Renewables in Africa - Meeting the Energy Needs of the Poor

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Abstract

This paper presents estimates of renewables energy technologies disseminated in sub-Sahara Africa and evaluates the potential of renewables in meeting the energy needs of Africa's poor. Using data mainly from eastern and southern Africa, the paper examines five major renewable energy technologies, namely: (i) large-scale biomass energy; (ii) small scale biomass energy (iii) solar photovoltaic; (iv) solar thermal; and, (v) wind. It then evaluates how suitable each renewable energy technology is to meeting the energy needs of the urban and rural poor. The paper ends with key measures that could encourage the large-scale dissemination of renewable energy technologies to the poor in Africa.

Keywords: *Renewable energy technologies, Africa, poor*

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1. What is Driving the Interest in Renewables?

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 has doubled from about 15-20% to 30-40% for a number of African countries (AFREPREN, 2001).

{Insert brief regional profile: SSA here}

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).

Figure 1 Electrification %

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.

In contrast to energy efficiency that could have an immediate impact on fossil fuel exports, the long-term nature of renewables would allow a more gradual and less disruptive transition away from dependency on fossil fuels. Mobilizing support for renewables has, consequently, been somewhat less arduous. This viewpoint is bolstered by some evidence indicating that at the global level, the medium-term outlook for fossil fuels demand may not be as high as previously anticipated due to concerns over associated negative environmental impacts. In the long-term, fossils fuels may also become uncompetitive in cost as reliance on more costly oil reserves grows and alternative energy systems such as fuel cells become more affordable. Consequently, many African energy analysts believe that renewables constitute a reliable and ecologically sound long-term alternative for virtually all African countries including current oil-exporting nations, many of which have abundant and unexploited biomass, hydro, solar and wind resources. What is not yet clear is the extent to which renewables can assist in addressing the energy needs of Africa's poor - the subject of this paper.

2. Renewables and the Poor in Africa

2.1 Large-scale Biomass Utilization

Knowledge of large-scale biomass energy systems is not as widespread in Africa as that of small systems. Large-scale biomass utilization encompasses: direct combustion for process heat; ethanol production; gasification; heat co-generation; biogas production; and, briquetting. The best-known large-scale biomass energy systems with sound economic track records are co-generation using biomass as fuel stock and the production of ethanol as a substitute for petroleum fuel.

Figure 2 Power Generation – Mauritius: Capacity (MW) 1998

Co-generation using bagasse as feedstock to produce both process heat and electricity is a well-established technology in the Africa. 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). As shown in the following graph, 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 (Deepchand, 2000). 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 (Karekezi and Ranja, 1997).

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).

The potential impact of increased investment in co-generation for the poor is not well understood. Most of the potential benefits appear to be indirect. It is, however, possible that a growing co-generation industry could lead to increased incomes for the smallholder sugar farmers. Mauritius provides a model case example of where the benefits flowing to the low-income farmer have increased over time through direct policy interventions and an innovative revenue sharing mechanism. This mechanism could provide a model for the rest of region.

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).

Just as with the co-generation industry, the potential impact of the ethanol industry on Africa's poor is likely to be indirect. However, the implementation of a revenue sharing mechanism akin to what is operating in Mauritius (for the co-generation industry) could ensure that poor small-scale sugar farmers benefit from any revenues that flow to the ethanol industry.

The development of large-scale anaerobic digestion (popularly known as biogas) technology in the region is still embryonic, but the potential is promising. Tapping of methane can also prevent air pollution; mitigate greenhouse gas emissions; and, abate the hazard of fire and explosions arising from accidental ignition of methane leakages. A recent initiative to tap energy from waste land fills, was the US $ 2.5 million Global Environment Facility (GEF)-financed project in Dar-es-salaam, Tanzania which was expected to utilize an estimated 23,000 m^3 of methane generated by the process of anaerobic digestion (Global Environment Facility, 1993). It was estimated that large-scale replication of the pilot GEF Tanzania biogas project could result in the generation of electricity equivalent to over 10% of the Tanzania's total electricity generating capacity (Global Environment Facility, 1993).

This promising initiative was, however, ended prematurely primarily due to problems of cost escalation which were partially linked to technology selection problems. The project also faced significant institutional constraints. Establishing a self-sustaining institutional system that can collect and process urban waste on a large scale; and, effectively market the generated biogas fuel is a surprisingly complex activity that calls for sophisticated organizational capability and initiative (Karekezi, 1994; Karekezi and Ranja, 1997). The growing problems of urban waste management (in many cities of the region less than 50% of waste is collected and disposed of in an environmentally satisfactory fashion) that Africa faces appears to indicate that this option may still prove to be attractive for the region.

If well designed, large-scale urban waste-to-energy projects can benefit the urban poor who are already extensively involved in waste collection, sorting, recycling and disposal. It is conceivable that the waste collection and sorting functions could be wholly sub-contracted to the urban poor thus providing a steady and attractive income stream.

2.2 Small-scale Bio-energy Technologies

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, makes it more attractive than woodfuel (Karekezi and Ranja, 1997). It is the principal 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 major contributor to land degradation in many peri-urban regions of sub-Saharan Africa. Efforts to improve and modernize small-scale biomass energy systems to ensure environmentally sound use of 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 1 Estimated number of improved bio-fuelled stoves disseminated in selected sub-Saharan African countries in early 1990s

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.

Table 2 Small and Medium-Scale Biogas Units in Selected sub-Saharan African Countries

First, collection of animal dung turned out to be more problematic than was originally thought, particularly for farmers who did not keep their livestock penned in one location. Secondly, small-scale farmers with small herds of livestock were not able to get sufficient feedstock to feed the biodigestor unit and ensure a steady generation of biogas for lighting and cooking.

Thirdly, the investment cost of even the smallest of the biogas units is prohibitive for most poor African rural households. Evidence from the experiences in many African countries is still limited, but the general consensus is that the larger combined septic tank/biogas units that are run by institutions such as hospitals and schools have proved to be more viable than the small-scale household bio-digestors.

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. In addition to energy, biogas provides valuable fertilizer in the form of effluents that can improve agricultural productivity. Through anaerobic processes the effluent is effectively sterilized which checks one of the important vectors of rural diseases. There is anecdotal evidence indicating that the liquid effluent from biogas plants can be an effective and organic pesticide (Karekezi and Ranja, 1997).

Biomass energy is an important fuel for many small and medium scale industries in eastern and southern Africa. Examples include brick manufacture, lime production, fish smoking, tobacco curing, beer brewing, coffee and tea drying. Many of these industries operate in rural or peri-urban areas and provide employment to both the urban and rural poor sectors, which are poorly covered in official statistics. Although information on this important biomass energy consumption sub-sector is poor, the author believes that more pro-active development and dissemination of appropriate biomass energy technologies for small and medium scale rural industries could yield significant benefits to both the rural and urban poor of Africa.

2.3 Solar Photovoltaic Technologies

An important driving force to the wide-scale use of PV technology in Africa has been a dramatic drop in production costs experienced over the last 20 years. The production of photovoltaic modules, worldwide, has increased over the past two decades, rising from about 1 MWp in 1976 to over 35 MWp by mid 1988 and 48 MWp in 1990 (Karekezi and Turyareeba, 1994). Although reliable, region-wide data on the dissemination of PV technologies have not yet been compiled, available information for selected countries indicate growing use in eastern and southern Africa (Table 3).

One of the main PV initiatives in the region is the Zimbabwe GEF-financed decentralized rural electrification programme. The Global Environment Facility (GEF) project provided US $ 7 million for investment in a revolving fund that, within five years, supplied 25,000 rural homes with modern lighting (Thondhala, 1994). South Africa has launched a major PV solar lighting initiative aimed at the rural institutional market, namely rural health clinics and schools.

Table 3 PV Systems in Selected sub-Saharan African Countries in 1990s

PV technology has proven very successful in high-tech applications of communication. It is also an ideal alternative for powering vaccine refrigeration. Vaccines can dramatically improve the health of the rural poor and in this respect PV can play a role in delivering benefits to Africa's rural poor. There is growing evidence that PV does not benefit the rural poor because of prohibitive cost and high import content. A number of African energy analysts believe that PV should be confined to the few niches where it has proven to be cost-competitive and not be perceived as an important option for meeting the modern energy needs of Africa's rural poor.

2.4 Solar Thermal Technologies

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 some developing countries, LPG subsidies make it difficult for solar water heaters to be competitive (Vanderhulst et al 1990).

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 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. The urban and rural poor have not enjoyed significant benefits from solar water heating technologies.

One solar water heating technology that could yield major benefits to the poor is solar pasteurisation. Exposure of water in a clear plastic bag to sunlight for a few hours can substantially reduce harmful micro-organisms. Slightly more sophisticated solar waters pasteurizers incorporating some form of distillation can provide potable water.

Although solar cookers have not proven particularly popular with end-users (because of several cultural and socio-economic barriers), the extensive work and field tests of solar cookers have provided valuable technological insights, field experience and dissemination that could be effectively deployed in the dissemination of low-cost solar pasteurisation technologies to the rural poor of Africa.

In eastern, southern and western Africa, extensive research has been carried out to develop reliable solar dryers. Research projects have developed suitable solar crop dryers in Ghana, Kenya, Mauritius, Nigeria, Uganda, Zambia and Zimbabwe among other countries (Brenndorfer, et al, 1985; Karekezi and Ranja, 1997). Solar dryers that dry agricultural products such as grain, tea leaves and other crops, fish, and also timber (called solar kilns) are available.

In general, research has shown that solar dryers perform well and produce better results than the traditional method of drying crops in the open sun (Wereko-Brobby and Breeze, 1986; Bassey and Schmidt, 1987; Karekezi and Ranja, 1997). Solar dryers can assist in reducing post-harvest losses because dried produce is less susceptible to natural deterioration and insect infestation (Garg, 1990). Existing solar dryers are, however, still too expensive for the average small-scale farmer (Sebbowa, 1987; Brenndorfer et al, 1985; Karekezi and Ranja, 1997). Consequently, only the middle to large - scale farmers can afford them. More work on the development of low-cost solar dryers could potential deliver significant benefits to Africa's rural poor.

2.5 Wind Energy Technologies

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 the temperate westerlies (Grubb and Meyer, 1993). Therefore, low wind speeds prevail in many sub-Saharan African countries particularly in land-locked nations (Bhagavan and Karekezi, 1992; Kimani and Nauman, 1993; Dutkiewicz, 1990; UNDP/World Bank, 1982, 1983; Milukas et al, 1984).

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 (Table 4). Wind energy development continues to be hampered by the absence of adequate wind energy resource assessment especially at the micro-level.

Table 4 Wind Energy Potentials and Number of Wind Pumps and Wind Generators for Selected Countries

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).

Prices for wind pumps in several countries have been estimated to range from US$ 2,500 to US$ 13,000 (Bogash et al, 1992; BHEL, 1994), which limits this technology to large and medium-scale farmers and rural institutions. In spite of these limitations, a number of sub-Saharan African countries have registered some encouraging progress, notably Namibia and South Africa which have disseminated over 30,000 and 100,000 wind machines, respectively (Linden, 1993). Botswana, Kenya, Zambia and Zimbabwe have several well-established manufacturers of wind pumps (Karekezi and Ranja, 1997). It is estimated that over 90% of the value added of a typical wind pump is now undertaken in the region.

3. Key Benefits of Renewables

To the casual observer, the problems facing the development of renewable energy technologies in Africa may appear overwhelming. A closer look would, however, demonstrate that the nature of the energy sector in Africa provides enormous opportunities for formulating and implementing ambitious renewable energy programmes that will bring an environmentally-sound and secure energy future for Africa's poor closer to reality (Davidson and Karekezi, 1992).

Firstly, although a number of sub-Saharan African countries have significant unexploited reserves of fossil fuels, the prospects for major increases in fossil fuel supply are constrained by the unequal distribution of reserves, which entails large-scale investments in distribution. For example, it is estimated that over 80% of sub-Saharan Africa's oil reserves are in Angola and Nigeria while 76 % of the region's natural gas reserves and 90 % of the region's bituminous coal reserves are in Nigeria and South Africa, respectively. Renewable energy resources are, on the other hand, relatively well distributed in the region and would not require major investments in new energy distribution networks.

Secondly, even if significantly new findings of fossil fuel resources were to be found, the already onerous debt burden and fragile economies of many sub-Saharan African countries would limit the investments that can be made in conventional, centralized energy systems. Competition for the limited capital available is more intense due to increased demand from the emerging market economies of Eastern Europe, Asia and Latin America. In addition, the performance of centralized and conventional power systems continues to be well below expectations in spite of accounting for the bulk of the energy investment in the region.

Thirdly, the capital requirements of renewables are generally lower than those of conventional and centralized investments. More importantly, the modular nature of renewable energy allows even the poorest of African countries to begin a phased energy investment programme that would not strain its national investment programme or draw investment funds away from other pressing basic nutrition, health, education and shelter needs.

Fourthly, the decentralized nature of human settlements in the region implies very high distribution costs for conventional centralized power systems. Contrary to popular belief, a large number of rural Africans reside in individual scattered homesteads and not in concentrated villages. Extending power from centralized generating stations to individual homes is a costly undertaking. In this context, renewables and other decentralized energy options are particularly competitive in delivering modern energy to Africa's rural poor.

Fifthly, numerous energy agencies in both the Government and non-Governmental sectors have emerged. In a number of sub-Saharan African countries, the rapid institutional development is beginning to be matched by the development of a critical mass of local energy expertise willing to face the challenge of formulating and implementing effective renewable energy programmes aimed at both the urban and rural poor. In addition, there are growing national and regional links that are being forged by energy institutions, especially in the non-Governmental sector, leading to better networking and information exchange. This can provide an important avenue for rapid diffusion of information on renewable energy technologies that can benefit the rural and urban poor.

Measures that would encourage the large-scale dissemination of renewable energy technologies to the poor in Africa can be grouped into the following six categories:

- Implementation of long-term renewable energy policy programmes;
- Development and application of carefully-selected technological and institutional leapfrogging strategies;
- Initiation of long-term renewable energy training and capacity building programmes;
- Institution of new and flexible financing mechanisms; and,
- Wider application of innovative dissemination strategies.

4. Policy Options for the Promotion of Renewables

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 centralized energy projects and can help to address problems of employment of the urban and rural poor.

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.

4.1 Technological and Institutional Leapfrogging

Many experts in the South have recognized the importance of technological and institutional leapfrogging in countries where physical infrastructure and institutional development are still in their embryonic stage. In contrast to other emerging market such as central and Eastern Europe, Africa does not possess a large stock of conventional energy investments (e.g. coal power stations) and can, therefore, more easily chart an alternative energy development path. Renewable energy technologies represent such an alternative.

In contrast to conventional energy technologies that are mature and have consequently evolved into large-scale investment industries, renewables are relatively newer technologies that do not require large-scale capital. Secondly, renewable energy technologies are relatively less complex and the level of sophistication is still embryonic. Consequently, the limited African technical expertise that is available in the region can be used to develop a significant renewable energy industry in the region. The chances that an African country (outside of South Africa) can become a significant player in the world's conventional energy market are, at best, very slim. With limited financial resources (available on a long-term basis), it may be possible for an African country to become a significant player in the global renewable energy industry.

At the institutional level, African countries needs to realize that the centralized energy model is becoming increasingly obsolete in developed countries where independent power producers riding on the back of the privatisation wave are increasingly the norm rather than the exception. Rather than continue to expand its centralized power systems, African countries should begin to develop a decentralized energy structure which would better match its current capital resources and management capability as well as position it well to adapt to future energy technologies and systems.

4.2 Training and Capacity Building Initiatives

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 utilizing 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 assistance, 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.

The energy policy research programme of the African Energy Policy Research Network (AFREPREN/FWD) which brings together over 104 African academics and policy makers from 10 sub-Saharan African countries provides a model example of how effective collaboration between energy researchers and policy makers can be realized (Christensen and McCall, 1994).

4.3 New and Flexible 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.

In Ghana, a national energy fund has been successfully utilized 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.

4.4 Innovative Dissemination Strategies

Support should be channelled towards wider application of the new renewable technology dissemination strategies that have demonstrated encouraging signs of success. Many of these strategies largely revolve around the idea of participation, income generation and small-scale enterprise development. The rationale is that if producers and distributors can make an attractive income from the manufacture and marketing of renewable energy equipment and users are fully involved in the dissemination process, then the issue of sustainability is resolved in a much more cost-effective fashion.

The second important innovation is the idea of using existing systems of production, marketing and information dissemination. By using an existing production system, the cost of disseminating renewable energy technologies is dramatically reduced. This piggyback principle is particularly effective in rural areas where the cost of establishing new marketing and distribution networks is costly. Renewable energy dissemination initiatives can be a component of an existing integrated income-generating project or environment programme or health extension programme.

The rural stove component of the Kenya stove programme successfully utilized this strategy and has managed to disseminate over 180,000 improved woodstoves using the existing nation-wide network of home science extension workers. In a similar fashions, solar and wind-energy technology programmes that have registered encouraging results have largely relied on existing agricultural extension or marketing networks to engineer rapid and low-cost dissemination.

Of particular interest to policy makers and development assistance agencies would be the provision of relatively reliable estimates of the critical mass of RETs systems, manufacturers or assemblers of RETs required to initiate a self-sustained dissemination process. This would provide programme managers with clear and measurable targets as well as re-assure policy makers and financiers that the assistance and subsidies channelled towards renewables have a finite lifetime after which a self-sustained industry and/or market would be able to move the programmes forward.

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Table 1 Estimated Number of Improved Bio-Fuelled Stoves Disseminated in Selected Sub-Saharan African Countries in Early 1990s

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

Source: Karekezi and Turyareeba, 1994; Karekezi and Ranja, 1997; AFREPREN Data Base, 2000

Table 2 Small and Medium-Scale Biogas Units in Selected sub-Saharan African Countries

Country	No. of Small and Medium Scale Digesters < 100 cubic meters
Tanzania	> 1,000
Kenya	500
Botswana	215
Burundi	279
Zimbabwe	200
Lesotho	40
Burkina Faso	20

Source: *Ward, 1982; Wauthelet et al, 1989; Traore, 1984; and, Manawanyika, 1992; Karekezi and Ranja, 1997; AFREPREN/FWD, 2001*

Table 3 PV Systems in Selected sub-Saharan African Countries in 1990s

Country	Estimated No. of systems	Estimated kWp
Uganda	538	152
Botswana	5,724	286
Zambia	5,000	400
Zimbabwe	84,468	1,689
Kenya	120,000	3,600
S. Africa	150,000	11,000

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

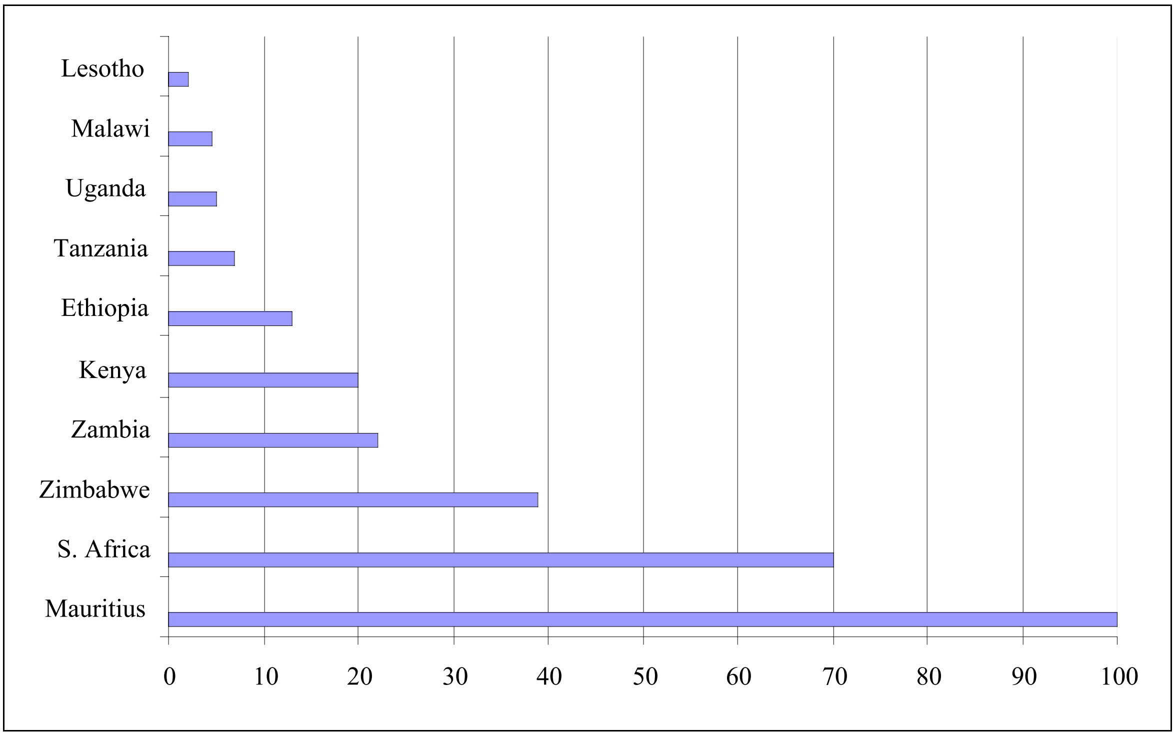
Table 4 Wind Energy Potentials and Number of Wind Pumps and Wind Generators for Selected Countries

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: *Abramowski et al, 1999; Milukas et al, 1984; World Bank, 1987; Bhagavan and Karekezi, 1992; World Bank, 1988; Dutkiewicz and Gielink, 1992; Ranganathan, 1992; Katihabwa, 1993; Stockholm Environment Institute, 1993a, 1993b; Linden, 1993; Maya and Rudidzo, 1989; BHEL, 1994; Mbewe, 1990; Ward, 1992; Sawe, 1990; Mwandosya and Luhanga, 1993.*

Captions to Figures

Figure 1 National Electrification Levels (%)
Figure2 Power Generation – Mauritius: Capacity (MW) 1998



Source: AFREPREN/FWD, 2001

Figure 1 National Electrification Levels (%)

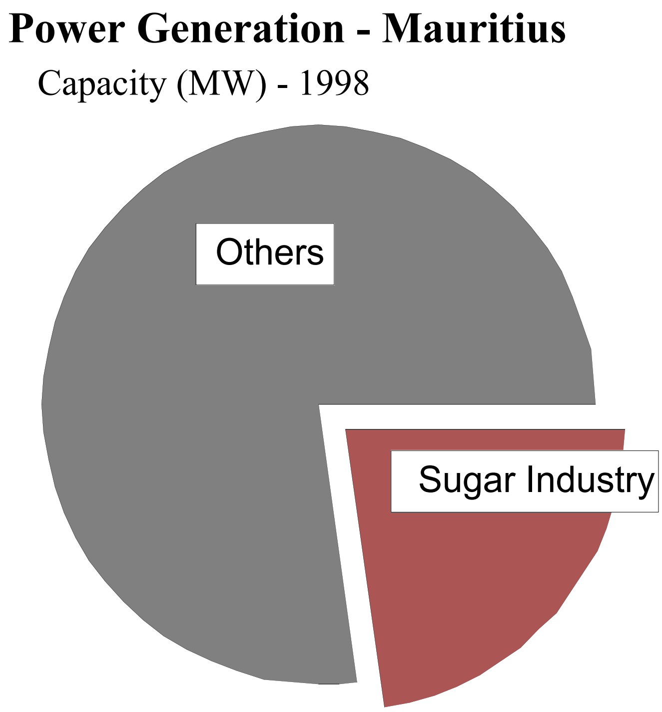
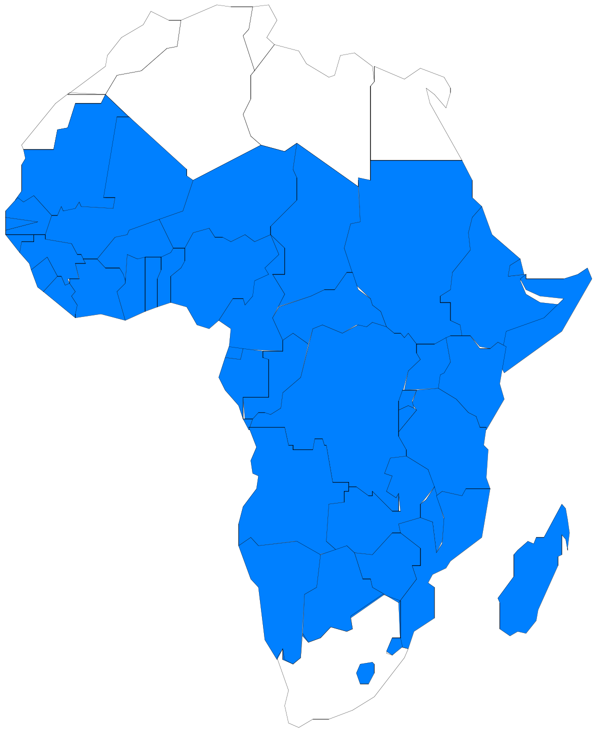


Figure 2 Power Generation – Mauritius: Capacity (MW) 1998

Brief Regional Profile



Sub-Saharan Africa (excluding South Africa): Selected Indicators
• **Population (million):** 600.8 (1999) • **Area (km^2):** 22,407,000 • **GNP per Capita (US$):** 306 (1999) • **Modern Energy Consumption per Capita (kgoe):** 355 (1997) • **Rural Population (million):** 420.7 (1999) • **Urban Population (million):** 179.7 (1999) • **Number of people living below US$ 1 a day (%):** 50 (1998) • **Number of people living below US$ 2 a day (%):** 81 (1998) • **Biomass Contribution to total energy consumption (%):** (40-90)

Sources: World Bank (2000); World Bank (2001); AFREPREN (2001)