sustainable in the long-term.

Electrical renewable energy technologies (e.g. solar PV) are unlikely to be widely disseminated in the region, due to the lack of technical know-how locally on their operation. As mentioned earlier, a significant proportion of conventional energy investments have gone to waste mainly due to the heavy emphasis on electricity and on imported technology. In addition, a significant portion of the components in electrical technologies is imported. This raises the costs and reduces the opportunities for local technological development.

Mechanical and thermal/heat technologies (e.g. windpumps, small hydro, and improved cookstoves) build on local knowledge and skills. Consequently, maintenance is a less of problem, which results in greater and more sustainable dissemination. In addition, these technologies are modular (can be increased gradually over time), and can be locally manufactured. This translates to opportunities for employment and enterprise creation locally. With increased financial support at national and international levels for such technologies, it may be possible for an African country to become a significant player in the global renewable energy industry. For instance, with the exception of solar photovoltaics technologies, over 60% of the components required in many renewable energy technologies can be sourced locally.

Long-term renewable energy training programmes designed to develop a critical mass of locally-trained manpower with the requisite technical, economic and social-cultural skills are urgently needed. Many of the engineering and technical courses that are currently taught at universities and colleges in Africa provide little exposure to energy technologies. Modest changes in the curricula of existing colleges and universities could significantly increase the supply of skilled renewable energy engineers, policy analysts and technicians.

Both capacity and demand for local analytical expertise to provide comprehensive evaluations of available renewable energy resources and options for utilising them are needed in Africa. Non-partisan groups, such as NGOs and independent research institutes and networks are well placed for performing such studies. Fostering the development of human resources and encouraging their use is a valuable area for investing donor support, as it directly equips recipient countries with tools for managing their resources on their own.

Efforts to integrate analytical expertise within the energy sector with that of other key actors in the development process - such as expertise within the banking, social/community development and public sectors - should be included in this area of support. This is key to understanding not only the resources and technologies available but the institutional setting through which they may be adopted and the needs and interests of the target communities as well.

4.3 Innovative Financing Mechanisms

Priority should be given to the establishment of innovative and sustainable financing programmes for renewable energy technologies. This may range from the creation of a National Fund for renewable energy projects financed by a modest tax on fossil fuels to credit schemes specifically aimed at developing renewable energy industries and endowment funding of renewable energy agencies.

Experience has shown that most renewable energy technologies (especially those that can be locally manufactured) require subsidies only in the initial stages, and can become financially sustainable in the short to medium term after a certain level of technology dissemination has been attained, (see table 17). After attaining a dissemination of certain critical mass number of units and assemblers / manufacturers, the renewable energy industry can become self-sustaining and subsidies can be gradually withdrawn without any adverse effects on continued dissemination of renewable energy technologies.

Table 17: Critical Mass Numbers for Selected Technologies

	Units	**Assemblers/Manufacturers**
Improved stoves	7,000-10000	7-10
Solar water heaters	4,000-5,000	5-7
Bio-gas digesters	300-500	3-4
Wind-pumps	150-120	2-3

Karekezi, 2002

In Ghana, a national energy fund has been successfully utilised to finance renewable energy projects and energy efficiency activities on a sustainable basis. An important challenge is the bundling of discrete renewable energy projects into large programmes, which can be financed by major bilateral and multilateral donor and financing agencies.

In order to increase access to loans, banks should find alternatives to stringent requirements e.g. the collateral requirements. But since bank policy is unlikely to change in the near future, one possibility is to encourage potential consumers to form self-help groups or cooperatives so that they can acquire loans through cooperative banks, most of which do not have stringent collateral requirements. In addition, small credit institutions (micro-finance institutions) could provide financing for RETs investors and users at affordable and accessible terms. Small-credit institutions are crucial in ensuring continuity when external support ceases. Many have a nationwide network in place and are able to provide service even to remote rural areas.

4.3.1 The Clean Development Mechanism – Opportunities for Africa

The Clean Development Mechanism (CDM) presents a useful financing opportunity for Africa. This mechanism allows industrialised countries to meet part of their commitment to reduce emissions by investing in projects of developing countries that reduce GHG emissions. The rationale is that emissions reduction is less costly in developing countries.

The CDM could solve the financing barrier of RETs in Africa in several ways. Firstly, one of the basic requirements of the CDM is that the projects that industrialised countries invest in should meet the host country's development priorities. This provides room for the host country to select the projects for investment, and hopefully this would ensure that the host country has more leverage on the implementation of the project. The range of technologies being considered under the CDM project is wide, and includes renewable energy technologies.

5.0 The Way Forward – Renewables in the NEPAD Energy Initiative

Renewable energy technologies have an important role to play in Africa's energy sector. With the right approach, the renewable energy industry in Africa can become a major player in the energy sector, and meet the energy needs of a significant proportion of the population. Renewable energy technologies can play a major role in national development in terms of job creation and income generation as well as providing an environmentally sound energy service. Aggressive lobbying for renewables at national, regional and sub-regional levels is required.

Renewables can play complementary roles to large-scale conventional energy technologies. For example, RETs can be important alternatives for power generation in many drought-prone countries, when the conventional electricity sector (largely hydro-based) experiences deficits. Geothermal (Kenya) and cogeneration (Mauritius) ably met the energy deficit during the drought periods in Mauritius in 1999 and in Kenya between 1998-2000 (KenGen, 2000 and CEB, 1999). During the 2-year drought, the two geothermal power plants at Olkaria, Kenya offered continuous base-load power with almost 100% availability, unaffected by the prevailing weather condition (Bosshard, 2002). In Mauritius, energy from sugarcane bagasse increased from 259 GWh in 1998 to 343 GWh in 1999 (CEB, 1998; CEB, 1999).

The architects of the NEPAD energy program should ensure that the needs of the majority of Africa's population are not forgotten and are assured the requisite level of policy attention and eventual program and project finance. Of particular interest to Africa would be renewable energy projects that promote local small and micro-level enterprises as well as provide employment to rapidly growing population of Africa.

To ensure that Africa's energy community is able exploit the unique opportunity that NEPAD provides for the development of renewables in Africa, the following multi-pronged strategy is proposed:

- A near-term fast track program (1-5 years) that would aim to implement low-risk and low-cost near term initiatives.

- A long-term track program (5-10 years) that is built around major renewable energy sector initiatives that are currently taking place.

The near-term fast track program would consider implementation of projects that have proven track records and that maximise the use of local resources, expertise and available grant finance. Some of the aforementioned barriers to RETs development could also be addressed in the near term. Typical projects that could be implemented under such a program would include the following:

- Biomass-based co-generation
- Geothermal energy
- Small-scale renewables (improved cookstoves and kilns, solar dyers, solar water heaters, windpumps, small hydro)

The long-term track program would build on successes from the near term fast track program to develop medium and long-term initiatives. It would rely largely on ongoing and planned energy sector reform to establish an enabling environment that would attract both bilateral/multilateral as well as private finance for major investments in both national and regional RETs projects. Examples of such projects include:

- Large-scale wind power projects
- Large scale urban waste-to-energy projects
- Long-term capacity building & training, policy and financing programs.

6.0 References

Abramowski, J., Posorski, P., Simonis. P., Mueller, H., 1999. Wind Energy Projects in Morocco and Namibia. Journal of Energy in Southern Africa. Cape Town.

AFREPREN, 2002. AFREPREN Occasional Paper No. 10: Renewable Energy Technologies in Africa. An Energy Training Course Handbook. Nairobi: AFREPREN/FWD

AFREPREN Data Base, 2000. Energy Data Reference Handbook VI. African Energy Policy Research Network (AFREPREN/FWD), Nairobi, Kenya.

AFREPREN 2001. African Energy Data Reference Handbook: AFREPREN Trimestrial Report, Volume. IV. Nairobi, Kenya.

BCSE, 2003. geothermal Market Assessment Report, "The Eastern Africa Market Assessment Acceleration" Geothermal Conference Agenda. Business Council for Sustainable Energy (BCSE), Washington, DC.

Bronicki, L. ORMAT'S Experience in implementing Geothermal Projects. The Example of Olkaria III. ORMAT International, Inc.

Baguant, J., 1992. The Case of Mauritius. In: Bahaghavan, M.R., Karekezi, S., (Eds.), Energy Management in Africa. ZED Books and African Energy Policy Research Network (AFREPREN/FWD). London, U.K.

Central Electricity Board (CEBM), 1996. Annual reports, Ministry of Public Utilities, Curepipe, Mauritius.

Chiwaya, A., 2001. Energy Sector Reform Theme Group: data and Statistics Compilation – Malawi. African Energy Policy Research Network (AFREPREN/FWD), Nairobi, Kenya.

Deepchand, 2002. Promoting equity in large scale renewable energy development: the case of Mauritius. Energy Policy, 2002. Elselvier Science, Oxford. U.K.

Dube, 2001., Energy Services for the Urban Poor. Medium Term Studies: Case of Zimbabwe. African Energy Policy Research Network (AFREPREN/FWD), Nairobi.

Diab, R.D., 1988. 'The Wind Energy Resource in Southern Africa', Renewable Energy Resources and Technology Development in South Africa, Eberhard, A.A.(ed.), Elan Press, Cape Town, p.167.

Diab, R.D., 1986. The Wind Energy Resource in Southern Africa. In: Eberhard, et al. (Eds.) Renewable Energy Resources and Technology Development in South Africa. Elan Press Cape Town.

EcoSystems, 2002. Solar and Electric Vehicles. http://www/ecotopia.com/st/solarcar.htm

Frankel, P.,Crick, F., Derrick, A. and Bokalders, V., 1993. Windpumps- A Guide for Development Workers, Stockholm Environment Institute (SEI), Stockholm, Sweden,.

Fagbenle, R., 2001. Solar Photovoltaics Technologies in Africa. In: Occassional Paper Number 10. African Energy Data and Terminology Handbook. Nairobi: AFREPREN/FWD

Grabb, J.M., Meyer, I.N., 1993. Wind Energy: Resources, Systems and Regional Strategies. In: Johansson et al. (Eds.), Renewable Energy: Sources for Fuels and Electricity. Island Press USA.

Hankins, M. 2001. Commercial breaks – Building the Market for PV in Africa, in Renewable Energy World, July-August, 2001. James & James (Science Publishers) Ltd, London, UK.

IEA (International Energy Agency), 2001. Energy Statistics and Balances of Non-OECD Countries. Paris: OECD/IEA.

IT Power, 1988. Global Wind pump Evaluation Programme- Botswana, IT Power Limited, Rugby.

Kammen D.M., 1991. Solar Cooking For Developing Nations. Harvard University, Cambridge, MA.

Kammen D.M., 1992. The Kenya Solar Box: Appropriate Dissemination in Africa. In: African Technology Forum, Vol.3 No. 1. February/March, 1992. Africa Technology Forum, Cambridge.

Kantai, Parselelo, 2002. 'Hot and Dirty', EcoForum Vol. 24. No. 4, Hot and Dirty: Inside Kenya's 23 billion shilling charcoal industry. Nairobi: Environment Liaison Centre International

Karekezi, Stephen, 2002a. 'Renewables in Africa – Meeting the Energy Needs of the Poor', Energy Policy, Vol. 30 Nos. 11-12, Special Issue – Africa: Improving Modern Energy Services for the Poor. Oxford: Elsevier Science Limited

Karekezi, Stephen, 2002b. 'Renewables in Africa – Poverty Alleviation Instrument' First World Renewable Energy Forum: Policies and Strategies. Papers and Documents of the International Conference of the World Council for Renewable Energy.

Karekezi, Stephen and Kimani, John, 2002. 'Status of Power Sector Reform on the Poor', Energy Policy, Vol. 30 Nos. 11-12, Special Issue – Africa: Improving Modern Energy Services for the Poor. Oxford: Elsevier Science Limited

Karekezi, S. and Karottki, R., 1989. A contribution to the Draft Paper on the Role of New and Renewable Energy Sources of Energy from the Perspective of Environmental Problems Associated With Current Patterns of Energy use and Consumption. Foundation for Woodstove Dissemination/ Danida Centre for Renewable Energy, Nairobi.

Karekezi, S. and Kithyoma, W., 2002. 'Renewable Energy Strategies for Rural Africa: is a PV-led renewable energy strategy the right approach for providing modern energy to the rural poor of sub-Saharan Africa?' Energy Policy, Vol. 30 Nos. 11-12, Special Issue – Africa: Improving Modern Energy Services for the Poor. Oxford: Elsevier Science Limited

Karekezi, S., and Ranja, T. 1997. Renewable Energy Technologies in Africa. ZED Books and AFREPREN. Oxford U.K.

Karekezi, S. and Turyareeba, P., 1995. Renewable Energy Technologies: Mini and Micro |Hydro Power in Eastern and Southern Africa, AFREPREN, Nairobi, Kenya. Pp.2, 6-8

Kenya Engineer, 1994. 'Two Wind Turbines Installed at Ngong', Kenya Engineer, Nairobi.

Kenya Power and Lighting Company (KPLC) 2000. report and Accounts for the Year Ended 30th June 2000, Nairobi Kenya.

Linden, E., 1993. Namibia's Energy Sector – A Country Review, Namibia's Economic Policy Research Unit (NEPRU), Namibia.

Maarita, N. O., 2002. The Impact Of Large Scale Energy Development on the Poor: Environmental and Social Economic Impact of a Geothermal Power Plant on a poor Rural Community in Kenya. Energy Policy, 2002. Elselvier Science, Oxford. U.K.

Madhlazi, W., 2000. South Africa Country Proposal for Renewables and Energy for Rural Development Theme Group. Pretoria.

Mapako, M. (2000). Renewables and Energy for Rural Development Theme Group: Data and Statistics Compilation - Zimbabwe. African Energy Policy Research Network (AFREPREN/FWD), Nairobi.

Mbewe, A. (2000). Renewables and Energy for Rural Development Theme Group: Data and Statistics Compilation - Zimbabwe. African Energy Policy Research Network (AFREPREN/FWD), Nairobi.

Milkukas, M. Ribot, J., Maxson, P., 1984. Djibouti Energy Initiatives. National Energy Assessment, Volunteers in Technical Assistance, VA, USA.

Mosimanyane, M.T., Zhou. P and Kgathi, D.L., 1995. Renewable Energy Technologies in Botswana – The Case of Wind Energy for Water Pumping. SEI/AFREPREN/FWD, Draft Report.

Mwandosya, M. J. and Luhanga, M.L.P., Energy Resources Flow and End Use in Tanzania, Dar es Salaam University Press, Tanzania

National Electricity Regulator (NER), 2001., National Electricity Regulator Annual Report 2000/2001. NATIONAL electricity Regulator, Sandton.

Razanajatovo, M., Juliette, Y. and Jean- Louis, A., 1994. Renewable Energy Technologies Dissemination in Seychelles, AFREPREN/FWD, Nairobi, Kenya.

Sampa, R. C., 1994.'Renewable Energy Technologies Dissemination in Zambia ', paper prepared for the first Regional RETs Workshop, 31May- 1 June 1994, Naivasha, Kenya, SEI-AFREPREN/FWD, Nairobi, pp.14-15.

Sawe, E.N., 1990. Issues In New and Renewable Sources of Energy(NRSE) Activities And Policy Formulation in Tanzania, Ministry of Water, Energy and Minerals, Dar es Salaam, Tanzania, p.14.

Stassen, 1986. Die Regering se rol in die ontwikkeling en implementering Van alternatiewe hernubare energiebronne in Suid-Africa, M.Phil. thesis, Rand Arrikaans University, Johannesburg.

Smalera, A., Kammen, D.M., 1995. Design and Field Testing of a Savonius Windpump in Kenya. Princeton University, Princeton.

Vanderhulst, P. LANSER, H., Bergmeyer, P., Albers, R., 1990. Solar Energy: Small Scale Applications in Developing Countries. TOOL, Amsterdam.

Ward, R. F., Ashworth, J,H., Burril, G., 1984. Renewable Energy Technologies in Africa: An Assessment of Field Experience and Future Directions. Bureau for Africa/Agency for International Development. Washington.

WEHAB Working Group, 2002. A Framework for Action on Energy – World Summit on Sustainable Development, Johannesburg 2002

World Bank, 1996. African Development Indicators 2003. Washington DC: The World Bank

Teferra, M. 2000. Energy Sector Reform Theme Group: Data and Statistics Compilation - Ethiopia. African Energy Policy Research Network (AFREPREN/FWD), Nairobi, Kenya.

World Bank, 1996., Rural Energy and Development- Improving Energy Supplies for Two Billion People, World Bank, Washington, DC.