Status of Renewable Energy Policy and Implementation in Kenya

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July 2008
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Introduction

This chapter chronicles the status, development and dissemination of renewable energy technologies (principally solar photovoltaics and biomass energy, and to a lesser degree wind and small hydropower) in Kenya and India.

In investigating the issue of non-diffusion of renewable energy technologies in Nigeria, it is helpful to evaluate the methods employed by similar developing countries that have implemented such technologies with some measure of success.

Kenya and India have been chosen as case studies because the two countries offer peculiar experiences laden with instances of success and failure from which instruction can be drawn. The aim is to analyse the procedure followed by these countries in renewable energy implementation, in order to identify the factors responsible for the varying degrees of success and failure recorded.

1.0 Republic of Kenya: Geopolitical and Socioeconomic Background

![Location map of Kenya](image)

Fig. 1: Location map of Kenya. *Source: The Central Intelligence Agency World Factbook online, last updated 19 June 2008.*
Kenya, a country located in the eastern part of Africa, straddles the equator, which bisects it into two nearly equal parts lying between 4.5° N and 4.5° S (Acker et al., 1996). Bounded by Tanzania, Uganda, Sudan, Ethiopia and Somalia, it covers a total area of 582,650 square kilometres. Perhaps by virtue of its somewhat central location in East Africa, Kenya is the hub for finance and trade in the region (CIA, 2008).

The current estimated population of Kenya is 38 million people\(^1\), of which about 80 percent live in rural areas. The population growth rate stands at an average of over 3 percent, and if it continues at this pace, it is expected that the country’s population will double by the year 2030 (Rabah, 2005).

Kenya has an agriculture-based economy, accounting for about 29 percent of the total gross national product of the whole country (Day et al., 1990). The GDP per capita is US$ 1 700 (2007 estimate), compared to US$ 2 000 for Nigeria. Its main agricultural products are tea, coffee, corn, wheat, sugarcane, fruit, vegetables, dairy products, beef, pork, poultry and eggs. Of these, the principal cash crops are tea and coffee, with tea being the chief foreign exchange earner as at 2003 (Murison, 2004). Coffee is the fourth largest foreign exchange earner (Ibid.).

Kenya’s economic growth has been hampered by several factors ranging from corruption to underdevelopment of the manufacturing sector. The country relies largely on the low income from the primary raw goods it exports, thereby foregoing the maximum profits obtainable from the export of processed and finished goods. This much is evident in the fact that the industrial sector contributes only 16.7 percent to GDP (CIA, 2008).

The country has a rich endowment of natural resources including limestone, soda ash, salt, gemstones, fluorspar, zinc, diatomite, gypsum, hydropower and wildlife. Worthy of note is the country's vibrant wildlife industry which makes it a popular tourist destination. Generating around US$ 400 million per annum, wildlife tourism is Kenya’s second largest source of foreign exchange (Swanson, et al., 1992). Other industries include small-scale consumer goods (plastic, furniture, batteries, textiles, clothing, soap, cigarettes, and flour); oil refining; aluminium; steel; lead; cement; commercial ship repair and horticulture. The most notable

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\(^1\) This figure is a July 2008 estimate of Kenya’s population approximated by the American Central Intelligence Agency, taking into account the effects of excess mortality due to the rather high occurrence of HIV/AIDS in the country.
amongst these is the horticulture industry, which is the third largest foreign exchange earner for the country after tea and tourism (Murison, 2004).

For all its natural endowment, Kenya does not possess oil in commercial quantities and therefore must import all its oil. (Acker et al., 1996). As a result, the country has proved economically vulnerable to fluctuations in petroleum prices and world oil shocks (Ibid.). This is sufficient incentive for the country to actively develop and deploy alternative sources of energy.

### 2.0 Energy in Kenya

Kenya has no known fossil fuel resources (Senelwa et al., 1999). It is not an oil-producing nation, neither does it have any coal reserves, therefore it must import fuel energy for local consumption (Rabah, 2005). Petroleum supplies 22 to 26 percent of energy in the country, including electricity. 2 to 4 percent of total energy (mainly grid-connected electricity) is generated from hydro and geothermal sources while a meagre 1 percent is supplied by coal (Senelwa et al., 1999). The energy supplied by petroleum and grid electricity collectively constitutes one-third of the total energy used in industrial, commercial and household sectors (Osawa et al, 2004).

Traditional biomass fuels (particularly fuelwood, charcoal and animal dung) are the most common sources of energy in Kenya, used mainly in households to generate non-electricity energy. These locally available fuels are used by over 70 percent of the total Kenyan population for cooking and space heating (O’Keefe et al., 1984), constituting over two-thirds of national energy demand. In the rural areas, fuelwood constitutes about 90 percent of the total energy consumed and its demand is increasing at 3.6 percent per annum (Walubengo et al., 1992). Unfortunately however, wood is being used at an annual rate 4.7 percent higher than is sustainably available, raising concern about meeting the country’s future energy needs and economic and ecological security (Karekezi et al., 1989; Wamukonya 1995).

Fuelwood is neither bought nor sold in rural areas; it is freely gathered at no monetary cost to the consumers (Karekezi et al., 1991). This accounts for its popular use by rural dwellers whose incomes are typically not sufficient to sustain the use of conventional market fuels such as liquid petroleum gas and kerosene. Though the price of kerosene is controlled by the government, it is often much
higher in rural areas than in urban areas (Wamukonya, 1995). Even where there are households that can bear the cost, supply of these commercial fuels to rural areas is normally unreliable with urban areas having priority on distribution (Ibid.). Nonetheless, the availability of these conventional fuels in urban areas does not necessarily imply affordability. Charcoal, which costs far less than kerosene and liquid petroleum gas, remains the dominant fuel used for cooking in urban areas (Hyman, 1987; Wamukonya, 1995).

Due to the massive share of traditional biomass in Kenya’s energy mix, the dominant energy user is the rural household sector (52 percent, most of which is attributable to non-electricity energy). Industry accounts for 24 percent, transport 14 percent and the urban household sector 6 percent (O’Keefe, 1995). Agriculture accounts for only 2 percent of energy use despite its importance to the Kenyan economy (Ibid.).

If the availability of non-electricity energy is unreliable in Kenya, the shortage of electricity energy is severe. The annual electricity demand currently stands at 6 percent and is increasing (Rabah, 2005). To meet this demand is an installed grid-connected generation capacity of 1,225.4 megawatts dominated by hydropower at 55.6 percent, while thermal and geothermal contribute 32 percent and 10 percent respectively (Osawa et al., 2004). An additional 30 megawatts of electric power is imported from Uganda Electricity Board (Central Bureau of Statistics Kenya, 1994; cited in Rabah, 2005).

Consumption of electrical energy is dominated by the industrial sector at 63 percent, followed by domestic and small scale industrial at 33 percent, while consumption by rural customers comprises only 4 percent of total demand (Osawa et al., 2004).

Although the national electricity grid connects major densely populated areas, about 80 percent of urban and 99.5 percent of rural households have no access to electricity from the grid (Rabah, 2005). Access to grid electricity for households currently stands at a low 15.3 percent nationally and less than 2 percent in rural areas (Osawa et al., 2004). This dire situation is bought about by the fact that investments in the Kenyan power sector have lagged behind growth in demand (Ibid.).
The effect of the nationwide energy deficiency is being felt throughout the Kenyan economy, largely in the form of lost production due to inadequate power supplies (Osawa et al., 2004). Senelwa (1997) cited in Senelwa et al. (1999) asserts that the limited availability of cheap conventional energy in agriculture and manufacturing is to blame for the comparatively low manufacturing levels and therefore the underdevelopment of industries. However, Osawa et al. (2004) argue that the underperforming production sector is the very reason that demand for energy is low. From all indication, it would seem that the Kenyan economy is undergoing a cyclical phase in which it is difficult to separate cause and effect.

In response to the problem, Kenya is in the process of diversifying power generation sources (Rabah, 2005). Various fiscal incentives for investments in regular and non-conventional renewable energy projects have been suggested for inclusion in the national energy policy document (Osawa et al., 2004).

### 3.0 Rural Energy and Enterprise in Kenya

Household fuel in rural Kenya is typically gathered by women and children who sometimes have to walk up to two hours each way to locate ever depleting sources of firewood. Women in particular are most burdened, having to return home to carry out heaps of chores that traditionally fall within their job description. A United Nations study showed that women in Africa grow 70 percent of the food, fetch 80 percent of the fuel and 90 percent of the water, process 100 percent of the food, and do all of the child care and cleaning (Day et al., 1990). This use of time and human resource is highly inefficient and largely unproductive.

Apart from its adverse effects on the well-being of rural people, incessant wood gathering has destructive effects on the environment. By constantly using up wood supplies without replanting the forests, rural people unwittingly upset the natural balance of the ecosystem. The consequences of this disturbance could be far reaching in the long term, giving rise to flood, erosion, drought, desertification and other “natural” disasters.

There are limited options for energy supply in rural Kenya. As Wamukonya (1995) observes, biomass seems to be the only feasible source of fuel for the rural population in the foreseeable future. Cooking is mostly done over open fires, traditional stoves or improved stoves at floor level. It is common to find kitchen areas outdoors or even completely separate from the main building. This,
however, does not totally eliminate the potential of health hazards that can be brought about by continuous smoke inhalation.

Despite being subsidised through a levy on electricity bills, electrification of rural households through grid extension is not widespread (Hankins, 2000). By 1999, only about 61,500 homes, less than 2 percent of the 3.7 million rural households had been connected during fifteen years of the national utility’s programme of rural electrification (Ibid.). As dismal as this performance may seem, it actually surpasses the results of the Rural Electrification Programme (REP) run from 1973 to 1988, during which only 5,000 new households were connected to the national grid (Rabah, 2005). As at 2003, the rate of new connections, at approximately 10,000 per year, was not sufficient to keep pace with rural population growth (Maher et al., 2003). Of those who do eventually receive a connection, most are upper and middle class households who can afford to make a significant contribution towards the connection costs and who do not represent the majority of the rural population (Ibid.).

It is evident from history that government rural electrification schemes in Kenya have been quite problematic. Nyoike et al. (1996) cited in Acker et al. (1996) state that rural electrification in Kenya has been plagued by the political nature of grid extension decisions and the poor coordination between local authorities and the rural electricity board. Rabah (2005) observes that there is no decentralised policy to facilitate provision of power in rural and lower income urban areas. Senelwa et al. (1999) are however convinced that the Kenyan government is committed to rural grid electrification and is only constrained by the huge financial implications of doing so. The solution, they reckon, is for government to concentrate on promoting new sources of more affordable energy such as the decentralised solar home systems that are fast gaining acceptance in the country.

At present, 3 percent of rural Kenyans get power from a solar home system, 5 percent from a battery-only system and the remaining 90 percent have no access to electricity in any form (Maher et al., 2003). From these statistics we see that batteries provide the greatest access to electrical power in any form for the rural population. Dry cell batteries are used to power small loads such as torches and radios. Applications that require larger or more continuous power input such as television sets and fluorescent lamps are powered by rechargeable lead-acid batteries, the type used in automobiles. This system however is difficult to
sustain, as battery owners typically have to walk long distances and pay significant rates to recharge at stations connected to electricity.

Notwithstanding all the apparent difficulties, the performance of the service industry in rural Kenya is remarkable. By far, Kenya has the most diversified rural product and service networks in East Africa (Doyle, 2002). The flourishing rural household goods and services sector in the country partly thrives on the high-yield tea and coffee-growing enterprise run by rural farmers. Of course, the profits from this booming industry are not equally distributed, with the lion’s share going to rural elites and absentee landlords (Acker et al., 1996). Nevertheless, the influence of this profitable rural enterprise is evident in the rate of purchase of alternative energy products and services, particularly solar photovoltaic systems. For example, Doyle (2002) reports that in 2002, the solar photovoltaic and lead acid battery market in Kenya was US$ 6-8 million.

In addition to energy service outlets, several other outlet types exist, most of which have strong working linkages with urban suppliers (Doyle, 2002). These outlets may not be overly sophisticated in product quality and service delivery, but they do go a long way in meeting the basic needs of the present population. As it stands, this outlet network is partly responsible for the high diffusion rate of improved biomass and solar home systems in the country. It is important to note though that there exists a lot of potential for developing and improving this network so that it is able to deliver higher quality service than it currently does.

4.0 Renewable Energy Technology Application in Kenya: An Overview

Prior to discussing the topic of renewable energy technology (RET) diffusion in Kenya, it will be useful to examine the general state of these technologies in the country. The RETs currently being developed in Kenya (to varying degrees) are bio-energy, solar photovoltaics, geothermal energy, small hydropower and wind energy.

Bio-energy technology in Kenya can be divided into two major categories: small-scale and large-scale. The most prominent small-scale bio-energy solution is the development of improved cookstoves that are designed to burn biomass fuel more efficiently than traditional stoves. It may appear as though the energy used per unit of these cookstoves is negligible, but their importance lies in the very large number of end-users that they serve (Karekezi, 1994). Taking into account
the fact that over 80 percent of Kenyans rely on biomass stoves to meet their cooking, heating and lighting needs, improved cookstoves could very easily emerge as the most relevant RET application in the country. Aside from its application in domestic stoves, small-scale bio-energy is also an important source of fuel for small and medium scale enterprises such as tea and coffee drying; fish smoking; brick manufacture and beer brewing (Karekezi, 1994).

Another small-scale bio-energy application used in Kenyan households and small farms, albeit to a much lesser extent than improved cookstoves, is the biogas plant. Biogas technology is particularly suited to farm use, partly because of the need to use crop residue and animal dung as feedstock, but mostly because the waste product of the biogas-production process is a rich source of fertiliser. Despite the fact that biogas plants have been used in Kenya for about twenty years (Day et al., 1990), their use is not as widespread as improved stoves. Establishing a self-sustaining institutional system that can collect and process animal dung or urban waste and effectively market the generated biogas is a surprisingly complex activity that calls for sophisticated organisational capacity and initiative (Karekezi, 1994).

A major reason for lack of diffusion of the technology is the fact that it is relatively expensive. The maintenance and operating costs of biogas plants limit their dissemination significantly as does the complexity of monitoring and maintaining the fuel supply (Murphy, 2001). Evaluation of a biogas demonstration project implemented on a Kenyan farm in 1990 by Day et al. showed that it would take an average farmer about three years to save up enough money for a biogas plant. Discouraged by the cost factor, most farmers decide it will be cheaper to do without the technology. Besides issues of cost, a 1986 survey of twenty five biogas plants in Kenya revealed numerous other problems, including poor design, construction and maintenance; an inadequate supply of water; too much labour required to operate the plant and poor social acceptability.

Compared to the significant advancements made in small-scale bio-energy, development of large-scale bio-energy systems in Kenya is below par. This is the case even though there are resources available to generate a lot more energy than is currently being produced from industrial-scale ethanol plants and briquetting factories. The Kenyan government is presently investing in the development of ethanol as an alternative to gasoline for use in automobiles. There are also some functional briquetting plants processing traditional biomass
fuels to produce small brick-like units that burn more efficiently and are easier to transport.

Solar photovoltaic technology (solar PV) is an option that has defied a lot of odds in Kenya to gain widespread acceptance and use, particularly in rural areas with no other option for electricity. A handful of other developing countries such as Zimbabwe and Sri Lanka have registered some degree of success in establishing and disseminating solar PV, but the Kenyan record surpasses them all (Acker et al., 1996). In 1994, the number of private homes and small businesses around the country that had bought and installed solar PV systems was estimated at 20,000 – 40,000 (Ibid.). By 1998, the estimate had risen to 50,000 – 70,000 households (van der Plas, 1998). Despite heavy taxes and duties levied by the government on PV products, solar electricity continues to be widely and increasingly used (Ibid.).

Electricity from solar PV is mostly used by rural dwellers to power television sets, radios and lights. The limited application is reflective of restrictions placed by cost on the maximum size of PV panel a household can afford. This leads us to observe a remarkable fact: in a complete departure from the common model of donor-driven markets for RETs in developing countries, Kenya’s household solar PV market is almost one hundred percent privately owned. The extraordinary path trailed by Kenya in developing its private solar PV market is discussed in further detail in the next section.

Another very promising renewable source of energy that has been identified in Kenya is Combined Heat and Power (CHP) production (or cogeneration) from bagasse. Bagasse is the by-product obtained when sugarcane is crushed to extract its juice in sugar production plants. When burnt in large quantities, this waste product can provide enough heat to supply all the energy needs of a typical sugar factory – with some to spare. The surplus energy can be fed into an electricity grid for onward transmission to grid-connected homes and industries.

Bagasse cogeneration in Kenya is viable to the extent that it could easily provide 10 percent of the national electrical energy demand (Osawa et al., 2004). The country’s greatest advantage lies in the fact that it has an existing sugar industry which it can now exploit to meet part of its energy requirements. In 2002 alone, Kenya produced an estimated 1.8 million tonnes of bagasse worth approximately US $194 million. The projected economic benefits of this yet-to-be-exploited
source of energy for Kenya are huge: about US $90 million can be potentially saved on foreign exchange on an annual basis, and up to 500 000 new jobs will be created every year (Osawa et al., 2004).

Bright as the prospects seem, the sugar industry in Kenya cannot fully develop its cogeneration capacity without government support. The Ministry of Energy recently put policies in place to allow sugar factories generate power for sale to the national grid. The national power utility on its part is working on strengthening the transmission grid, to make room for future input from bagasse cogeneration. Though actual energy production is yet to be realised, these proactive measures taken by the government are quite encouraging.

Geothermal sources currently contribute 10 percent of Kenya’s national energy supply (Osawa et al., 2004). Geothermal energy is the natural heat from the earth’s interior stored in rocks and water within the earth’s crust (Mariita, 2002). 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 (Ibid.). Natural geothermal manifestations have been known to exist for a long time around volcanic fields in Kenya’s rift valley. Geothermal investigation and exploration in the country started as far back as 1956. However it was not until 1981, following joint exploration efforts by the Kenyan government and the United Nations Development Programme (UNDP), that geothermal power was first tapped in Kenya. That made Kenya the first African country to tap power from the crust of the earth in a significant fashion (Johansson et al., 1992).

Although geothermal electricity is the cheapest form of electrical power in Kenya (Tole, 1996), less than 10 percent of the country’s geothermal potential is currently being utilised. However, it is likely that geothermal energy will be increasingly exploited for electricity generation in the near future (Ibid.).

Of all the RETs, small hydropower and wind technologies are the least developed in Kenya, even though resource availability in the country is significant (Maher et al., 2003). Development of small hydropower is limited to pilot projects demonstrating the viability of the technology for energy generation. Wind energy technology is somewhat more developed, with the emphasis being on wind-powered water pumps, or wind pumps. Wind pumps have been manufactured locally in Kenya for over twenty years (Harries, 2002), and have been used to provide water for irrigation and domestic use to remote rural populations (Ibid.).
5.0 Diffusion of Renewable Energy Technologies in Kenya

Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 1995). The term ‘dissemination’ is sometimes used to refer to diffusion that is deliberately planned and directed, as opposed to diffusion that occurs spontaneously (Ibid.). The scope of the discussion here encompasses both interpretations. By definition, an innovation is a new idea that is introduced into society in the expectation that it will engender some form of social change. Some innovations do spread and are sustainable over time, thus proving to be successful; others don’t.

Modern renewable energy technologies are new innovations that offer a lot of advantages over conventional energy sources: reduction of greenhouse gas emissions; provision of energy security; access to decentralised power for the world’s poorest. Theoretically, rapid diffusion of such useful technologies should be guaranteed. In reality, that has not been the case. Karekezi (1994) stresses that the establishment of viable and cost-effective dissemination systems is a complex task which requires substantial commitment of resources and substantive local participation. Different countries have had varying degrees of success with RET dissemination. Even within individual countries, rates of diffusion vary for different RETs. The question that arises is, what are the factors that promote or hinder diffusion of these RETs?

Kenya is one country that has set impressive records in the dissemination of two particular RETs: improved cookstoves and solar photovoltaic technology. In attempting to identify some of the factors crucial to widespread dissemination of RETs, it will be helpful to analyse Kenya’s approach to the development of those two technologies.

5.1 Solar PV Technology

The Kenyan solar PV industry provides an empirical example of technology diffusion that has been shaped by the interaction of technological change, energy demand, and political and economic forces (Acker et al., 1996). Since its inception in 1985, it has grown to become one of the largest and most dynamic commercial solar PV markets among developing countries, with one of the highest per capita sales (Murphy, 2001; Otieno, 2003). Cumulative solar sales in the country over the past two decades are estimated to be in excess of 200,000 systems, with annual sales growth has regularly topping 15 percent (Jacobson, 2004).
The growth of the solar PV industry in Kenya, in spite of several shortcomings, provides a good example of consumer participation in market development (Sebitosi et al., 2005). The private nature of the market, as opposed to the more common donor-driven model prevalent in developing countries, makes the development of the Kenyan PV industry a case worthy of note. This is not to say that donor agencies made no contribution to the establishment of the industry; on the contrary, the donor market was initially the only PV market in Kenya (Acker et al., 1996). However, these donors - mostly international aid agencies - focused on commissioning large scale PV projects for public facilities such as schools and hospital, with little attention given to household electrification. Today, however, the story is very different. An estimated 75 percent of solar equipment sales in the country is attributed to the sale of household solar electric systems, particularly in rural areas (ESDA, 2003 cited in Jacobson et al., 2005). With more than 20,000 new families buying solar panels every year, the rural PV market continues to grow, even at a much faster pace than the rate of new rural grid connections (Jacobson, 2004; Jacobson, 2007).

The results of a year 2000 survey carried out by the Tegemeo Institute of Agricultural Policy and Development in Kenya bear out the fact that solar electricity has emerged in the country as a key alternative to grid-based rural electrification (Jacobson, 2007). It was found that 4.2 percent of rural Kenyan households owned a solar system, against 4.3 percent who were connected to the national electric grid. By 2003, the number of rural Kenyans who got their electricity from the sun was more than twice as large as the number connected to the national electricity grid (Otieno, 2003).

There has been a rapid reduction in the cost of PV over the last three decades (Karekezi, 1994). During the 1980s and 1990s when the Kenyan PV industry started to blossom, the reduction in the delivered price of energy from solar PV panels was as much as ten-fold (Maher et al., 2003). In spite of this, solar PV technology is still regarded worldwide as being capital intensive, more so than other renewable energy sources such as biomass. What then are the factors responsible for the relative success of PV technology in such an unlikely economy as that of rural Kenya?

The Kenyan PV market possesses two distinct but interdependent characteristics: it is component purchase-driven and it is price-driven. To properly appreciate the
relationship between component purchase and solar PV growth in Kenya, it will be useful to understand something of how a PV system operates.

The basic components of a PV system are: module, battery, charge controller, inverter and end-use appliance. The module, usually a flat rectangular panel, is made up of an array of solar cells which do the primary conversion of sunlight to electricity. The capacity of a PV system can be multiplied or divided simply by adding or removing modules. The modular nature of PV technology makes it flexible for use with various load requirements. The battery is the single most expensive component of the system (van der Plas et al., 1998). It is also the component most likely to fail (Ibid.). The function of the battery is to store up energy within the system for use in the absence of solar radiation. The charge controller serves to prevent damage to the battery from overcharging and power surges. The inverter converts the direct current (DC) generated from the sun to alternating current (AC) for transmission to end use appliances such as televisions and radios.

The relationship between battery-based systems and solar PV has played an important role in the development of the Kenya solar market (Hankins, 2004). A common purchasing pattern for rural Kenyans is to first buy a battery and a television set (Ibid.). This trend, borne out of a desire to be connected to the rest of the world, was concurrent with the PV industry boom. At that time, a black-and-white television set imported from China could be bought in Kenya for as little as US$ 50. The only problem was that the people had no electricity to power their channels to the world. Thence emerged the innovative solution of using rechargeable lead acid batteries to power appliances. With no power to recharge the batteries, a whole new service industry sprung up for battery charging. This demand chain proved to be crucial to the build-up of demand for solar electricity that followed in later years.

By the time solar PV was introduced to Kenya in the early 1980s, the market was primed. The international agencies that initiated PV projects in those early days may not have catered to individual energy needs, but they did leave behind a legacy of training and development of local people in PV installation. The first Kenyan solar technicians were produced as a result of this training (Acker et al., 1996).
A handful of private companies, notably Solar Shamba\(^2\), also contributed to the training of the first crop of local technicians. By the time Solar Shamba closed down in 1988, a three-fold objective had been realised: local awareness and appreciation of PV had been created; the private PV market had been kick-started (with about 150 household systems installed); and local capacity in the development and installation of small scale solar PV had been created.

Ever falling PV prices combined with availability of local technical capacity, as well as the existing market for battery-operated television sets, finally tipped the PV balance in favour of the Kenyan people. Already in possession of two out of five PV components (the battery and an end use appliance), many rural families have gone on to purchase small solar modules. The PV systems, in addition to providing electricity, also eliminate the need to constantly haul batteries to charging stalls for recharging. With time, other system components such as charge controllers or extra panels may be added as the cash becomes available. In this way, rural Kenyan households build their systems over several years through purchases of as little as US$50-100 at a time (Jacobson, 2007).

Nonetheless, this unsubsidized, largely-low income market does not operate without its disadvantages. In trying to be innovative in meeting the demand for power at the least possible cost, a lot of compromise is usually made on the quality of PV systems. The battery is perhaps one of the most commonly compromised components. Ideal solar PV systems use deep-cycle batteries that provide a low of energy for an extended period of time, in contrast to shallow cycle batteries that give large bursts of energy for short periods (Hankins, 1995; Acker et al., 1996). However, due to household budgetary constraints, Kenyans do not buy ideal systems (van der Plas et al., 1998). As has been described, a typical Kenyan household PV system is a cloned one, i.e., the components are bought and assembled separately, often times over a number of years. Rather than buy new, expensive deep-cycle batteries, people make do with the cheaper, popular lead-acid batteries which are not recommended for use in PV systems. The previously mentioned advantage of not having to walk miles and pay extra to charge the batteries acts as further incentive for their use as solar system batteries. Even after battery life expires totally, people can still carry on using PV

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\(^2\) Shamba is Swahili for small, or rural. Solar Shamba’s objective, under the management of American founder Harold Burris, was to provide small-scale solar home systems for the rural Kenyan populace, particularly the rich farmers of the time. The company closed down after only four years in operation when Burris moved out of the country.
modules to power their appliances in the presence of sunlight. The clause to this is of course that the systems won’t be able to store charge for use after sunset.

Battery life and quality is often further compromised by leaving out the charge controller component. This makes the battery vulnerable to damage by power surges, making an ideal system a lot less cost effective in the long run. In a 1998 survey of 410 PV systems installed in rural Kenya, van der Plas et al. discovered that only 10 percent of the systems had a charge controller. The decision not to use a charge controller is a serious omission in technical terms, but to people who have to make every shilling count, it is a justified omission. This especially when a charge controller costs about as much as the price of a small PV module. Quite apart from issues of cost, the people do not see the need for a charge controller. Realistically, the low-tech specifications of the cloned systems make it possible for them to function reasonably well without charge controllers.

Of the two types of PV panel available on the market (amorphous silicon panels and crystalline panels), most Kenyans use the amorphous silicon (a-Si) type which is cheaper but also of lower conversion efficiency than the crystalline type. Because the a-Si PV modules are available in smaller power outputs (10-12 Wp), they are proving very popular as part of entry level systems with households which previously would have been unable to afford a solar home system (Maher et al., 2003). However, it has been discovered that a-Si PV modules are subject to light-induced degradation by as much as 25 percent during the first few months of use (Duke et al., 2002; van der Plas et al., 1998). If an a-Si module is of sufficiently high quality to start with, its output will stabilise after the initial degradation period. Severe problems occur over the lifetime of an a-Si module when its quality is compromised, as is usually done in rural Kenya.

All that compromise eventually takes its toll on PV system performance. Not only do the systems not last as long as they should, they do not perform optimally over their lifetime. Apart from employing the downsizing techniques described above, users usually do not buy the most qualitative components off the market for two reasons. One is that price tends to rise with quality, and the other has to do with the inability of users to discern between high and low quality products.

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3 Peak Watt (Wp) is the unit of measurement for the output power of a PV module. The output rating of a PV panel is usually determined under simulated laboratory conditions (solar insolation of 1000W/m² and temperature of 25°C). In real conditions however, a-Si PV panels in particular perform below their advertised ratings as solar insolation may fall below 1000W/m² and temperatures can rise above 25°C.

4 This is otherwise known as the Staebler-Wronski effect, named after Staebler and Wronski who in 1977 discovered that changes in the properties of hydrogenated amorphous silicon can be induced by exposure to light over extended periods.
Product quality problems have been a persistent concern in Kenya (Murphy, 2001). Two out of five a-Si PV brands tested between 2004 and 2005 performed well below their advertised levels (Ibid.). Imported components are generally more reliable than locally made components, but they are far more expensive and therefore less commonly used. Local manufacturers and retailers take advantage of users’ ignorance to offer substandard products for sale. Some manufacturers have been known to put well-recognised labels of high quality PV modules on their own substandard products. Users purchase these modules expecting top performance, only to be greatly disappointed when the systems fail soon after. Many users have to save for several years after buying a battery and a television set, for instance, to purchase a solar panel. When they end up with poor quality systems, they lose not only their investment, but also their confidence in the technology. This poses problems that can seriously undermine the reputation of the industry in the long term. Otieno (2003) confirms that the lack of trust in the Kenyan market could be a bottleneck for further development of the business.

The major benefit of using solar PV in Kenya comes with being able to power such appliances as televisions and radios and in providing a low-cost lighting source for rural homes (Murphy, 2001). Appliances that consume more power, such as pressing irons, electric cookers and refrigerators will require larger and more efficient PV systems than rural Kenyans can afford. A rising trend is the use of PV electricity to charge mobile phones. This is in consonance with Jacobson’s (2007) observation that electricity from solar PV in Kenya is used mostly for “connective” purposes.

Summarily, solar PV technology has had more social than economic significance to users in rural Kenya. Connection, communication and transfer of information amongst rural people as well as between them and their urban and international counterparts apparently ranks high on Kenyans’ list of priorities. Of all the connective uses, television viewing is traditionally the most important, much more so than the need for lighting. It is instructive that most rural Kenyans who can afford a PV system choose to buy a television set before they purchase lights (Jacobson, 2007). Television ownership is so central to the growth of the Kenyan solar PV market that solar systems are four times more likely to be marketed by manufacturers and retailers as a means to power television than as a means to power lights, as observed by the nation’s leading daily newspaper in 2003 (Ibid.).
As downsized and simplified as the typical Kenyan PV system has become, widespread ownership is still restricted by cost. Systems are mostly owned by select groups of “rural middle class” professionals such as teachers, bankers, doctors and clergymen, as well as businessmen and farm landlords – people whose incomes are well above those of their less-privileged neighbours. In this sense, a quasi-capitalist system operates in rural Kenya in which the benefits of PV are not equally accessible by all. This situation, Jacobson (2007) argues, challenges characterisations of solar PV as a tool for poverty alleviation in developing countries. Van der Plas et al. (1998) advocate the provision of credit facilities to qualifying households, stressing that at least 75 percent of rural Kenyans know about solar energy and have demonstrated a willingness to pay for it.

Even though the Kenyan PV market has evolved almost entirely independently of government intervention, it is unlikely that the market will reach its full potential without policy and institutional support from government.

So far the Kenyan government has put in some effort to control the cost and quality of PV systems in the country. Import duties and taxes applied to PV system components, particularly imported ones, raise system prices by as much as 44 percent (van der Plas et al., 1998). On prompting from the World Bank, the Kenyan government has declared zero duty and VAT on imported PV panels, causing a significant reduction in system prices. However, there are still heavy tariffs on other imported components such as direct current lights (Otieno, 2003), so that overall system prices are still higher than they need to be.

In tackling the issue of quality, the Kenyan Bureau of Standards (KBS) is in the process of developing PV industry standards. However, largely due to insufficient technical and financial resources, procedures to establish these standards have not been thoroughly carried out as yet. Consequently, despite the threat that poor quality systems pose to the PV industry in Kenya, enforcement of quality standards is still an elusive task in the country.

5.11 Improved Cookstoves

Worldwide development of improved cookstoves (ICS) to date has occurred in three phases (Karekezi et al, 1997). The first phase started in the 1950’s in developing countries like India, where improved cookstoves were introduced with the primary aim of alleviating chronic poverty and improving living conditions in
rural areas. The second phase, beginning in the 1970’s, assumed a predominantly technological approach, with socio-economic issues taking a back seat. The priority of the energy experts at that time was to find a once-for-all solution to the fuelwood crisis that had started to develop. What resulted was a plethora of very efficient stoves that were not used by people. During this phase, stove promoters learned a valuable lesson – efficient technology on its own does not necessarily guarantee user acceptance. Armed with this realisation, international organisations collaborated to usher in a third phase of improved stove development in the 1980’s, with much greater emphasis on mechanisms of dissemination. It was during this third phase that significant development of improved cookstoves began in Kenya.

Development of cookstoves in the country started as a response to the urban energy crisis. Unable to afford more modern cooking fuels, most urban dwellers use charcoal stoves, or *jikos*\(^5\), for cooking. The traditional jiko consumes a lot of charcoal, delivering only 10-20 percent of the heat generated to the pot (Kammen, 1995). As a result urban dwellers frequently spent a significant fraction of their income on the purchase of cooking fuel (Ibid.). Research and development efforts between 1977 and 1980 produced several improved charcoal stove models such as the *Umeme* and the *Haraka* (Hyman, 1987). However, these early models only had very minor improvements over the traditional stoves, and the implementing agencies did not encourage women’s participation in development and dissemination. Not surprisingly, these early designs were not popular amongst consumers (Ibid.).

The breakthrough in urban improved stove development came in the early 1980’s when the Kenya Renewable Energy Development Project (KREDP) was initiated by the Kenya Ministry of Energy and Regional Development. The project was facilitated by Kenya Energy and Environment Organisation (KENGO), a local non-governmental organisation, and funded by the United States Agency for International Development (USAID). The project team set about developing an improved stove based on the model of a ‘bucket’ stove which had produced encouraging results in Thailand. For a start, a group of stove developers was sent to Thailand to learn firsthand the principles of designing the bucket stove. It was a trip that proved to be worth it.

\(^5\) *Jiko* is Swahili for stove.
In 1981, the KREDP team successfully adapted the ceramic liner component of the Thai bucket stove and incorporated it into the Kenya traditional metal stove to produce the first version of the Kenya Ceramic Jiko (KCJ). Though more efficient than its predecessors, this first prototype still had a lot of deficiencies, the most critical of which was cracking of the ceramic liner due to overheating (Kammen, 1995). The project team continued to work with local craftsmen, or jua kali, in search of a satisfactory solution.

Over the next three years, an arduous process of continuous testing and redevelopment took place using feedback from women user groups. Finally, in 1984, the women suggested recasting the problematic metal bucket design into the current hourglass shape of the jiko (Kammen, 1995). That modification at last produced a charcoal stove functional and efficient enough to engender user confidence in the improved stove technology. The new stove had a combustion efficiency of up to 40 percent, enabling users to make substantial savings on fuel expense.

From that point on, the KCJ increasingly became the stove of choice amongst urban Kenyans. Its diffusion was so widespread that the KREDP met and exceeded all its targets in record time. The goal of the project was to have at least 20 enterprises manufacturing and selling 5,000 KCJs by 1986. By mid-1986, over 15 enterprises were involved in manufacturing and 125,000 KCJs had been sold (Hyman, 1987). By 1995, with a total over 780,000 KCJs disseminated (Karekezi et al., 1997), more than half of all urban households in Kenya owned the KCJ, with 20,000 new jikos being sold every month (Kammen, 1995).

The KCJ has not attained a hundred percent success rate, but it is one of the most successful charcoal stove projects in the East African region and indeed in the developing world (Karekezi et al., 1997; Karekezi, 1993). Several other countries have attempted to replicate the KCJ model but have achieved less dramatic results. These countries include Uganda, Rwanda, Tanzania, Sudan, Ethiopia, Malawi and Burundi (Karekezi et al., 1997; Kammen, 1995).

The effectiveness of the KCJ technology is definitely a major factor for its success. However, several other non-technical factors combined to create and sustain the huge impact made by the improved stoves on the Kenyan market:

1. The KCJ was not designed with only fuel efficiency in mind. Users’ needs and preferences such as stove affordability, durability and the desire to
retain as much of existing cooking practices as possible were factored into the design of the final product. This led to dramatic gains in acceptance (Kammen, 1995), thus creating demand for the stoves.

2. Extensive training was a key element of the KREDP. Local informal sector artisans (potters and metal workers) were trained systematically in the production of KCJs. To minimise training time and cost, the artisans employed were those already experienced in the manufacture of the traditional jiko. In this way a solid supply base was established.

3. Existing private sector distribution channels with access to a broad spectrum of urban households were used to sell the jikos (Hyman, 1987). However, marketing and dissemination were carefully controlled in the initial stages of development, to ensure that demand did not at any time outstrip supply.

4. The market was allowed to develop on its own merit, completely free of subsidies. As a result the KCJ reflected its true price of production. The informal sector was employed in production because the artisans typically have low overheads, thereby minimising costs and maximising profit. This profit incentive plays a crucial role in the survival of the KCJ industry.

Encouraged by the success of the KCJ, several enthusiastic donor agencies were eager to replicate the same impressive results in rural Kenya. Unfortunately however, the rural experience of improved stove dissemination proved to be far less spectacular than the urban experience.

Work on improved stoves in rural communities started in 1983 in Western Kenya, with the Women and Energy Project (WEP) initiated by the Kenyan Ministry of Energy and funded by the German Agency for Technical Cooperation (GTZ) (Blum, 1990). Working with the Maendeleo ya Wanawake (Women in Development) women’s group, stove designers developed a less expensive variant of the KCJ and named it the Maendeleo6 stove, after the women’s group. At a cost of about US$ 1.50, the Maendeleo was the cheapest available improved stove on the Kenyan market, saving 30-50 percent of the firewood used in traditional stoves (Ibid.). The original model developed by GTZ consisted of a clay liner (similar to the one used in the KCJ) inserted into a fixed mud surround and held in place by sticky soil, stones or any other suitable material which is locally available to the user.

6 Maendeleo means ‘progress’ or ‘development’.
The attraction of the Maendeleo lies in its simple, easily transferable and locally available technology. The main component of the stove – the clay liner – is quite easily produced by the existing pottery industry which is traditionally dominated by women in Western and Central Kenya (Overseas Development Institute, 1989). This is one reason why women have always been central to Maendeleo production in rural Kenya. Women’s groups, which constitute an integral part of the society, provided a ready pool of local labour for Maendeleo production. Implementing agencies were able to use these groups as points of contact for reaching the wider community. Khennas (2003) observes that working on Maendeleo projects with women’s groups has proved to be a very effective way of reaching rural women.

Notwithstanding the enabling environment, the Maendeleo failed to achieve widespread dissemination in rural Kenya. In a costly instance of oversight, implementing agencies had neglected to take into account the fundamental difference between urban and rural energy use patterns. While urban dwellers have to purchase charcoal, rural dwellers mostly gather fuelwood free of charge. As such rural dwellers have no financial incentive to cut down on energy use. Though there are several non-financial benefits to be gained by using efficient stoves, many of them are not as important to rural energy users as potential cost savings. Even at rock-bottom prices, the cost of a Maendeleo stove is still significant relative to average rural incomes. A 1985 survey showed that 37 percent of Western Kenya households had no cash income; 44 percent earned 500 Kshs\(^7\) (or US$ 7.35) per month; 12 percent 501-1000 Kshs (US$ 7.36-14.70) per month; 3 percent 1001-2000 Kshs (US$ 14.71-29.40) per month; 1 percent 2001-3000 Kshs (US$ 29.41-44.11) per month\(^8\) (Overseas Development Institute, 1989).

In an effort to improve the rate of Maendeleo dissemination, the WEP introduced a number of support strategies. The Ministry of Agriculture assigned Home Economics Officers (HEOs) to act as intermediaries between the stove producers and the public. The HEOs regularly picked up finished stoves from the women’s workshops and transported them in government vehicles to points of sale. This way stove producers were relieved of the responsibility of locating a market for their products. GTZ lent its support by subsidising transportation costs for

\(^7\) Kshs = Kenyan shillings
\(^8\) Conversions are based on the 2008 exchange rate of US$ 1 = 68 Kshs.
producers who had to convey their stoves via public transport and by initially controlling the prices of stoves sold by the HEOs, in the assumption that the rural poor could not afford higher prices (Young 1992; Khennas, 2003). The drawback to this arrangement was that the stove producers and buyers were protected from real market conditions. As a result of the strategy employed, few incentives for independent middlemen to buy and sell stoves were developed (Khennas, 2003). The subsidies compromised the sustainability of Maendeleo production: when the WEP withdrew support in 1994, most of the women’s groups were not able to market their stoves without assistance and were forced to stop production. This ineffective dissemination model had far-reaching effects which impacted negatively on later efforts to develop sustainable commercialisation of the Maendeleo.

Recognising that the problem was not necessarily one of cost or technology, the Intermediate Technology Development Group9 (hereafter referred to as Practical Action) decided to implement a totally different dissemination model. Working with the Keyo Women’s Group, Practical Action designed a pilot project in which group members were trained not only to produce the Maendeleo stove, but also to build profitable businesses out of it. The pilot project succeeded and formed the basis for the Rural Stoves West Kenya (RSWK) Project launched by Practical Action in April 1990. The project ran from 1990 to 1995, during which time Practical Action trained more than thirteen women’s groups in the art of making Maendeleo stoves. Probably in a bid to complement the re-branding efforts, the name of the stove was changed from Maendeleo to Upesi. In 1996, a second phase - the Upesi Rural Stoves Project - was launched. While the aim of the RSWK Project was to establish a market for the Maendeleo stove in West Kenya (Khennas, 2003), the Upesi Project was aimed at commercialisation of stove production (Waudo et al., 2003).

The new project launched an intensive campaign to improve the sustainability of stove-related income generating activities among women’s groups (Waudo et al., 2003). It involved training individuals and women’s groups in marketing, stocking and selling of stoves (Ibid.). A whole new stove supply chain comprising producers, stockists, promoters and retailers was established, and linkages were

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9 Intermediate Technology Development Group, a non-governmental organisation that aims to demonstrate and advocate the sustainable use of technology to reduce poverty in developing countries, is now known as Practical Action. Practical Action programs follow closely the model for technology development and adoption established by the late British economist E.F. Schumacher in his 1973 book Small is Beautiful (Kammen, 1995).
created between the various intermediaries. The key intermediary of focus was the promoter who had to create awareness, sell and install the stoves at a profitable price (Waudo et al., 2003).

The Upesi Project aimed to give economic relevance to improved stove production in rural Kenya, and in so doing create a sustainable incentive for market growth. All efforts were directed towards ensuring the stove industry’s survival at the end of the project. Therefore Practical Action progressively minimised its intervention as the project went along, seeking rather to ensure that the activities of stove producers, users and intermediaries in the stove supply chain remained the principal forces shaping the market. Each intermediary received payment for services rendered, so that the final cost to the user closely reflected the true costs of production and distribution. However, promotion campaigns (particularly local radio advertisements) had to be subsidised by the project because of the rather high expense involved. Still, the content of all promotional material was designed by local stove marketers, whose ideas conveyed the improved stove message in highly creative ways.

Despite the commercial focus of the Upesi Project, Practical Action did not lose sight of its characteristic grassroots objectives. The project was implemented using two main approaches: the PEOPLE approach and the Group Led Action Plan (GLAP) approach (Owala, 2001). The PEOPLE approach was aimed at identifying and meeting individual needs, while the GLAP approach ensured that women’s groups received adequate support to enhance group productivity. Where there were poor group interrelationships or group organisational problems, the GLAP helped the women resolve their conflicts and provided training in group dynamics to enable them work better together (Ibid.).

In addition to the fixed Upesi stove, two other variants were developed by the project: the Portable Upesi Stove (A ceramic stove liner fitted in a metal cladding and sold as a portable stove) and the Upesi Lira Stove (An Upesi stove made with a base, three small legs and two handles, and used without installation) (Waudo et al., 2003). Final selling prices for the stoves in 1996 were US$ 3.00, US$ 7.00 and US$ 3.00 respectively.

In spite of higher stove prices, the Upesi Project yielded significantly better results than those before it. By the time the project ended in 2001, it had accomplished 60 percent of the intended activities (Waudo et al., 2003). Practical
Action fell short of its target not due to technical or institutional incompetence, but due to financial inadequacy (Ibid.). Nonetheless it had proven the viability of improved stove commercialisation in Western Kenya, as well as its potential for replication in other rural communities. The all-important criterion of sustainability had also been instituted: even after the project ended, 87 percent of the trained women groups continued production and distribution, and at least 97 percent of the stoves sold were still being used by the owners (Ibid.).

It is estimated that for the duration of the project, a total of about Kshs 1 950 000 (US$ 28 846) was generated by the intermediaries in the stove supply chain (Waudo et al., 2003). This extra income produced a marked improvement in the livelihood of the individuals and communities involved with the project. The change is evident in families’ ability to acquire new goods such as bicycles, home appliances, firing kilns and land (Khennas, 2003). People were also able to either pay their children’s school fees or pay for them to learn a trade (Owala, 2001).

As important as these financial gains are to the survival of rural people, they are outweighed by several other benefits which, though not measurable in monetary terms, impact on individual wellbeing and strengthen the social fabric of the community (HEDON, 1995). Most of these benefits are received directly by women, but being home keepers, they invariably transfer the impact to their families and the wider community:

1. Women groups usually work flexible hours producing stoves in stations close to their homes (Khennas, 2003). This enables the women to easily divide their time and attention between their commercial activities and their domestic duties.
2. The major participatory role played by women in stove development has enhanced their self-esteem and increased their confidence in their own creative abilities. Many women have gone on to modify standard stove designs to suit specific client requirements.
3. There is increased respect and recognition for women producing stoves in Western Kenya.
4. Actors in the stove supply chain have heightened ambitions and an enlarged outlook on life as a result of the enlightenment they received through training sessions and field visits to other project communities.
5. This exposure has opened up many new possibilities in totally different fields of endeavour. Women now take the initiative for new development
programmes (Klingshirn, 2000) and apply the knowledge gained in stove marketing to other social and business enterprises.

At the other end of the spectrum, rural users do not derive direct financial benefits from switching to improved stoves. Yet a plethora of non-financial benefits is potentially accessible by them: time saving in cooking and fuelwood gathering; comfort; safety; convenience; improved nutrition and reduced kitchen smoke (HEDON, 1995). However the question that remains is whether users attach as much value to these health and social benefits as they do to financial gains. Despite the fact that the Maendeleo/Upesi stove has been promoted for nearly twenty years now, only 4 percent of the Kenyan population currently use the stoves (Ingwe, 2007).

The task at hand seems to be that of making rural people realise and appreciate the value of the non-financial benefits of improved stove use. This will likely be a tedious process requiring a lot of effort and cooperation between users and project implementers. The time and effort it has taken to design, test, re-design and disseminate the Upesi stove speak volumes about what it takes for successful technological change in the rural energy sector (Murphy, 2001). It has been what Hobday (1994) refers to as a “hard slog”, rather than a leapfrog.

The other issue is that there are very often conflicts between the priorities of rural energy users and those of implementing agencies. This is clearly portrayed by Kenya’s early experiences in rural cookstove dissemination. Well-meaning donor agencies launched improved stove projects on the assumption that energy saving would be a major concern for rural users. However users’ circumstances dictated differently, and it was realised after several failed attempts that cost saving actually ranked higher on users’ list of priorities. There has to be found a way of aligning the priorities of users and donors, or at least of drawing a line of best fit which accommodates the most important users’ considerations while still meeting donors’ objectives. Until this is done it is unlikely that dissemination of improved stoves in rural areas of developing countries will achieve its maximum potential.
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