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The Strategy of Decentralized Production and Distribution of Improved Charcoal Stoves in Kenya

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Abstract

A relatively large number of fuel-efficient, household charcoal stoves have been disseminated in Kenya. This program has been successful because it 1) built on the design of the traditonal stove and improved stoves in other LDCs; 2) followed several years of earlier activites in this area; 3) incorporated extensive field testing and modification of the technology; and 4) relied on informal sector artisans for production and distribution of stoves.

Introduction

Efforts at promoting more fuel-efficient charcoal stoves to replace traditional charcoal stoves in Kenya offer some lessons for the dissemination of appropriate technologies in energy and other sectors. These efforts have been much more successful than most of the improved woodstoves projects throughout the world. This paper discusses the strategy of decentralized production and distribution that was responsible for this relative success. The economic, social, and environmental impacts of this program are analyzed elsewhere (Hyman submitted).

The Kenyan experience shows the potential desirability of relying on local artisans to manufacture consumer durables and using existing private sector channels to market these goods. It also highlights the importance of going beyond a laissez-faire approach by supporting training, demonstration, and publicity to facilitate the workings of the private sector. Nongovernmental organizations (NGOs) as well as the government played important roles, but technology choice was relatively unsubsidized and left to the preferences of consumers. Since many different characteristics of a technology affect its acceptance by consumers, the stove designs were not be optimized for the single characteristic of fuel efficiency alone.

Trends in Charcoal Consumption in Kenya

In 1980, about 637,000 tonnes (t) of charcoal provided 21.1 million Giga Joules (GJ) of end-use energy in Kenya. It took 5,306,000 t of wood to produce this charcoal in traditional

earth kilns. In comparison, 12,900,000 t of wood were burned directly as fuel in 1980. This charcoal was used in the following ways: 49% by urban households for cooking; 25% by rural households for cooking; 10% by rural industries in the informal sector (mainly blacksmiths and butchers); 9% by households for other purposes such as space heating or ironing; 5% by small-scale urban firms (mainly restaurants); and 2% by schools and hospitals for cooking. Thus, 477,000 t of charcoal were consumed in household cooking in 1980 (O'Keefe, Raskin, and Bernow 1984).

Accounting for expected changes in population, household size, income, and relative fuel prices, the Beijer Institute projects an annual increase of 6.7% in charcoal consumption between 1980 and 2000, assuming no change in government policies and the types of stoves used. About 73% of the projected charcoal consumption is by urban households and over 15% by rural households. The projected total consumption by all households amounts to 2.1 million t of charcoal per year, the equivalent of 17.5 million t of wood annually if traditional charcoal conversion methods are used (O'Keefe, Raskin and Bernow 1984).

In the absence of any technological or policy innovations, the mean annual increment of wood predicted for the year 2000 could meet only 35% of the annual woodfuels demand (Ibid.). The shortfall could be met through unsustainable tree cutting rates in the short-run and through decreases in woodfuels consumption. Part of the shortfall could be eliminated if households adopted more fuel-efficient charcoal or wood stoves. In Kiswahili, the word "jiko" means any stove for cooking food, including an open fire. For

clarity, this report will only use "jiko" to mean a charcoal stove, whether of the traditional or improved designs.

About 17% of rural households and 83% of urban households in Kenya owned charcoal stoves in 1980 (Ibid.). This proportion implies that 490,900 rural and 577,400 urban households owned jikos in mid-1985, for a total of 1,068,300 households. Openshaw (1985) estimates that about 630,000 of these households use charcoal as their primary cooking fuel, including 545,000 urban and 85,000 rural households.

Practically all of the charcoal stoves in use in Kenya before 1980 were of the traditional design. If 80% of the 84,000 improved liner jikos and 4,000 Umeme stoves produced commercially through March 31, 1985 remain in use and their components are replaced as needed (Energy/Development International), over 6% of the Kenyan households that cook with charcoal had improved liner stoves by that time. This proportion may be lower if some households own more than one improved jiko or have replaced one improved jiko with another.

Many Kenyan households have more than one type of stove because they cook with several different fuels, depending on the kind of food cooked, season, and time of day. A family using charcoal as its sole fuel source for cooking and heating water by a traditional stove might consume 0.7-1.1 t of it per year. However, the average charcoal-consuming household uses much less than this amount because it also cooks with other fuels. The average charcoal consumption per jiko-owning household is 0.544 t per year; but the average is 0.662 t per year for urban households and 0.405 t per year for rural households that own jikos.

The Traditional Technology For Charcoal Combustion

The traditional (established) jiko design was introduced into Kenya in the early 1900s by Indian laborers working on construction of the railroad. For many years, Indian artisans kept the construction process as a trade secret. As Indians switched from being artisans to merchants, black Kenyans took on this occupation. It took about 50 years for this stove to become the predominant type of charcoal stove in Kenya through market forces. This stove is also commonly used in Tanzania, Uganda, and Burundi (Sambali and Schneiders 1984) and more infrequently found in Malawi.

The traditional jiko is made of scrap metal and is assembled by local tinsmiths on a cottage industry scale. It is shaped like a cylinder and has a door for draft control and ash removal, 3 hinged triangular-shaped flaps that can hold one cooking pot, 3 legs to support the round base, a metal grate, and a handle. Since the traditional jiko is uninsulated, it radiates heat out to the air as well as to the pot.

This jiko is available in various sizes. The most common size has a diameter of 28 centimeters (cm) and a height of 28 cm including the legs. A jiko with a 25 cm diameter is too small for large families or for roasting maize. The traditional jiko is very portable which is important in urban areas. The most common size for households weighs about 3 kilograms (kg). The traditional jiko is used for cooking and heating water, but not for baking or lighting.

Following the U.N. Conference on New and Renewable Sources of Energy in 1981, a large number of organizations sponsored or carried out work to develop, promote, disseminate, and commercialize improved charcoal stoves in Kenya. Most of these efforts have been devoted to upgraded versions of the traditional jiko that incorporate design features from engineering principles and experimentation as well as from stoves in use in other countries. The active efforts of a large number of local NGOs and international organizations, and the government, in conjunction with private artisans and distributors, have begun to disseminate this technology faster than the original rate of dissemination of the traditional jiko. The Kenya Renewable Energy Development Project (KREDP) funded by U.S. AID through the Ministry of Energy and Regional Development (MOE), began in September 1981. The project included components for improved charcoal stoves and woodstoves, agroforestry, industrial fuel conservation and substitution, more efficient charcoal kilns, and biogas. The jikos component inclued 1) applied research and prototype development; 2) training, extension, and demonstration; 3) development of productive enterprises; and 4) monitoring and evaluation. The administrative costs of the jikos component of the KREDP including those borne by other organizations amounted to K.S. 3,680,000.[1] The bulk of the costs were incurred for salary, fringe benefits, and overhead for staff. Prorated over the number of improved jikos produced by commercial enterprises through the first quarter of 1985, the administrative costs were only K.S. 43 per

[1] As of July 1985, there were 16 Kenyan shillings (K.S.) per U.S. dollar.

jiko. The improved jiko design which has been begun to be adopted in significant numbers mainly in and around Nairobi is an outgrowth of this project. These stoves have a metal shell, a ceramic liner, and an insulating layer of cement/vermiculite that attaches the liner to the shell.

Energy/Development International (E/DI) was the contractor for the KREDP. E/DI convinced Max Kinyanjui (the director of the jikos component) and the MOE to focus on charcoal stoves for low-to-moderate income groups which could be built by informal sector artisans rather than relying on the more frequently-tried approach of user-built stoves. The National Christian Council of Kenya was influential in persuading E/DI that this strategy was appropriate and in making suggestions on how to implement it. The project was scheduled for completion in June 1984, but an extension was granted allowing the Kenya Energy Non-governmental Organizations (KENGO) to spend remaining funds from the jiko component until June 1985.

In late 1981, the KREDP tested various Thai cookstove designs brought in by Keith Openshaw, a researcher with the Beijer Institute for Energy and Human Ecology. Another major influence on the KREDP was a subsequent 4-week study tour of the stoves industry in Thailand.

The Intermediate Technology Development Group (ITDG) in conjunction with Kenyatta University College tested the efficiency of various stove designs. KENGO was the subcontractor for a 6-month stove field testing program supported by the KREDP in late 1983. A large number of the NGOs affiliated with KENGO participated

in the training, production, and standardized survey work of the field test.

A follow-up project that builds on the achievements of the KREDP began in mid-1985. Appropriate Technology International (ATI) is providing a grant of K.S. 4,065,552 to KENGO to accelerate the production and dissemination of the improved household jiko design in areas outside of Nairobi. This 3-year project will provide training, technical assistance, and loans covering 75% of the capital costs of establishing production of the improved stove in up to 20 existing informal sector, jiko production units throughout the country. These production units are expected to supply 10% of the annual demand for charcoal stoves. In addition, support will be provided for public education, a marketing program, and a quality control certification process.

UNICEF began working on charcoal stoves in 1980 and an entirely different design, the Umeme, was developed in 1981 by Philip Hassrick, Eric Brunet, and Frans Claassen. It is an all-metal, double-walled charcoal stove with an insulating layer of air, soil, or ash. UNICEF's Haraka stove is a single-walled variant of the Umeme.

Description of the Improved Jikos

KREDP Liner Stoves

The most popular improved jiko designs are liner stoves adapted from the all-metal traditional jiko. Following the example of Thai stove designs, the improved Kenyan stoves have three other components: 1) a fired ceramic liner, 2) an inserted grate, and 3) an insulating layer between the cladding and the liner and also on the bottom of the ash box. The metal cladding protects the liner

and supports the pots while the liner reduces heat transfer losses from lateral radiation. The grate aerates the combustion bed and channels heat toward the pot. The insulating layer increases the lifetime of the cladding by reducing its exposure to heat. Like the traditional jiko, the improved stoves can cook one pot of food at a time. Both stoves can be used for barbecueing if a grate is placed on top. Neither stove is appropriate for slow drying or smoking of fish or meat for preservation due to the high temperatures generated.

Kenyan liner stove designs have evolved a great deal and are still undergoing further refinement. The current version, the bell-bottom stove, was developed in late 1983 and refined further in 1984. This stove has a waisted shape which is narrowest in the middle. The shape provides a firm assembly because the cladding conforms to the shape of the liner. Gravity and the insulation hold the liner in place. As a result, the liner is less prone to cracking caused by differential expansion in heating. The liner only extends halfway down the height so that the stove 1) is more portable because it weighs less, 2) is cheaper to produce, and 3) has a smaller firebox, reducing the possibility of waste from charcoal overload. The wide bottom of the stove makes it easy to light. Since the air inlet is bigger in the bell-bottom stove, it can be used for roasting maize. This stove can be constructed out of sections of the circular tops and bottoms of metal drums which are of little use in making most other products.

The current version of this stove has a one-piece ceramic liner in which the perforated floor of the liner serves as a grate. It was found that grates that are separate from the liner are more subject to cracking. The bell-bottom stove has strong metal pot rests and a wide base to facilitate stability in stirring. Several types of insulation were tried in these stoves; a cement/vermiculite mixture appears to be best. Over time, the weight and bulk of the cement/vermiculite insulation was reduced and its thickness was made more uniform to protect against cracking and to lower production costs. The bell-bottom stove is available in several sizes; the most popular size is approximately 28 cm in diameter and 28 cm high and weighs 7 kilograms.

In Mombasa, some cement/vermiculite lined stoves have been produced in small numbers instead of ceramic-lined stoves. Although some suitable clay deposits exist in Mombasa and are used for the manufacturing of bricks and tiles, there is less of a tradition of local clay pottery making. These stoves have straight sides rather than the bell-bottom shape and are made of heavier-gauge metal to suit local preferences. These stoves are cheaper and nearly as efficient as the ceramic-lined stoves, but are less durable.

The UNICEF Stoves

The Umeme is an all-metal stove with five components: 1) an outer body with a door frame and a sliding door to control the air intake, 2) an inner cylindrical wall body which is the combustion chamber, 3) an inner cone for holding the charcoal, 4) an additional grate for large pots, and 5) a top ring which closes the insulating chamber between the two walls and holds three prongs for the pot

rests. The insulating layer may be filled with ash, soil, or just air.

A major difference between the Umeme and the liner stoves is that an average-sized pot sits on three prongs inside the Umeme rather than resting on top of the stove. The Umeme is 28 cm in diameter. Spacers limit the size of the pots that can fit inside, but larger pots can be placed on top of the stove. Three legs are attached to the base of the Umeme. Without the insulation, the Umeme weighs 6.5 kg, but the weight may increase to 12.5 kg if soil is used as an insulation. Adding the soil does not increase the efficiency any more than just using air as the insulation (Sambali and Schneiders 1984). However, cooking can continue for up to 2 hours after the charcoal fire is burned out if the soil is added (UNICEF Technology Support Section n.d.).

The Umeme has a high fuel efficiency due to the enclosed combustion chamber, greater convective heat transfer to the inserted pot, insulated chamber wall, and regulated air flow. Other advantages are that it remains hot for a long time, cooks fast, and is durable. Also, the large firebox diameter provides stability. It only takes one type of artisan to make the Umeme since it is all-metal and this avoids some of the quality control problems that have been experienced with ceramic liners.

The Umeme has several disadvantages. Although production of the stove only requires one type of material, metal is an expensive material. The metal work is more time-consuming for the Umeme than for a bell-bottom stove. The Umeme is also more difficult to use than the traditional stove or the liner stoves.

The Haraka stove is a variant of the Umeme with a single wall. The inner wall of the Umeme forms the outer wall of the Haraka's cylindrical shape. The insulating second wall for the combustion chamber and pot are only raised up to the grate which rests on the half wall. Small pots are surrounded by one wall when partly inserted in the stove while large pots sit on the rim. The Haraka has a handle that can be swung for air circulation to make lighting the stove faster. The Haraka is cheaper to produce than the Umeme because it requires less metal and labor. The Haraka weighs 4.5 kg (Sambali and Schneiders 1984).

Table 1 compares the initial cost, replacement cost, expected lifetime and fuel efficiency of the traditional jiko, the bell-bottom stove and the two UNICEF stoves.

Production Achievements

The KREDP originally set as a goal the manufacture and sale of 5,000 improved jikos in 2 1/2 years. This project is one case in which the achievements have far surpassed the goal. By December 1983, private workshops had produced more than 13,000 liner stoves as a result of the project. Total production rose to 66,000 by the end of 1984 and 84,000 after the first quarter of 1985. The production rate increased dramatically from 2,000 in the third quarter of 1984 to 5,600 in the fourth quarter of 1984 to 18,000 in the first quarter of 1985. Production of the liner is the limiting factor in the manufacture of these stoves.

The project also set a goal of creating at least 20 self-sustaining enterprises producing improved jikos. There are over 15 enterprises now making liners. However, most of the liners produced

Table 1

Comparison of Kenyan Traditional and Improved Charcoal Stoves

	Traditional Jiko	Bell-Bottom Stove	Umeme Stove	Haraka Stove
Retail price In Nairobi (K.S.)	40	60-85	85[a]	70[a]
Parts needing replacement	Metal grate	Ceramic liner/grate and insulation	Metal grate	Metal grate
Price of Replacement Parts in Nairobi (K.S.)	10	30[b]	15-20	20
Frequency of replacement of parts (months)	3	8-12	6-12	6-12
Expected lifetime at full use (months)	12	24	48	24
Efficiency in laboratory tests (%)[c]	20-22	29-32	33-36	28-31

[a] The artisans receive scrap metal through UNICEF at a reduced price. At market prices for scrap metal, the Umeme stove might cost K.S. 120 and the Haraka stove might cost K.S. 100.

[b] Including labor.

[c] PHU_2--percent of charcoal's heat utilized in boiling and evaporating 2.0 liters of water for 60 minutes.

Sources: Joseph, Shanahan and Young 1982; Sambali and Schneiders 1984; Stewart 1984; Allen 1985; Claassen 1985; Kinyanjui 1985; Schneiders and Mkallata 1985.

to date have been made by 3 relatively large enterprises in the Nairobi areas: Clayworks, Ltd., which has ceased production, Jerri International and Miaki Jikos.

Metal claddings for the bell-bottom jiko are made by about 100 informal sector artisans; half of these artisans are located in Nairobi (Opole 1985). Jikos are assembled by the liner manufacturers as well as by metal artisans. Nearly all Kenyan towns with a population of 2,000 or more have metal artisans capable of making claddings.

Clayworks is the largest brick and tile producer in Kenya. In 1983, the MOE decided not to provide any assistance to Clayworks in order to protect fundis (small-scale, informal sector metal artisans) from unemployment, but also due to the political and tribal affiliations of its owners. Since Clayworks made liners from the same clay mixture it used for bricks, these liners were brittle and withstand thermal stress poorly. The grates made by Clayworks are separate from the liners and tended to burn out quickly. Since Clayworks did not use cement/vermiculite insulation, the liner and grate on their stoves can fall out and break easily. Several former Clayworks employees who were most skilled at making jikos left the company for Jerri International several years ago. Due to quality control problems, Clayworks stopped producing liners in mid-1983 although it still sells liners from its inventory. Because of the size and profitability of its other domestic and export operations, Clayworks is not very interested in jiko production.

Jerri International is owned by Richard Kimani, whose large investment in jiko production and marketing savvy accelerated the dissemination of the bell-bottom stove. Jerri makes a large number

of diverse pottery products. Through March 31, 1985, Jerri had manufactured almost 51% of the total number of liners produced. The dominance of the market by such a large producer has kept profit margins high. Jerri purchases metal claddings from small-scale artisans and sells assembled stoves to individuals at the factory and to retailers in and outside of Nairobi. It does not sell liners to metal artisans or middlemen. These stoves are painted grey for brand recognition.

According to several reports, quality control for liner production has slipped recently at Jerri as key employees have left the company to start their own enterprises. The design used by Jerri has a deeper firebox than is recommended. Although this makes the stove easier to construct and requires less cement/vermiculite mix, it increases clay costs, reduces the efficiency and lifespan of the jiko, and may result in waste of charcoal. The grate is too thick and susceptible to cracking, the sizes and shapes of the liners are sometimes irregular and grate holes are punched improperly. Jikos comprise only a small portion of the business of Jerri. As of early 1985, Jerri was holding an inventory of over 3,000 liners because sales dropped due to the relatively high price and declining quality of their jikos (Chege 1985).

Miaki Jikos Co. is owned by Kinyanjui, who has been instrumental in the design and promotion of the bell-bottom stove. This company makes high quality liners following the recommended design. Miaki makes some claddings, but buys most from fundis at Shauri Moyo. Miaki sells completed jikos to households and also

wholesales liners to metal artisans. Miaki has made almost 14% of the liners produced through March 31, 1985.

Shauri Moyo is a public market in Nairobi with a large number of fundis in open-air workshops. Since the fundis at Shauri Moyo do not own the land they occupy and are not supposed to build permanent structures, they lack adequate storage facilities for jikos and many are unwilling to construct enclosed work areas which would allow production to continue when it rains.

Informal sector artisans often make changes in the recommended designs and some of these changes reduce a stove's fuel efficiency or durability. Some inferior liner stoves are being sold as improved jikos at high prices by artisans who have not been trained properly or are trying to cut corners in construction. Most of the quality control problems are with the liners and insulation, rather than the claddings. Some of the problems with these stoves include non-uniform thickness and shape leading to a mismatch between the cladding and liner, a poorly joined upper and lower cladding; loose handles; weak legs that are not riveted securely; cracking of liners and grates; pot rests that are weak, badly hinged, or resting on the liner; doors or latches that are not properly riveted or do not work well; weak seam joints; a grate that is not level with the seam joining the upper and lower parts of the cladding; misproportioned door and ashbox depth; irregular grate holes; lack of insulation; or insufficient curing or rain damage to the insulation (Kimani 1985). Sometimes, these stoves are painted for greater aesthetic appeal, but their fuel efficiency and durability are poor.

Design guides for producers and consumers could reduce the prevalence of poor quality stoves. Most Thai consumers know what to

look for in the fabrication of a charcoal stove; Kenyan consumers have had less experience with the improved technology and need to be educated. The Kenyan Bureau of Standards has developed performance standards for many products, but it is not interested in doing so for jikos now on the grounds that this is not yet a mature technology. Product certification is not one of the functions of the MOE.

KENGO is considering establishing a quality control certification procedure. KENGO could randomly sample stoves made by producers who agreed to participate in the program and allow a seal of approval to be stamped into the liner of producers meeting the standards. Counterfeiting of the seal of approval could be a problem as would getting the seal back from jiko manufacturers that no longer meet the standards. A quality control certification process worked well in a stoves project in Botswana although only a small number of stoves were produced there. Another possibility would be for producers to offer warranties to replace defective stoves. Presumably, customers would be willing to pay more for jikos with a certification of quality or a warranty. Quality control may be a simpler task for stoves such as the Umeme and Haraka which are built by a single type of artisan.

It is important that no single firm obtain a monopoly in liner production, or the manufacture of claddings. The government's goal of encouraging small-scale production has been compromised by the army's initial purchase of 25,000 bell-bottom stoves and contract for an additional 2,000 replacement stoves every 18 months from Jerri International. Fortunately, the degree of concentration in

bell-bottom stove production has begun to decline. Due to high transport costs and profits to middlemen, centralized production of jikos is likely to become less competitive over time as increasing numbers of small, local producers gain the skills to enter the market. As the prices of bell-bottom jikos drop, the gross margin for jiko makers may be driven down toward subsistence levels and the large, diversified producers might switch to producing other things.

There is also a need to increase production of bell-bottom stoves in other urban areas besides Nairobi. It is inconvenient for these users to take improved jikos back to Nairobi for repair, and as a result, households either will return to using traditional jikos or will have to buy a new improved jiko prematurely. Centralized production of liners might result in large breakage losses in transport to distant parts of the country. Decentralized production would make it easier for a consumer in other parts of the country to have the liner/grate and insulation replaced and would also generate some additional employment outside Nairobi for fabrication and repairs. An intermediate production strategy might be feasible, e.g. centralized fabrication of claddings in Nairobi, Mombasa, or Thika where metal prices are low and decentralized production of liners and assembly of jikos. Alternatively, metal could be purchased in bulk by a cooperative of metal artisans and transported to decentralized units.

The Umeme stove is being produced at 2 workshops in Nairobi. According to the entrepreneurs, the Likoni Road workshop currently produces 30 Umemes per month and a workshop at Shauri Moyo produces 25 per month. There are also reports of spontaneous production of Umeme stoves elsewhere (Hassrick 1985). An estimated 4,000 Umeme

stoves have been produced in Kenya through early 1985 (Claassen 1985). Production of the Umeme has been demand-limited because UNICEF has not carried out an extensive promotional program for this stove. These 2 workshops have made a few examples of the Haraka stove, but not in commercial quantities. Middle-income households often are willing to pay a little more for an Umeme than a Haraka, but the latter may be more attractive to low-income households.

The Dissemination and Promotion Strategy

Since the major share of the improved charcoal stoves produced and distributed in Kenya has taken place through the KREDP, this project's strategy for dissemination and promotion of the technology deserves attention. The project benefited from the efforts of an enthusiastic Kenyan who has a thorough understanding of how small-scale producers operate and how to communicate with them and also with technicians. The project's approach was based on three assumptions.

First, it was assumed that the efforts of government and NGOs could be most effective if they built on Kenya's strong private sector. Consequently, profit provided the incentives for the production and distribution of goods. The costs also were minimized by relying on the informal sector which has low overhead, pays little or no rent, relies on inexpensive labor, and has access to cheap sources of scrap metal. The project began working with small-scale artisans who already were producing metal products or pottery on the grounds that these artisans have the basic skills and raw materials needed for jiko production. Since informal sector

artisans can produce stoves competently when given simple designs, the project provided them with some training on the principles of efficient stove design as well as step-by-step instructions on construction. Some important lessons on how to organize the production of charcoal stoves and train artisans were learned during the field visit to Thailand early in the project.

Second, since the initial cost of an improved jiko exceeds that of a traditional jiko, it was assumed that households would be willing to pay the higher price if they could be shown the benefits of doing so. Thus, emphasis was placed on demonstration of the improved jiko to a wide range of potential buyers. Existing private sector channels of distribution with access to a broad spectrum of urban households were used to sell the jikos. In early 1985, at least 22 wholesalers distributed the jikos; 40% of the wholesalers were in Nairobi. There were over 73 retail distribution points in Kenya for the bell-bottom stove including workshops, open air markets, food stores, hardware stores, and appliance stores (Opole 1985). Nevertheless, most of the purchasers of bell-bottom stoves to date are middle-income households. Low income households are less willing to take risks on a new technology and may have trouble accumulating the extra initial cash cost.

Third, it was assumed that households would maintain their same basic cooking practices in judging the improved jikos. Thus, the stove designers sought user feedback in the course of the project on how the technology could be modified.

Training

The project recognized that different forms of training are necessary to meet diverse needs. Training was provided to artisans, trainers, and managers. The first priority in training was to reach some artisans who already were involved in jiko making so that production of the improved models could begin. Experienced metal workers can learn to fabricate the cladding for the bell-bottom stove in 3-4 training sessions. Production of the ceramic liners is more complicated, requiring a month of intensive training for informal sector potters (Kinyanjui 1984). Some of the early training took place on the sites where the artisans usually work. Some village polytechnics were involved in training, but these efforts were limited and eventually dissipated. The polytechnics generally lacked adequate tools and materials, as a result, they generally made substandard jikos (Opole 1985).

Some follow-up visits were conducted to ensure that these artisans retained what they learned. To stimulate production for the field test and ensure that their newly-acquired skills were not forgotten before they could be applied, the project ordered metal claddings from qualified artisans shortly after they completed the training. The large order generated by the field test allowed production bugs to be worked out. In addition, it gave jiko makers the motivation, experience, and cash needed to expand their production later.

Mobile training units that travel to the work sites of the artisans were planned from the beginning. Each mobile training unit consists of two trainers equipped with stove prototypes at different stages of production plus one set of templates, tools, and

materials. However, the first of these units was not operational until mid-1984.

It was hoped that a network of trainers could train large numbers of additional artisans. Since many of the artisans are semi-literate or illiterate, it was important to reach them through their peers. Special attention was paid to identification of skilled artisans who could become good trainers.

Most of the training was conducted at the regional agroforestry centers in 1983. The locations of these centers are more appropriate for the tree nurseries component of the project than for the stoves component because the locations are far from the artisans and major markets for jikos. Moreover, only a small proportion of these trainers were effective. Trainers often quit their jobs after a short period of time because of the low pay. Some former trainers started their own jiko-making businesses and although this slowed the progress of training other artisans, it did indicate the income-generating potential of improved stove manufacturing.

In general, the training courses for artisans had only limited impact because most trainees continued making traditional jikos and other metal products rather than improved jikos. The trainees often complained that they could not obtain ceramic liners, sufficient capital, or orders to produce improved jikos. Few had sufficient management skills or experience in bookkeeping, analysis of cashflows, or marketing. It might have been better to give more emphasis to training of entrepreneurs and to promotion of improved jikos among consumers.

Some training was aimed at building technical and management skills among managers in the national and local government, NGOs, and private entrepreneurs. The impact of the training of managers is unclear.

Demonstration

It is more difficult to encourage households to accept new stove designs than to train artisans to produce the stoves. A thorough demonstration program requires a substantial amount of resources to inform people about the benefits and costs of the stoves. The KREDP mostly confined its demonstration activities to a field test and displays at exhibitions. The field test distributed about 450 Kenyan bucket stoves to households in Nairobi and Mombasa in late 1983 (KENGO 1984). In addition to providing important information on the efficiency and durability of the stove in use, the field test had a secondary goal of encouraging people to talk about the stoves. Information gained during the field test led to important design modifications that resulted in the bell-bottom stove. Later, the KREDP gave away about 250 bell-bottom stoves to households. UNICEF made few efforts to demonstrate the Umeme stove other than distributing about 50 free Umeme stoves to households (Hassrick 1985).

In early 1984, the Kenyan army began a large program to distribute bell-bottom jikos to soldiers who prepare their own food and carry their fuel. This program could have important demonstration effects as local people observe the use of the new stoves by soldiers and as soldiers inform their relatives and friends. It was discovered that soldiers damage their jikos through

rough handling so some consideration is now being given to design modifications for army jikos such as reinforcing the liners with chicken wire.

Although most households mainly buy improved jikos for the energy savings, the greater prestige of having a modern device also may be important. A metal stove can be a status symbol, particularly in rural areas where it is seen as a step up from an open fire. Consumer subsidies were not necessary to stimulate a significant number of middle-income households to purchase the stoves. However, many low-income households are not aware of the existence or benefits of improved jikos, or cannot afford the extra initial cash cost. A mid-term evaluation (Kernan, Little, and Evans 1984) suggested that the government or NGOs support an arrangement allowing the poor to exchange their old traditional jikos for new ones, but this recommendation was never implemented.

Liner stoves and traditional stoves were compared in cooking tests at seven major agricultural fairs in different parts of the country, and members of the audience were involved in the demonstrations. It was learned that the public became frustrated if improved stoves were not available for sale immediately after a demonstration.

Only modest efforts were made at demonstrating improved jikos at public markets or through local institutions. KREDP management was concerned about creating a potential demand that could not be met before production had expanded sufficiently. Although this strategy reflected the initial reality, a stronger demonstration and marketing program is timely now. Promotional efforts should go beyond just influencing the decision to purchase an improved jiko

because users must understand the importance of having the stoves repaired properly and must be able to identify when repairs are needed.

Since the literacy rate in Swahili or English is relatively high in Kenya and the national newspapers have large circulations, a press campaign could help publicize improved jikos. The KREDP printed 5,000 booklets describing the improved jiko, but these were not really aimed at households. More could also be done to publicize improved jikos through radio announcements. Promotional efforts could be expanded through greater coordination with other governmental programs, church groups, and women's groups. Promotional campaigns at schools may be quite effective because children often bring information to their mothers.

A wide variety of organizations are involved in the distribution of improved jikos: retail shops, market vendors, some of the jiko factories, government field extension centers, churches, and chief's camps. In the early stages, retailers were encouraged to stock improved jikos by arranging their first deliveries on consignment so that they would not have to risk their own cash in advance on a new product that might not sell. The Kenyan Grain Growers Union cooperative stores are selling improved jikos now.

Each production unit should have a sales manager paid solely on commission to have an incentive to market jikos effectively. Retailers could reduce the risk to consumers by letting people borrow improved stoves for a short, trial period or allow them to return purchased stoves if they did not like them.

A government loan program to enable consumers to buy jikos

probably would not be appropriate because there are many other things people would rather buy first before jikos and many households are wary of government loans. Jerri International has had some success arranging for large employers to provide jikos for their employees and recover all or part of the cost gradually through payroll deductions. One jiko seller in Chevakali offers a rent-purchase agreement to customers, with rent payments credited to the purchase price (Opole 1985). AID's regional housing office for Africa is considering including jikos in its housing programs and this could have important demonstration effects.

More follow-up to ensure proper use and maintenance of the stoves would be desirable. Key questions for this follow-up include the extent to which households replace liners when they break or buy another improved jiko when their first one burns out. Since the initial purchase of an improved stove may be on impulse, maintenance and replacement expenditures may be a better indicator of eventual consumer acceptance than the initial purchase. NGOs probably are the most appropriate vehicle for this monitoring.

Production Assistance

The project provided grants to 4 entrepreneurs for start-up costs and/or construction of a kiln and shed. One entrepreneur was provided with an indoor masonry kiln for free, but only uses it during rainy season because he worries that the heat will damage the iron sheet roof of his workshop. The rest of the year he uses a traditional earth pit kiln outdoors. The KREDP provided K.S. 500-1,000 to each of about 30 artisans for partial financing of the costs of tools and initial materials (Kinyanjui 1985). These

Somalia, and Rwanda although different designs are being promoted in accordance with local preferences and materials. The U.N. High Commission on Refugees is ordering a large number of Kenyan bell-bottom stoves for refugees in Sudan. If gradually done, their order could increase the commercial viability of Kenya jiko production units and could have positive demonstration effects in Kenya. It is also possible that sudden, temporary large orders could lead to a "boom and bust" situation that eventually bankrupts many producers.

UNICEF has disseminated 2,000 Umeme stoves in Rwanda in a year and a half. As of early 1985, GTZ-Tanzania had disseminated over 600 Umeme stoves in Dodoma, and, over 150 in Arusha (Roeske 1985; Schneiders and Mkallatta 1985). Sudan's Department of Community Development has also introduced a modified Umeme stove. The Haraka stove is being produced in Somalia and Zambia.

Lessons From This Experience

Some broader lessons about the factors affecting the design, adoption, and use of appropriate technologies in general can be gleaned from the Kenyan experience. First, the choice of the technology was not based solely on laboratory experiments or engineering principles. Instead, the design work accepted the traditional (established) technology as a starting point which helped ensure widespread acceptance by households. Like the traditional stove, the improved stove is easily portable. Users were not expected to make any major changes in the way they used the stove.

A totally different design would have been unfamiliar to the users and there would have been a greater likelihood that it would not have met their perceived needs. Yet, the fact that there was a readily-observable difference between the traditional and improved stoves (i.e. the new bell-bottom shape) was important so that consumers can recognize the difference between the improved and traditional technologies easily. Since "the best can be the enemy of the good", emphasis was placed on getting a satisfactory design into production rather than concentrating efforts on modifying designs to optimize all factors.

Second, improvements in the technology were made after examining the experience in other LDCs. This sharing of experience can reduce time-consuming and expensive duplication of efforts as long as it is recognized that the appropriateness of a technology varies with local conditions. It often is best to emphasize use of resources and skills that are readily available locally so that production and training costs can be kept down, bottlenecks in input supply can be minimized, and parts can be repaired or replaced easily.

The KREDP was timely because it built on the earlier activities of a large number of locals and expatriates. The project also avoided the common pitfalls of inflexibly pushing a single design set in advance of implementation, or spending a lot of time and money trying to change people's cultural preferences for stoves. After laboratory tests narrowed the range of alternative technologies, field tests were conducted to obtain feedback from potential users. Following the field tests, further sorting out of

the technologies was left to the natural selection process of consumer purchases.

Many stove projects elsewhere have not taken off because the private sector was not given a role in the design or implementation of the projects. The informal sector lacks the capacity for R & D or testing of a new technology, but has the ability to adapt rapidly to introduced designs if they are appropriate. Reliance on existing informal sector artisans avoids the expense of having to establish a whole new infrastructure and completely train inexperienced and less committed workers. Although artisans do not have incentives to train anyone other than their own apprentices, a moderate amount of project resources can substantially increase the specific skills of a significant number of experienced artisans. Since one-time, short-term training is often inadequate, follow-up sessions that include observation of the trainees' work are essential.

Decentralized training and other support can be provided to artisans effectively through NGOs where these groups have the necessary knowledge, resources, and management ability. These prerequisites are most likely to be met if the activities of various NGOs are well-coordinated and there is a tradition of self-help in the project area.

The Kenyan experience demonstrates the advantages of artisan-built rather than user-built stoves. The informal sector is capable of producing simple consumer goods in large numbers at a relatively low cost and in a way that can maintain a competitive and self-sustaining industry in the long run. Generally, informal sector artisans have a low overhead and can spread the risks of labor-

intensive production of a new product across the large number of other products that they make.

Maintaining quality control can be a problem with production by small-scale artisans. Eventually, competition will drive low-quality producers out of the market or force them to improve their products. In the short-run, however, some consumers could become dissatisfied with the technology as a result of the inferior performance and poor durability of the imitations. To reduce this problem, consumers need to be educated about what to look for in a design and in the fabrication of the good. Quality control stamps on the products or warranties also could be helpful.

Introducing a new technology to households is a gradual process that should begin with thorough field testing to obtain consumer feedback on design features. Charcoal stoves are used by households who pay cash for cooking fuels; these households could save at least 25% of their charcoal expenditures by switching to improved stoves. By initially focusing on urban markets which are more geographically compact and contain a larger proportion of households that purchase fuels, distribution may be facilitated and the demonstration effects may spread faster.

An existing distribution system of small-scale merchants and larger shops often is convenient for informal sector artisans as well as consumers. Private sector distribution of charcoal stoves may be more cost-effective than government distribution of woodstoves. Nevertheless, the informal sector needs some initial support from public agencies, the media, and/or NGOs in promotion and demonstration of a new technology. An educational program can

include demonstrations at exhibitions, markets, churches, schools, and other community organizations; radio and newspaper publicity campaigns; and simple pamphlets that can be retained for future reference.

Government policies affecting the prices of wood and charcoal can contribute to deforestation and forest resource degradation and may have slowed the progress of this project. Although the price controls on charcoal are not well-enforced, they do have some effect on retail prices and hence reduce the incentives to conserve charcoal.

The Kenyan jikos experience shows that in some cases there is no need for extensive producer or consumer subsidies to disseminate a new technology once it has been developed, tested, and demonstrated. Producer subsidies include direct cash payments, provision of in-kind goods below cost, or special tax benefits. Producer subsidies tend to lead to inefficient production by firms and frequently stifle competition and further innovation. Providing financing at a commercial interest rate is not a subsidy, and may be important in stimulating production.

Consumer subsidies include price rebates, price controls, and special tax benefits. Where the benefits can be captured by consumers and a technology is affordable, consumer subsidies are unnecessary. In fact, consumer subsidies might slow the project's replication in other locations if consumers defer purchasing the stoves while waiting for a subsidy program to be expanded. Price controls on the products of a new technology can interfere with production goals or can aggravate quality control problems. Thus, it may be best to leave price determinations to the market while

encouraging further competition that eventually will reduce prices.

In conclusion, publicly financed research and product development is necessary, but the findings must be linked to private sector production and marketed to satisfy consumer preferences. These activities need to be sustained over an initial gestation period. A wide variety of technologies and approaches may deserve support at first while leaving selection of the most appropriate ones to the marketplace.

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