SOCIOECONOMIC IMPLICATIONS OF THE WIDER USE OF BIO-ENERGY AND WIND ENERGY TECHNOLOGIES

by

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ABSTRACT

Renewable energy technologies dissemination in Eastern and Southern Africa has been slow despite the efforts made over the last ten years. This paper addresses the development and role of renewable energy in Eastern and Southern Africa with emphasis on bio-energy and wind energy. Experiences in the dissemination of renewable energy technologies in the region are reviewed and factors affecting the dissemination these technologies are briefly analyzed.

The technologies which are considered to be mature and have been disseminated in the region include:

- bio-fuelled stoves for households and institutional cooking;
- biogas digesters for cooking and lighting in households and institutions;
- briquetting for production of a substitute to woodfuel for cooking;
- gasification for operating small engines;
- wind turbines for electricity generation.

The factors influencing RETs dissemination addressed in this paper are:

- Institutional Development;
- Organisation, Management and Maintenance;
- Human resources development and retention; and,
- Financing.

In addition, a brief examination of the socioeconomic implications of the dissemination of these technologies using a case study approach is undertaken. The impacts addressed include: reducing deforestation in the region, waste recycling, reducing womens' burden in collecting fuelwood and water by increasing availability of water close to domestic establishments, reducing indoor air pollution in households and

institutions, reducing dependence on foreign sources of energy for electricity generation, reducing expenditure on fuel importation, and job creation in the region.

A closer examination of the positive effects associated with RETs is further justification for strategies to overcome any barriers and increase investments in RETs dissemination in the region.

1 STATUS OF DISSEMINATION OF BIO-ENERGY AND WIND ENERGY TECHNOLOGIES

Bio-energy and wind energy technologies which are considered to be mature and have been disseminated in the region include:

- bio-fuelled stoves for households and institutional cooking;
- biogas digesters for cooking and lighting households and institutions;
- briquetting for production of substitute to woodfuel for cooking;
- gasification for operating small engines;
- wind pumps for water pumping; and,
- wind turbines for electricity generation.

Improved bio-fuelled stoves (also known as improved stoves) are one of the RETs which have experienced significant success in the region. There are improved stove projects in almost all the countries in the region which range from small-scale grassroots community based organisations to large scale national programmes which are usually donor supported (Karekezi, 1993). Improved stove programmes, particularly those targeted at urban households, are increasingly becoming an established component of national energy programmes. A wide range of institutions are involved in stove work and have developed innovative dissemination approaches that are low-cost and sustainable. In terms of number of stoves disseminated, there has been a notable improvement in the 1980s as compared to the 1970s. For example, in Kenya, an estimated 6,000 stoves had been disseminated by 1981. By 1990, the figure was estimated to be well over half a million (Karekezi, 1993). The number disseminated is now estimated to be over 700,000 (Kammen and Kammen, 1993; GTZ, 1994).

Biogas is a combustible gas produced by the fermentation of organic material in the absence of oxygen. It is composed of about 60% methane (CH_4) and 40% carbon dioxide (CO_2). It can be used in gas cookers, lamps, to run refrigerators, generate electricity and to power stationary diesel and petrol engines among other things (Hankins, 1987). Biogas has attracted considerable attention in the region over the last three decades (Ward, 1992; Wauthelet et al, 1989; Traore, 1984; Manawanyika, 1992; Peters et al, 1992). Many countries in the region have active country-specific research, including Zimbabwe and Zambia (Hall, 1993). In South Africa, there are large scale biogas plants for electricity generation. One of the largest biogas programmes in the region is in Tanzania where over 1,000 units have been installed (Ministry of Water, Energy and Minerals, 1993).

There is also a planned large scale biogas project in Tanzania funded by GEF. The project is designed to be economically self-sufficient through the sale of electricity, fuel and fertilizer. It aims at reducing methane emissions by managing wastes adequately.

Briquetting is the densification of loose granular material into compact and easily transportable fuel. Biomass suitable for briquetting includes residues and waste products from the wood industries, rubbish, charcoal residues and other combustible waste products. Large scale briquetting is done by motor on an industrial or regional basis (Kristoferson and Bokalders, 1987) while small scale briquetting activities are mostly manual. There are large scale functional briquetting plants in Ethiopia, Kenya, Malawi, Uganda, Sudan, Zambia and Zimbabwe (Makau and Obura, 1991; Turyareeba, 1991; 1993; Hassan, 1992; FAO, 1990). Three briquetting plants were established in Uganda of which two have been closed down while the third is operating below capacity. In Sudan, briquetting was developed along decentralized carbonization and a centralized briquetting strategy (Ali and Hood, 1992).

Gasification is the conversion of biomass into a gaseous energy carrier known as producer gas by means of partial oxidation at elevated temperatures (Hos and Groeneveld, 1987). The gas produced from this process is applied mainly as fuel gas for electricity generation and heat production. The biomass converted into gaseous form is obtained mainly from wood and crop residues such as coconut, cotton, maize, rice, and wheat residues. These can be acquired directly from energy plantations or from commercial and non-commercial biomass markets. A gasifier system was installed in Ethiopia in 1987 about 140 km from Addis Ababa but unfortunately this system is no longer operational (Turyareeba, 1991). Gasifier systems were also installed in Sudan, Zimbabwe and Tanzania for sawmill operations and in Uganda to generate electricity for briquetting plants. The operations have been intermittent and thus the briquetting plants have relied mainly on the national grid for electricity supply. A plan to introduce, test and develop producer gas techniques for applications such as sawmilling, small scale generation and vehicle usage was established by the Tanzanian Wood Industry Corporation (TWICO). Funding has been coming from both the Tanzanian Government and the Swedish International Development Authority (SIDA). The plant has proved practical and economically feasible (SEI, 1990; Mwandosya, 1990).

Wind pumps are strictly mechanical devices that utilize wind energy to pump water. In eastern and southern Africa, South Africa has the largest number of installations, with about 280,000 windpumps (Stassen, 1986). Namibia has the second largest number of installations in the region with approximately 30,000 units (Linden, 1993). Kenya is next with 360 units installed. Over 200 of these are of `kijito' type, which are manufactured by Bob Harries Engineering Limited. Pwani Fabricators is the other major manufacturer of wind pumps in Kenya. The existing market for wind pumps is approximately 30 units/yr (Fraenkel et al, 1993). In Zimbabwe, sales of windpumps are around 30 units per annum (Fraenkel et al, 1993). In Zambia, the Department of Energy is currently implementing a wind energy project and has financed a local manufacturer. A wind pump has been installed at a test site near Lusaka (Sampa, 1994). By 1983, there were 30 wind pumps in mainland Tanzania (Mwandosya and Luhanga, 1983). Less than a third of these are operational.

There is a Southern Cross Windmills Project in Singida region where about 10 villages already get regular supply of water pumped by the large multi-blade fan mill type wind mills, funded by the Australian and Tanzanian Governments.

The components of wind turbines for electricity generation include a two or three-blade rotor to capture the wind. The rotor blades are slender, with aerofoil cross sections similar to those of airplane wings. Other components are: the gearbox, which transfers the aerodynamic torque from the rotor to the electric generator; the generator (which may be an AC or DC - generator); and, the tower (Frandsen, 1991). The dissemination of wind turbines in the SSA region has been very low.

2 FACTORS INFLUENCING THE DISSEMINATION

It is quite clear that bio-energy and wind energy technologies which are considered mature in the region have not experienced an impressive rate of dissemination as envisaged, despite their advantages over conventional sources of energy. The factors influencing their dissemination addressed in this paper are:

- Institutional development;
- Human resources development and retention;
- Organisation, Management and maintenance; and,
- Financing.

Institutional Development

The key institutional actors in the renewable energy sector are government and commercial agencies. Key agencies in the government include the ministries of energy and their respective departments as well as research institutes. Government agencies are particularly important in the regulation and licensing of key institutions operating in the energy sector.

The support of government is crucial especially where the technology being promoted is not commercially viable in the near term and there is uncertainty about it's future prospects. Governments in the region have not been very supportive of bio-energy and wind energy technologies. This is especially true with regard to allocation of funds to promote these technologies.

There are currently no research institutions dedicated to renewable energy technologies in the region. Many of the research efforts in RETs continue to decrease. The development and dissemination of RETs such as wind energy technologies has been hampered by the lack of information from relevant institutions such as Government Ministries, NGOs and research institutions. For instance, in Kenya, there is very little "institutional memory" on wind energy developed (IBRD, 1993). Virtually no information on wind pumps or wind generators has been accumulated in Government institutions. Furthermore, Governments generally prefer large-scale fossil-based solutions to energy supply and water problems, thus discouraging the adoption of RETs.

In many countries in the region, Governments continue to grant subsidies to the national utilities, thus making electricity generation from wind energy and other RETs which are not subsidised to be uncompetitive compared to grid electricity.

In some countries, however, renewable energy technologies are beginning to attract significant Government support. For example, the Government of Botswana in its National Development Plan VII (1991-1997) has demonstrated strong support for the development and promotion of renewable energy technologies by setting aside a total of US $ 1.3 million for renewable energy programmes.

Another major institutional bottleneck in the promotion of RETs in the region is the poor linkage between the various institutional agencies in the RETs field. The aftermath of this poor coordination is the emergence of shortcomings such as overlapping responsibility, duplication and redundancy at both research and policy formulation thus hindering the implementation of innovative renewable energy initiatives and programmes. This is exemplified by the case in Kenya where in an attempt to make a wind pump suitable for the local conditions, many researches were carried out by NGOs, donor agencies, each ignoring findings of previous researches and the end result was that most of the prototypes developed were unsuitable and funds to implement their findings had run out.

Human Resource Development And Retention

The introduction of unfamiliar technologies requires the development of skills. Capacity building has to be carried to ensure the sustainability of RETs installations. However, the experience in the region in the past has been that expatriates have made RETs installations but have failed to train the locals so that when they depart, the installations eventually become non-functional and send a very negative picture of RETs. For instance, briquetting technology was imported from Europe and was not adapted to local conditions (Boiling Point, 1991) hence there have been problems faced as far as operating and maintaining the machines is concerned. Most countries in the region still do not have the required expertise and thus rely heavily on foreign experts. There is a case in Uganda in which some briquetting equipment which arrived in Uganda between 1986 and 1987 was not installed until December 1992 due to lack of local knowhow.

However, there are cases in which there was capacity building which contributed to the success of those projects. A good example is in the research, design, and dissemination of improved stoves in Kenya. Many actors were involved in the search for an appropriate model of the Kenya Ceramic Jiko (KCJ) and in the process, local people got acquainted with the technology. Even the previous manufacturers of the traditional stove got trained on the manufacture of the KCJ and incorporated this activity to their businesses.

Organisation, Management and Maintenance

The marketing approach adopted by improved stove disseminators which was usually incremental improvements on traditional and existing marketing and information networks has contributed largely to the success of this activity. A good case example to illustrate this is the Kenyan Ceramic Jiko (KCJ) initiative.

One of the key characteristics of this project was its ability to utilize the existing production and distribution system for the traditional stove to produce and market the KCJ.

However, the improved stove dissemination story is not entirely successful. This is true because in the past, development agencies attempted to introduce improved mud stoves in rural areas using the owner-built approach. This led to quality control problems. Although the stoves performed well in laboratories, they turned out to be less efficient than the un-shielded open fire. This was caused by the inability to adhere to the standards in stove building specifications and inadequate maintenance.

Marketing of briquettes in Kenya (especially in the household sector) has been hampered by competition from charcoal and fuelwood which cost less. The management of briquetting plants has also been a major draw back as far as production and marketing the briquettes is concerned (Makau and Obura, 1991). According to a market survey conducted in Kenya, briquettes were considered to be more marketable as a fuel for industrial and institutional purposes, rather than a household fuel (Walubengo, 1989). A paper manufacturing company in Kenya recorded annual savings of Kshs 60,000 (approximately US$ 4,000) when using briquettes as a fuel in mid-1980s (KENGO, 1987).

Though the use of biogas is seen as a panacea to the woodfuel crisis in households with cattle, collection of animal dung turned out to be more problematic than was originally envisaged, particularly for farmers who did not keep their livestock penned in one location. Small scale farmers with small herds of livestock were not able to get sufficient feedstock to feed the bio-digester unit to ensure a steady generation of biogas for lighting and cooking. In addition, the concept of using human waste to provide cooking fuel was not easily accepted in the region.

From the section on status of dissemination of bio-energy and wind energy technologies, it is apparent that small scale briquetting has not been widely adopted in the region. The reason for this is that small scale briquetting units run on a communal basis have often failed due to various organizational and management problems. The modalities of briquetting for household use have not been well documented although this practice is common near wood processing industries and for charcoal fines in urban areas.

Maintenance problems, as has been evidenced by the case in Uganda, are yet another major barrier to the success of the dissemination of the gasification technology and other RETs that should be looked into.

Since wind technologies are a decentralized option, they are usually scattered in different parts of the country. In the case of the 'Kijito' windpump in Kenya, Bob Harris Engineering Limited, the company which manufactures these windpumps has incurred alot of money in its efforts to maintain windpumps installed all over the country. This has worked to reduce the profits made by it. Most machines become non functional due to lack of maintenance as illustrated in the case of Uganda where approximately half of the wind pumps installed in Karamoja are no longer functioning, largely due to lack of maintenance (Turyahikayo, 1994).

Financing

The investment cost of even the smallest of the biogas units, which ranges from US$ 1,500 to US $ 2,400, is prohibitive for most rural households (Peters et al, 1992; Turyareeba, 1993). Tanzania has the highest number of biogas units disseminated in the region. This is because the government partly funded and supported projects as the investment costs were too high for the individuals. This move helped greatly in disseminating the technology. Strong incentives are, thus, required to convince end users to use RETs rather than petroleum fuels.

Since power is available from wind, the economic attractiveness of a project increases dramatically as average wind speeds increase (CORECT/AID, 1988). Unfortunately, even where the average wind speeds favour electricity generation from wind, foreign suppliers of the wind turbines charge very high prices, thus hindering the dissemination of wind generators (Razanajatovo et al, 1994).

Briquettes generally cost more than wood charcoal (Boiling Point, 1991). They are also unlikely to become cheaper than traditional fuels and may only find a niche where prices of traditional fuels have risen sharply (McChesney, 1989). Production and transportation costs can, however, be reduced if un-carbonized briquettes are made within the proximity of the consumers who are mainly large institutions and industries.

3 SOCIOECONOMIC IMPLICATIONS OF USE OF BIO-ENERGY AND WIND ENERGY TECHNOLOGIES

The dissemination of these technologies has had socio-economic implications on the region. The next section addresses some of the impacts.

Reducing expenditure on fuel importation

Biogas is a good replacement for fossil fuels which not only has higher carbon dioxide emissions but whose purchase diminishes foreign exchange reserves.

A wind pump neither consumes nor generates electricity. The lack of need for fuel makes them suitable for solving rural water supply problems, and they have clearly contributed to rural development in several countries.

Reducing dependence on foreign sources of energy for electricity generation

Producer gas can be considered as one of the substitutes for petroleum fuels in both engines and furnaces where either a `clean fuel' or accurate temperature control is important. In this case, gasification helps in reducing dependency on and vulnerability to high energy prices or energy shortages.

Wind electricity saves the foreign exchange which non-oil producing countries spend on oil imports. In the long run, wind generators are cheaper than diesel generators because the former have lower running costs. This is particularly true in remote rural locations where the supply of fuel cannot be assured.

Job creation

The process of gasification is labour intensive and therefore creates employment.

Improved stoves create employment in many areas. For instance, over 200 artisans make the improved stoves in Kenya (Ashley and Young, undated). In addition, liner production is carried out by semi-automated establishments which employ over 5 workers each. Some women in Kenya who are involved in the production of the Maendeleo stove have been able to earn additional income for their households.

Reducing Women's burden of collecting firewood and water

Improved stoves are designed to reduce heat losses, increase combustion efficiency and attain a higher heat transfer efficiency (Turyareeba, 1990). For example, enclosing the fire reduces heat loss by convection, insulating the firebox reduces heat loss by radiation, controlling flow of air through the fire and incorporating a grate in the firebox increases combustion efficiency (Turyareeba, 1990; Hankins, 1987). They therefore reduce specific fuelwood consumption hence reducing the time spent by women collecting firewood. In an impact study of the Maendeleo stove programme, time saving was estimated to vary from 3 to 20 hours per week depending on the size of the household and on whether the wood was simply collected or had to be chopped into smaller pieces. The time saved was generally used to undertake either additional productive activities or essential household chores (Klingshirn, 1992). Other key benefits included household budget savings and income generation.

Increasing availability of potable water

Wind pumps play an important role in the provision of potable water in areas which have no piped water but have good wind resources. For example, in Kenya, water distribution has shaped the whole demography and economy of the country. Wind pump installations are spread all over rural Kenya, but mainly in remote areas where living conditions are simple and water supply is a frequent problem. This reduces the burden of women in rural areas, who physically carry water from rivers and streams. The water from the wind pump is generally used as the main supply for both domestic and livestock needs at the site (occasionally modest irrigation as well) (Borg and Oden, 1995).

Reducing Deforestation

Biomass as a renewable source of energy is always considered to be conditional. This is because it is not renewable if exploitation exceeds regeneration. The rate of desertification and the subsequent desertification is alarming in the region. Though felling of trees for construction and the clearing of land for agricultural activities, rather than to meet the increasing demand for energy has been proved to be the major cause of deforestation, the role played by the production of charcoal and supply of firewood cannot be underestimated.

Improved stoves reduce fuel consumption. The reduced fuelwood consumption means that environmental degradation through deforestation is minimized. Briquettes can be an important alternative for households especially during periods of charcoal and fuelwood shortages (KENGO, 1987).

There is strong evidence to show that, due to both the increased prices of petroleum fuels and their frequent unavailability, more institutions are switching from petroleum products to wood and charcoal (Joseph and Walubengo, 1988). It is probable that more institutions will continue to switch to fuelwood as the price of charcoal continues to escalate at a faster rate than that of wood. For instance, sawmills, mainly concentrated around Mountains Kilimanjaro and Meru, were powered by diesel engines as electricity was not available. In the 1980s, oil prices went up and as a result, TWICO decided to test the operations of the sawmill on charcoal gas with charcoal produced from the sawmill residue.

Reducing Indoor Air Pollution

One driving force behind improved stove development has been the growing concern that smoke from bio-fuelled stoves such as the three-stone hearth is a major health hazard for the overwhelming majority of users in the region. In rural areas, particulate concentrations of 10,000 ug/m^3 have been recorded, which is over 50 times the World Health Organisation's recommended level of exposure (Smith, 1993; Pandey et al, 1989). There is growing evidence linking respiratory diseases in developing countries with high exposure to smoke emissions (Karekezi et al, 1995; Ramakrishna, 1995; Hong, 1995). The most vulnerable group are women and children. Consequently, removal of smoke, cleanliness, convenience and safety are important reasons that have promoted the dissemination of improved stoves (Karekezi, 1992).

Waste Recycling

Biogas production facilitates a cheap, environmentally sound waste recycling. Wastes provide food and shelter to animals and insects that may spread infectious diseases, give rise to odours and smoke as well as pollute ground and surface water (Moshi, 1993). All these problems can be curbed by using these wastes economically to produce biogas. Users are able to effectively get rid of wastes and at the same time produce biogas for domestic use and electricity production.

Briquetting is an economical way for energy processing industries to deal with wastes. The industries are able to deal with their waste disposal difficulties and at the same time produce fuel (briquettes) to meet their energy requirements (Gamser, 1987).

4 CONCLUSION

In view of the foregoing, it is apparent that bio-energy and wind energy technologies have an important role to play in the region, but due to the named hindrances, they have not fulfilled this role. It is also clear that these technologies can improve the pattern of distribution of energy in our society in such a way as to bring about greater social equity and more balanced regional development. They can also stimulate economic activity, income and employment generation and improve the quality of life particularly in the rural areas.

With this in mind, there is great need to have the barriers to the dissemination of bio-energy and wind technologies removed. The following recommendations should be taken into consideration:

1. At the onset, renewable energy programmes should be aggressive, long-term, policy oriented, and aimed at senior decision-makers in both Government and private sector. All the institutions and agencies involved in the mature RETs should work more closely to integrate the support they provide in the development of mature RETs. Networking agencies such as AFREPREN should be strengthened.

2. Innovative and sustainable financing programmes for renewable energy technologies should be instituted. Governments, donor agencies, private sector, financial institutions and NGOs should be involved more in the financing of mature RETs.

3. There is need for greater emphasis on quality control as well as regular and preventive maintenance. Research, technical and maintenance skills should be developed.

4. Those technologies adopted from outside the region should be modified to conform with the social, economic and political norms of the region before being assimilated.

5. Long term renewable energy training programmes, designed to develop a critical mass of locally trained personnel with the requisite technical, economic and social cultural skill, should be initiated. There should be maximum use of local researchers and consultants.

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